Woodfuel supply chain integration in the South West of England:

A transaction costs approach to bioenergy development

Submitted by Pedro Andrés Garzón Delvaux to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Politics in September 2011.

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Pedro Andrés Garzón Delvaux: ..................................................
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Pedro Andrés Garzón Delvaux

Abstract

The wood energy market remains nascent in the UK, despite climate change policies and energy security concerns. Transaction costs have been identified as one barrier to woodfuel development. However, few studies provide explicit insights into such barriers to spontaneous exchange in this sector and how they influence its formation. The study approaches the development of woodfuel in the South West Region of England through Transaction Costs Economics (TCE) and aims to identify the appropriate governance structure of the supply chain as a response to existing transactions costs. When transaction costs increase, seamless market exchange gradually gives way to credible contracting and even to full vertical integration or unified ownership. The TCE approach provides insights to analyse friction and barriers to exchange and allows for a dialogue between economics, law and day-to-day business decision-making. Fuel procurement from woodfuel suppliers to woodfuel users is central to this project in looking at the barriers to exchange. Original data was collected through 42 in-depth interviews, mainly with suppliers themselves but also from Forestry Commission, regional agencies, NGOs and lobbies involved. The results suggest the influence of transaction costs. Also, there is some evidence that wood-energy regional actors are embracing organisational diversity from known rural business structures to less familiar ones in the UK, such as cooperatives and new partnerships as answers to, among other factors, transaction costs. The evidence suggests that not only support to demand and supply is necessary, as generally identified, but it is also needed at its interface by supporting the governance of the supply chain. Some practical implications for both public and private sectors are identified to better articulate the response to this need.

Keywords: woodfuel, wood energy, bioenergy, transaction costs, governance.
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Nomenclature

AONB  Area of Outstanding Natural Beauty
BERR  Department for Business, Enterprise and Regulatory Reform
BMDH  Biomass District Heating Plant
CEM   Contract Energy Management
CEN   European Committee for Standardisation
CIS   Commonwealth of Independent States
CLA   Country Land and Business Association
CPET  Central Point of Expertise on Timber Procurement
CUM   Cubic Metre
DCC   Devon County Council
DECC  Department of Energy and Climate Change
DH    District Heating
EFSOS European Forest Sector Outlook Studies
ERI   Sterling Exchange Rate Index
ESCo  Energy Service Company
ESOMAR The European Society for Opinion and Marketing Research
ESRC  The Economic and Social Research Council
FSC   Forest Stewardship Council
GHG   Green House Gases
HETAS  Heating Equipment Testing and Approval Scheme

IoS  Institutions of Sustainability

N/A  Non/Applicable

NI  Northern Ireland

NIE  Neo or New Institutional Economics

odt  oven dry tonnes

PPP  Public-Private Partnerships

RBV  Resource-Based View of the firm

Regen SW  Sustainable Energy Agency for the South West of England

TCE  Transaction Costs Economics
Part I

Background
Chapter 1

Introduction

1.1 Problem statement and general hypothesis

Climate change is acknowledged to have become one of the major threats facing societies (Royal Society, 2010). This change is closely associated with human activity and in particular to the emission of Green House Gases (GHG). This acknowledgement has prompted public intervention to support mitigation actions to abate emissions by both reducing energy consumption and promoting the development of low-carbon alternative energy sources, mainly of renewable origin.

Woodfuel or wood energy, has been identified as a potential contributor to the GHG mitigation effort as a renewable and almost carbon neutral source of energy (Climate Change Committee, 2010; Forestry Commission, 2007d, 2011b). According to the Climate Change Committee (2010) it has the potential to reduce emission through increased woodland cover and uptake of woodfuel as energy source, significantly contributing to the 36TWh expected to be produced from biomass by 2050.

The properties of this source of stored solar energy accumulated through photosynthesis not only offer positive externalities as being close to carbon neutral but as a land-based renewable energy source offers prospects of diversifying rural economic activity in successfully regulated forest environments such as the UK, the EU as whole and most industrialised countries and to contribute to energy security.

However, despite climate change policies, renewable energy targets and emerging energy security concerns, the wood energy market remains nascent in the UK. Also, it is a shared view that the UK does not have a clear plan on how it will meet all the new EU’s 2020 renewable energy targets (DTI and DEFRA, 2007; House of Commons, 2010). According to the Department for Business, Enterprise and Regulatory Reform
(BERR) (2008b), the current level of national public support and local level engagement to the development of renewable energy sources is expected to only generate 5% of all energy needs, far behind the 15% targeted by the UK for 2020. Woodfuel covered less than 1.5% of the 2008 UK heat needs according to the Department of Energy and Climate Change (DECC, 2010b; DECC, 2011). However, substantial potential to deliver renewable energy has been identified from various sources in the South West of England (RegenSW, 2008a). Nevertheless, the scenarios developed at the time for bioheat were not very optimistic given the current level of support. This tempered optimism is due to a larger level of risk associated with existing deficiencies of the regional woodfuel supply chain (RegenSW, 2008a, 2008b).

Transaction costs have been identified as one barrier to woodfuel development. However, few studies provide explicit insights into transaction costs as barriers to spontaneous exchange in the woodfuel sector and how they influence its formation. This study approaches the development of woodfuel in the South West Region of England through New Institutional Economics (NIE) and aims at identifying the appropriate governance structure of the supply chain as a response to existing transaction costs. When transaction costs increase, seamless market exchange gradually gives way to credible contracting and even to full vertical integration or unified ownership. The NIE approach provides insights to analyse friction and barriers to exchange and allows for dialogue between economics, law and day-to-day business decision-making about organisation. The operational NIE approach used here is that of Transaction Costs Economics (TCE), mainly following Williamson’s (1985) framework but not exclusively.

This thesis explores transaction costs, as one of the critical factors to the development of a wood energy or woodfuel market, to identify the requirements for a transition to a more favourable institutional environment. To this purpose, the general hypothesis formulated by the thesis is that transaction define factors structuring the woodfuel supply chain, by both hindering its development when causing friction and also in shaping its (more successful) modes of governance.

The existence of barriers to exchange or transaction costs has been identified as an important non-technical barrier to the development of renewable energy technology implementation (Altman et al., 2007; Bohlin, 2001; McCormick and Käberger, 2007; Roos et al., 1999) but only with limited development of what it specifically implies for woodfuel. A major weakness identified by the accounts covering the untapped potential of woodfuel is linked to its weak supply chain. Moreover, the “Woodfuel Strategy for England” (Forestry Commission, 2007d) established the need for a reliable

\footnote{1A more optimistic outcome may now be foreseen with a more likely implementation of the Renewable Heat Incentive announced in early 2011.}
woodfuel supply chain. According to the Forestry Commission, exchange is limited in the woodfuel market and is constrained by the “complexity of supply chain” (2007d: p. 14). This is where barriers to exchange need to be identified along with their implications. This situation was also echoed by initiatives in the South West of England. Woodfuel potential as a renewable energy option is plagued with uncertainty because of the risks associated with its delivery as concluded by the “Road to 2020: An analysis of renewable energy options in the South West of England” report (RegenSW, 2008a). The report, assessing various options at regional level asserted that “the biggest supply chain risk relates to (biomass) heat retrofit\(^2\) deployment where the small size of the current market means that supply could be a major short-term constraint to the rapid growth of the sector”. This offers particularly fertile ground for analysis of transaction costs and how they could be lowered to create positive incentives for regional woodfuel market growth. The type and degree of coordination of the woodfuel supply chain, in the light of transaction costs and their origin, is central to this research. This could imply the thesis is only concerned with a a supply-side analysis, at the expense of analysis of demand, a criticism raised by Jablonski et al. (2008) with respect to the dominant research on biomass energy in the UK as a whole. However, a neo-institutionalist approach avoids this risk. Although mainly grounded on evidence from woodfuel supplying businesses, the focus on transaction places the analysis at the interface between supply and demand. There is a clear need to focus on the nature and management of relationships along the woodfuel supply chain.

The thesis does not assert that transaction costs are the only factor structuring the woodfuel supply chain as other critical factors are relevant in explaining such structure\(^3\). However, by focusing on the institutional dimension of exchange, the approach looks beyond the persistent imagery of the “chicken and egg” situation (Booth, 1994) used for describing the difficulties in developing this sector in the UK, particularly on the causes and implications of governance choices in the sector.

1.2 Rationale

This policy-relevant research is looking to respond to both a need of the local economy (Forestry Commission, 2007d; Forestry Commission and SWRDA, 2005; GOSW and SWRDA, 2005) and an opportunity brought about by national and global environmental issues (DTI and DEFRA, 2007; Forestry Commission, 2007d). On the

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\(^2\)Heat retrofit deployment refers to the replacement of existing heating systems, in contrast to the installation of wood fired boilers and systems in new buildings where the needs of such energy conversion devices can be accounted for in the early planning phases of a building.

\(^3\)This echoes previous applied research on transaction costs, such as Hobbs (1995).
one hand, several energy and climate change objectives with their Green House Gases (GHG) emissions and renewable energy targets directly relevant to woodland management have made their way up the national (DTI, 2003, 2007a) and European agenda (EC, 2009). The EU has committed itself to 20% of all energy requirements to be provided by renewable sources by 2020, and to 15% for the UK. However, The development of renewable heat supply is considered “intrinsically very uncertain” (NERA and AEA, 2009: p. 12). Nevertheless, woodfuel has been the focus of a specific strategy in the Forestry Commission’s “A Woodfuel Strategy for England” with the objective of mobilising an extra two million tonnes by 2020, about half of the currently unharvested wood material grown each year (2007d). In meeting this goal wood would provide 16% of all renewable energy sources up from its current 10% (Forestry Commission, 2007d). Overall, this increase would provide between 0.1 and 0.2 % of all UK energy needs. Such projections have opened the way to perceive woodfuel as a dynamic product for the region’s woodlands beyond its current status as an untapped or marginally exploited by-product. Woodlands in the region have significant potential, covering 9% of the land surface, according to the South West England Woodland and Forestry Strategic Economic Study (Forestry Commission and SWRDA, 2005). With this asset, McKay et al. (2003) estimated that the region could provide about 24% of all the woodfuel for the UK, from all available sources. Despite such forest potential, woodlands are mainly privately owned in small holdings, which renders their exploitation less likely, or at least less profitable when compared to countries, where woodfuel is now widely used, such as in Sweden. As pointed out by Vikinge (2006), forest exploitation systems outside Sweden are of varying condition and tend to be made up of small properties with low levels of mechanisation which necessitate a creative way of developing a sustainable woodfuel market in a region such as the South West. Stakeholders generally acknowledge environmental services from forests but their formal exploitation has great difficulties in being profitable. The effects of such market failure are pervasive despite some efforts in the diversification of its products (i.e. timber, recreation) and government support. A contemporaneous weakness of the established timber industry has also been described as resulting from:

- Weak regional integration of the wood chain with an imbalance between increasing timber resources and declining processing capacity;

---

4It has to be highlighted that the accompanying Woodfuel Strategy Implementation Plan is yet to be launched, although being expected since 2009.

5Calculations of the author, assuming that biomass provides 83% (10% wood) of all renewable energy and provides about 3% of all UK energy needs (Forestry Commission, 2007d) for the high estimate and that the contribution of woodfuel was 1.39% of the needs in 2008 (DECC,2010b) for the low estimate.
• Lack of investment to ensure standards and proper training;
• Foreign competition (Forestry Commission and SWRDA, 2005).

Weak operational profitability generates biased incentives for the owners and potential investors, jeopardising the involvement of the region’s woodlands in sustainably supplying biomass. The owners are often motivated by a varied combination and varying degrees of financial and non-financial factors (Forestry Commission, 2007d; Kvarda, 2004 in Niskanen et al., 2007), of which some can be economic, including patrimonial value, but not necessarily. This is important, as it makes entrepreneurs only a fraction of all woodland owners. Emerging trends in types of ownership such as the “absent owners” has been detected in several OECD environments (Kittredge, 2005), creating new needs for management support beyond the services traditionally provided to investors in forestry. Certain of such developments suggest that direct profitability is not a sufficient condition to mobilise local wood energy supply. There are opportunity costs to account for like amenities and other competing products such as game, as well as the fact that profitability across large woodlands is not the same for small ones because of varying economies of scale (Niskanen et al., 2007).

The interest in developing woodfuel as a contributor to the energy mix of the South West is not only embodied in public policy but also through co-funding of this research by the private sector through the Clinton Devon Estates, a traditional yet innovative estate along with Great Western Research, a regional research fund.

1.3 Delimitation of issues and approach

The thesis focuses on the South West Region of England, comprising the Bristol/Bath area, Cornwall, Devon, Dorset, Gloucestershire, Isles of Scilly, Somerset and Wiltshire. The analysis, based on TCE, is centered on the determinants of the development of the woodfuel market in the South West by focusing on the dynamics of transaction costs. It then explores current inconsistencies between existing governance structures and the nature of transactions related to woodfuel supply and use. Given the initial stages of development of this source of bioenergy, recommendations to local private and public actors based on the conclusions from the institutional analysis are formulated. Some of these recommendations with respect to governance structures will also be applicable at the national and EU levels in areas where bioenergy feedstock supply chains are in their infancy.

6Please note that only the mainland areas were included in the field work for this project, thus excluding the Isles of Scilly.
In terms of the approach followed it is important to highlight that TCE has generally been applied to investigate the paradigmatic make-or-buy decision and inter-firm relationships on intermediate goods. As such transactions with end users or apparent end-users have not been the area of predilection of such investigations. However, when taking TCE as a theory of contract and the complexities of heat from wood, the choice of this approach is not only viable but desirable since wood as a fuel is an intermediate good, whether used by domestic or commercial users. The actual finished product, or rather service, is heat, as an energy service or electricity, when produced from biomass. The characteristic that energy commodities tend to share among them, as highlighted by Van Vactor (2004), is they have a component product dimension that requires non-trivial investments on both sides of a transaction. Energy conversion technologies are important investments and the problems faced by actors in woodfuel chain are similar whether the transaction is domestic or commercial as the transaction will share common features. Such features are those of a “difficult transaction” and is a relationship suffering from “transactional failures” (Williamson, 1971). An illustration of this dimension is that energy conversion can be outsourced by both commercial and domestic users, providing ground to analyse the woodfuel supply chain into an energy service as a chain of “technologically separable interfaces” (Williamson, 1985), shifting an apparently finished product back to its transaction as an intermediate good. Moreover, with the announcement of the launch of a Renewable Heat Incentive (RHI), space heating from biomass and other renewable options is clearly becoming an output with a new market: environmental and climate amenities. Although environmental and social sustainability required for this fuel source is crucial to its future development and is currently under scrutiny (Upham et al., 2011), they are only presented as dimensions of woodfuel and are not analysed further. Such an analysis could be more successfully linked to an ex-ante and ex-post assessment of the implementability of woodfuel promoting policy instruments.

1.4 Contributions

The study’s contributions to generalisation are threefold. First, it aimed at framing theoretically non-technical barriers to the development of bio-energy markets that have been listed or only weakly related to a priori models. Then, it focused on the analysis of the modes of governance (i.e. spot markets, contracts and hybrids, and vertically integrated firms) developed in other geographical and/or institutional settings as economising alternatives for the exchange in a woodfuel market. Finally, the thesis is an adaptation of a TCE framework generally used at firm level in established markets.
However, in this case it is applied to inform the construction of bio-energy market understood as an effort to circumvent and economise on transaction costs. The degree of generalisation possible is defined by the reliance on a case study with its inherent limitations derived from the analysis of a small sample. Although it is not possible to make direct statistical inference, the detail of the analysis on governance structures for woodfuel in an English Region is to suggest similar explanatory mechanisms in the UK and across other biomass renewable energy sectors.

1.5 Limitations

The thesis is not definitive and it is exploratory in nature with two factors shaping this limitation. The first is that modern woodfuel market development is a very young object of study that changed rapidly during the research and that still does so today. As such, the woodfuel sector in the South West can hardly be called a mature one. Secondly, during the period in which the study was conducted, not all the basic regulatory and policy environments were established. Although this aspect limits the explanatory power of the theory, generally used for a mature sector, it provides a crucial explanatory factor of the difficulties in developing a market in a very uncertain policy context.

1.6 Plan of thesis

The thesis is divided into four parts. Part I consists of two chapters including the introduction (Chapter 1) and Chapter 2, the background for the study. This contextual chapter offers an overview of wood energy characteristics along with its supply chain, in both European and UK policy contexts.

Part II includes Chapters 3, 4 and 5 and develops the approach of the study. Chapter 3 lays out an overview of the new institutional economics approached through Transaction Costs Economics. The chapter presents the main concepts and general applications of TCE by presenting it through its historical developments and limitations. Although strongly anchored on TCE tradition, the analysis also draws on complementary, although sometimes competing, theories of industrial organisation such as the Resource-Based View (RBV). In turn, Chapter 4 reviews and discusses empirical application of transaction cost analysis specifically developed around biomass energy in general and related sectors (forestry, wood energy, biofuels). This exercise allows for a more precise definition of the hypotheses tested in the thesis. Finally, Chapter 5 presents the methods followed to conduct case study research and details the procedure of data
gathering, analysis and interpretation. This chapter shows the study was theoretically driven and the support needed to provide reliable analysis given the modest number of sources gathered as evidence. Throughout the study several strategies are used so as to meet the challenges of developing a case study.

Part III is the heart of the analysis and with Chapters 6, 7 and 8, presents the evidence and its implications for a woodfuel market through a transaction costs analysis. Chapter 6 describes the woodfuel supply market characteristics in the location of study through the activities and actors involved in this sector. It highlights the great variety of organisations involved in formal woodfuel supply. Chapter 7 focuses on the evidence gathered about the type of critical factors shaping the supply chain identified and discussed by the actors contacted and interpreted through the lens of TCE. Chapter 8 aims at better understanding the main relationships along the supply chain through a discussion of governance mechanisms ruling transactions in the sector. Their presentation is grouped by type but also whether they represented an upstream, downstream or on both sides of the supply chain of woodfuel suppliers/brokers that take stock in the material. The second part of the chapter focuses on the classical determinants identified by TCE as influencing governance choice, followed by a discussion of their explanatory power in this context.

Part IV summarised the key findings of this study through a concluding chapter, Chapter 9. This chapter is divided into a summary of the thesis and a development of recommendations for both the public and private sectors.
Chapter 2

Context

2.1 Introduction

On the path to a wider production and use of renewable energy, and particularly renewable heat, woodfuel has been identified as a potential contributor, along with other biomass sources (DTI, 2003; DTI, 2007a; DTI and DEFRA, 2007). However, despite an increased interest in woodfuel as a potential significant contributor to both energy and green house gases targets, it only covered less than one and half percent of UK heat needs in 2008 according to the Department of Energy and Climate Change (DECC) (2010b; 2011)\(^1\), as pointed in the introductory Chapter 1.

This context chapter has two complementary aims. The first provides a context to the research, as required by the mainly qualitative methodology chosen (detailed in Chapter 5). The second aims at setting the problem analysed in its context.

The first part of the chapter introduces wood as fuel and its uses. The initial sections present its characteristics as a renewable energy source and technical energy conversion specificities. The variety of uses of wood as energy (FAO, 2008) and the information currently available for the UK and the South West are presented to provide a background.

In general, the literature on woodfuel has focused on either the technical development of energy conversion systems (e.g. boilers) or the degree of competitiveness of wood based heating systems with fossil-fuel based or alternative renewable energies. Being

\(^1\)From the Department of Energy and Climate Change (DECC) data, woodfuel contributed to 0.529 tonnes oil equivalent of energy (DECC, 2010b) and the UK space heating needs from the domestic, industrial and service sectors amounted to 37.4 tonnes oil equivalent, making the contribution of woodfuel 1.39\% of the needs in 2008. This contribution is less than that if all heating needs were accounted for.
a contextual chapter, it is useful to broaden the theoretical background beyond the
transaction costs approach which is developed in Chapter 3. Namely, this openness
benefits from the insights of innovation literature to look at wood energy within the
challenges facing renewable energy development in general. Although this thesis focuses
on institutional arrangements, it cannot ignore the engineering dimension of energy
conversion technologies linked to technological innovation and innovation in general
including governance innovation. The innovation literature places woodfuel market
development dynamically, within a context. In turn, the Transaction Cost literature
looks at where the management innovation is to arise from and provides some prediction
on its direction.

Finally, and following a brief review of the policies looking at promoting woodfuel in
the UK, the conclusions present how critical factors to bioenergy implementation has
been understood and locate the areas relatively less explored by previous endeavours.
In this case we will focus on the private governance of the woodfuel supply chains.

2.2 Wood as energy source

2.2.1 Definition

Woodfuel, as for all biomass fuels or biofuels can be defined as stored or transformed
solar energy (FAO, 2004). Through photosynthesis plants and trees store solar energy
that can then be released through different conversion techniques. The process is re-
alised through conversion of solar radiation into chemical energy and becomes stored
in carbohydrates in the biomass (Hakkila and Parikka, 2002). Trees are thus a natural
reservoir of carbon. In technical terms it is a renewable source of energy, as presented
in Figure 2.1.
By storing solar energy, wood provides an advantage compared with other renewable sources that are less predictable such as wind, and even direct solar energy which will depend on exposure and is less flexible in terms of the location of the conversion facilities.

Given the large spectrum of biomass potentially usable, we limit our definition to the European Standard EN 14588:2010 (CEN, 2011) which accounts for solid biofuels when originating from the following sources:

- products from agriculture and forestry;
- vegetable waste from agriculture and forestry;
- vegetable waste from the food processing industry;
- wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating, and which includes in particular such wood waste from construction- and demolition waste;
- cork waste;
- fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and heat generated is recovered.
Some fuels are produced by agriculture and are not the focus of this study given different institutional context compared to woodfuel which is more associated with forestry (Perley, 2008 in FAO, 2008). However, it is important to highlight important differences in how they are produced. One of the most relevant ones in terms of market development is the fact that most energy crops, which have to be harvested annually, are more vulnerable to oversupply and market volatility than forest plantations, even the energy-dedicated forests (Perley, 2008 in FAO, 2008). Moreover both direct and indirect energy intensity of energy crops through industrial inputs is higher than required by conventional forestry. This holds true even for energy crops, that tend to represent a lower input alternative compared to non-energy annual crops. However, such energy crops may not be water saving options (Karp et al., 2009).

2.2.2 Forms

Wood for energy can take several shapes and forms given the malleability of the material, from solid to gas and liquid, as in the case of (ligno)cellulosic ethanol. The focus of this thesis is on the solid, more conventional types, namely logs, simply processed woodchips and manufactured wood pellets. These basic forms of solid woodfuel are illustrated in Figure 2.2.

Figure 2.2: Logs, Woodchips and Wood Pellets

Source:
Logs: Reproduced from Joost J. Bakker (Creative Commons)
http://www.flickr.com/photos/ijmuiden/4829390369/in/photostream
Woodchips: Reproduced from dreamstime.com (Royalties free)
Wood pellets: Reproduced from Alternative Heat (Creative Commons)
http://www.flickr.com/photos/alternative_heat/5641434770/sizes/m/in/photostream/

Please refer to the subsection 2.2.3.
2.2.3 Bioenergy conversion essentials

Biomass can be converted to generate bioenergy through several means. Before being converted into energy, wood can be left with its solid form, transformed, or processed into gas and liquid form, as introduced above (subsection 2.2.2). Three main types of conversion are available: thermo-chemical, biochemical/biological and physical-chemical (McKendry, 2002 in Hammond et al., 2008). The possible paths and ultimate energy uses can be followed from Figure 2.3.

Focusing on woodfuel and following the thermo-chemical route, combustion is one of the possibilities to generate heat or mechanical energy through a steam engine/turbine and then electricity if desired. By high-temperature conversion of wood without oxygen or air, pyrolysis can produce bio-oils, biogas and char. Finally, a procedure called gasification that is also high-temperature conversion with limited air supply produces a mixture of gases among which hydrogen and methane can be then ignited in combustion.

However, for wood, a bio-chemical conversion called an enzymatic hydrolysis can convert cellulose into sugars that are then fermented to obtain cellulosic ethanol, towards a liquid expression of wood as fuel. This form of liquid biofuel is expected to provide new possibilities for wood and any woody fibre as an energy source as it can power transportation. This type of fuel belongs to what is known as second-generation or advanced biofuels, in contrast to basic biofuels derived from sugar cane, maize or rape seed. These new developments are only at an experimental stage (NREL, 2007), with few commercial cases. One famous case in Canada is the first gas station supplying a blend with this type of fuel (Burnham, 2009).

The last family of conversion processes is the physical-chemical technique with esterification. The process consists of extracting oil contents from biomass after which it is mixed with an alcohol to produce biodiesel. As this process is less applicable for wood as such it will not be developed further in this thesis.

2.3 Potential and sustainability

2.3.1 The concept of potential

Potential is an open concept. To make it operational it requires definition within assumptions and placed into context. The initial definition embraces all possible biomass sources from commercial forest, woodlands, hedges, parks, sawmill residues, waste wood, along with some other sources of woody residue. This sums up the “theoretical
Figure 2.3: Bioenergy conversion possibilities

Source: Reproduced from Hammond et al. (2008)
potential”. However, not all can be physically or technically mobilised to contribute to energy; what can be so, makes the “technical potential”. In turn the “economic potential” would represent what is realistically available given identified constraints and costs. For this purpose, we adapted the framework of Smeets and Faaij (2007) to illustrate this approach towards availability of wood in Figure 2.4.

Figure 2.4: Entire biomass and biomass available for energy purposes


It is important to acknowledge that Figure 2.4 is a static representation when actual dynamics are constantly at play, particularly between the economic and technical potentials. Nevertheless it does provide an image at any given moment in time.

The most relevant factors shaping the economic potential need to be understood as their omission can misrepresent the actual possibilities of wood energy in a particular region. The first aspects are the primary forestry costs, which are linked to the extraction and basic storage of the material, as developed in woodfuel production in Subsection 2.4.1. However this is only part of the economic dimension as the same material, once harvested, can be used by alternative users to energy demand. This aspect has only received partial attention (Bolkesjø et al., 2006). Forest-based sectors such as board manufacturers along with the pulp and paper industry are already using substantial shares of the material sourced from commercial forests. Tensions and preoccupation has been voiced by these traditional forestry sectors warning against an unchecked surge
in the use of wood for energy purposes in Europe (Lundmark, 2006). Recent examples in the UK are also common (Kirwan, 2010) and numerous in continental Europe. An example is France where supply difficulties allegedly attributed to bioenergy demand have been aired by board manufacturers, something rejected by the wood energy sector (Boughriet, 2010). However, the same source highlights that the French wood energy sector has faced stable wood energy demand over the last twenty years. More interest is now developing in evaluating the quantities of relevant material available at any give price by, for example developing a supply curve following the model of Lundmark (2006). Although competition with the forest industry is most vocally considered, other users also exist such as biodiversity\(^3\), soil and nature conservation, and food where relevant. The varied interaction with other uses needs attention as a whole and interactions are not limited to competitions but also occur as synergies (Berndes et al., 2003). A directly relevant example is Sweden where the forest industries are already large producers of energy both for internal and external use (Lundmark, 2006). As such, the potential level of conflict in term of uses can be managed, although not eliminated, by promoting synergies through a realistic account of the interaction in public policy (Berndes et al., 2003; Bolkesjö et al., 2006; Lundmark, 2006).

### 2.3.2 Woodfuel: UK current assets

Several studies have been conducted to assess the potential volumes of the wood resource available for energy purposes in the UK. Some regional studies have also been published, *inter alia*, for London and Wales (McKay et al., 2003). Before engaging with the most recent estimates, it is illustrative to recall previous endeavours throughout the last 30 years or so, through Table 2.1.

Early studies presented in Table 2.1 shared three characteristics that differentiate them from the latest nationwide and hopefully more accurate estimates developed by McKay et al. (2003). The first is their focus on the single potential contribution of thinnings and clearfells from conifer and broadleaved forests. Other sources, currently identified as major potential contributors were not part of the estimates. The second was composed of technical limitations with the estimates themselves as they were based on very approximate estimates of what can be used for energy purposes from forestry residues and did not account for site limitations in their projections. Finally, the possibility of alternative uses for the material potentially dedicated for energy was ignored (McKay et al., 2003), therefore creating a upper limit to their estimates but not a lower limit.

\(^3\)This aspect is partially covered in the UK and other developed countries through the establishment of effective protected areas and is already partially excluded in Figure 2.4.

36
Table 2.1: Summary of wood fuel resource estimates for the UK /or/ Britain (000’s odt $y^{-1}$)*

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitchell and Matthews, 1980</td>
<td>550</td>
<td>1140</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aktins et al., 1984</td>
<td></td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hare et al. (unpublished)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitchell et al., 1990</td>
<td>650</td>
<td>1120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hudson, 1993 (2000)*</td>
<td>800</td>
<td>1010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hudson, 1997 (2013)*</td>
<td>1144</td>
<td>1728</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McKay et al. 2003</td>
<td>3312</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1314***</td>
</tr>
</tbody>
</table>

* Green tonnes (Gt) are assumed to have 53% of moisture content. To transform Gt into oven dry tonnes (odt) the following relationship has been generally used: Gt*0.47=odt (Hudson, 1993)

**Projection for the years (2000) and (2013)

*** Only 1314000 odt if competing uses are accounted for in the volume estimates, refer to Table 2.2 for details.

Source: Reproduced and adapted from McKay et al. (2003)

This bias was more controlled for in Hudson (1997 in McKay et al., 2003) by being both more sophisticated in including arboricultural arisings approximations and sawmill residues data. A more comprehensive approach is further developed in the model, developed by McKay et al. (2003) and used by the Forestry Commission as the current reference for the country.
Table 2.2: Overview of woodfuel potential accounting for markets, per country, (000’s odt $y^{-1}$)

<table>
<thead>
<tr>
<th>Product</th>
<th>Scotland</th>
<th>England</th>
<th>Wales</th>
<th>Britain</th>
<th>UK***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stemwood 7-14cm diameter</td>
<td>70</td>
<td>34</td>
<td>15</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Poor quality stemwood</td>
<td>113</td>
<td>94</td>
<td>70</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td>Stem tips</td>
<td>14</td>
<td>15</td>
<td>6</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Branches</td>
<td>126</td>
<td>237</td>
<td>78</td>
<td>441</td>
<td></td>
</tr>
<tr>
<td>Sawmill conversion products</td>
<td>40</td>
<td>29</td>
<td>17</td>
<td>86</td>
<td>108</td>
</tr>
<tr>
<td>Arboricultural arisings*</td>
<td>18</td>
<td>313</td>
<td>10</td>
<td>341</td>
<td></td>
</tr>
<tr>
<td>Short rotation ** coppice</td>
<td></td>
<td></td>
<td></td>
<td>155-222***</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>381</td>
<td>735</td>
<td>196</td>
<td>1314</td>
<td>1422</td>
</tr>
</tbody>
</table>

*Arboricultural arisings - material from tree surgery and other arboricultural operations.
**Short rotation coppice - areas planted specifically to produce renewable energy.
***Updated with DTI and DEFRA (2007: p. 38), also including Northern Ireland, using data from McKay (2004).

McKay et al., (2003) gathered the most relevant data available for Britain and extrapolated results from a postal survey to tree surgeons but excluded wood resources from waste, which are detailed in Table 2.3. Current potential technically available woodfuel resource without competing markets were estimated to about 3312000 odt $y^{-1}$. As such, this amount corresponds to the “Technical” area in Figure 2.4. An estimate aiming at the “Economic” potential is detailed in Table 2.2 and was close to 1450000 odt $y^{-1}$ in 2003 by accounting for competing markets. From the data gathered by McKay et al., (2003) for “fresh” material, excluding waste, poor quality stems and branches are the largest untapped resource. Given the objective of this study, it is worth highlighting that for England, arboricultural arisings are the single most important uncommitted resource identified. However, this study is influenced by the recorded experience of public sector forests and may be biased when estimating the less known private harvesting constraints (McKay et al., 2003).

To this material from the forest, a potential of 10,586,000 tonnes\(^4\) of which only a part could be actually transformed into effective woodfuel\(^5\), could also be added to have a

\(^4\)Tonnes of heterogenous material, not odt.
\(^5\)Note that about 300 000 tonnes of this waste material is estimated to have been used for energy purposes in 2004 (Nikitas et al, 2005).
more complete estimate of the yearly resource available in the UK (Nikitas et al., 2005).

<table>
<thead>
<tr>
<th>Source of waste</th>
<th>England</th>
<th>Wales</th>
<th>Scotland</th>
<th>Northern Ireland</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal waste streams (MSW,</td>
<td>37</td>
<td>913</td>
<td>29</td>
<td>85</td>
<td>1065</td>
</tr>
<tr>
<td>excluding furniture)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial and industrial (C&amp;I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4481</td>
</tr>
<tr>
<td>Construction and demolition (C&amp;D)</td>
<td>4105</td>
<td>232</td>
<td>290</td>
<td>42</td>
<td>5040</td>
</tr>
<tr>
<td>Total Estimated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10586</td>
</tr>
</tbody>
</table>

Source: Nikitas et al. (2005)

Waste wood represents the largest quantity available but its sources, respective quantities and quality are highly variable. Given the more stringent regulation of emissions introduced by the Waste Incineration (England and Wales) Regulations (The Crown, 2002), not all wood is technically suitable for energy purposes. This material originates from three main sources (DEFRA, 2008) i) Construction and Demolition (C&D wood), ii) Municipal Solid Waste (MSW) wood and Commercial and Industrial (C&I) wood (Table 2.3).

2.3.3 Estimates for the South West

Starting with the local source of wood for fuel, the South West is considered one of the most favourable regions for growing trees (Bullard et al., 2004). With its 212000ha covering 9% of its territory, it has more woodland cover than the England average of 7.5% (Forestry Commission, 2002).6

In this context, early estimates have identified the South West as being the potential source for 17% of all woodfuel available in the UK (Atkins et al., 1984 in Hudson, 1993), excluding waste and arboricultural arisings. More recently, McKay et al., (2003) estimated that the region could be offering about 24% of all the woodfuel for the UK, from all available sources. However, it is not the only one. Other estimates for potentials put forward vary greatly for the region, illustrating the lack of consensus on the matter (Bullard et al., 2004; CSE et al., 2005).

6For details of the forest cover in the region and broadleafed and conifer ration by county, please refer to Section 7.2.
The review undertaken by Hammond et al. (2008) provided a range of estimates based on previous measurements with a focus on the South West. The range compared three approaches namely i) assessment of current bioenergy production and use; ii) assessment of the current theoretical maximum bioenergy potential, based on McKay et al. (2003); and iii) assessment of the future maximum bioenergy availability. However, these estimates gather all sources of biomass for energy and do not always provide the woodfuel details. Notwithstanding, it was estimated that the technical primary energy potential of woodfuel combining forest and waste sources could generate up to 500 GWh in the scenario of maximum available bioenergy resource. For comparison, this is half of what could be produced by straw residues or a third from municipal solid waste under the same assumptions (Hammond et al., 2008).

When looking at its regional implications, the McKay et al. (2003) general estimate for the country, has significant limitations of its own. Although it is more comprehensive in its approach than earlier attempts, it relies on the data gathered and the methodology used for estimating standing wood volumes. For material coming from the forestry sector, this methodology is currently thoroughly being revised by the Forestry Commission in order to update its National Inventory of Woodland Trees. Following a pilot survey conducted in the South West (Forest Research and RDI, 2009), this revision will be implemented across the country for an updated estimate. This revision for the South West only focused on conifer or predominantly conifer forests and re-evaluated the softwood timber production forecast. Despite this limitation in scope it is important to anticipate, as developed in Chapters 6 and 7, that softwood from commercial forest is currently the primary source for processed woodfuel (excluding logs). This technical development is highlighted because the analysis projects a decrease in volume availability from private managed woodlands within the SW Region over the forecast period (2009-2031), although the Forestry Commission estates are expected to have constant output over the same period, conversely the data used by McKay et al. (2003) pointed to a slight increase in private production and a small decrease from publicly managed estates. The projected decrease in output from private estates is assuming that they will put into the market the trees at their optimal felling age during the next ten years. Although production will probably exceed actually harvested volumes until the 2020s under these conditions, this is not at all likely. As acknowledged by the study, private owners may delay part of their stock beyond such optimal periods providing more material into later decades and allowing for a balance between production and harvest. It does reveal insufficient renewal projected for these forests with potential consequences for the future development of woodfuel in the long-term in the region (Forest Research and RDI, 2009). This trend does not embrace all the material available nor the trends
linked to broadleaved woodlands which are less commercially active.

2.4 Woodfuel production and logistic challenges

2.4.1 Harvesting and processing

Given the general emphasis on transactions rather than on the production function of different woodfuels relevant to the South West region, only a brief presentation of the process is made. However, special attention is given to the logistics on which this energy source depends on to be finally converted into a specific energy service such as heat or electricity. This is important given our assumption, following Altman and Johnson, that organizational adaptations can be the simplest way “to solve vexing technical issues in the biopower sector” (2008: p. 29).

Harvesting

At the harvesting level several avenues have been studied and detailed trials have been conducted in the UK. Basing their research on harvesting and general wood fuel supply studies trials financed by DTI, Hudson and Mitchell (1993)\(^7\) concluded that there are two most appropriate harvesting systems for Great Britain:

1. Whole tree harvesting systems which integrate the harvesting of roundwood and wood fuel together. For woodchips, this also allows for whole tree comminution for wood fuel (hardwood). However the long term cost effectiveness of integrated harvesting requires a change in the current practice and installed capital, committed to “shortwood working systems”.

2. A specific residue harvesting system when woodfuel is harvested in a second operation, after roundwood is extracted is also adequate. The residue harvesting system allows for the introduction of woodfuel harvesting in conventional shortwood or tree length systems in clearfells (Mitchell et al., 1990), may be easing such introduction in established processes.

Storage

A bridging step between harvest, processing and beyond is held by the need to store material. A fundamental challenge is generated by the seasonality of demand for fuel

\(^7\)With the Wood Supply Research Group –WSRG, University of Aberdeen.
(when only used for heating purposes) that creates risks of imbalance in supply that need to be assumed by storage and associated costs (Heding, 1990 in Hudson and Mitchell, 1993).

Storage, besides the space requirements, is open to microbial, chemical and physical processes associated with the stocking of highly moisturised matter. This generates a risk of spontaneous combustion as a result of aerobic microbial activity (Thörnqvist, 1988 in Hudson and Mitchell, 1993) and the loss of dry matter eaten away by fungi (also representing a health hazard because of the spores released in working environments). These problems are particularly acute when handling woodchips. Although logs are more stable, wood pellets require controlled environments to avoid losing the structure acquired during compression and drying.

**Processing**

A constant trade-off facing producers and many suppliers of woodfuel is where to process the material in relation to its source and to the end-user. This could be called the classical network location problem. To this fundamental issue a body of literature has developed that embraces forestry and logistics to model optimal solutions. Depending on the conditions and assumptions, processing of material may be done at the source, at different points from source to end user or is undertaken at a terminal, shed or depot where the material concentrated can then be delivered to the consumer. This concentrating area is also known as a tree station.

The more sophisticated models originate from operational research and process engineering systems literature (Dunnett et al., 2007). This body of research develops dynamic models not only accounting for the basic location problem described above but also integrating problems linked to storage losses and the implications of seasonality.

Returning to the simpler optimisation (or allocation) problem, Figure 2.5 presents a simplification of the main options available to woodchip and the basic problem can be summarised between choosing option B “Roadside chipping” or C “Terminal chipping”. Note that part of the challenge faced is that round wood at roadside requires drying. Such drying may or may not be possible at the harvesting site, implying an additional dimension to the optimisation problem. Figure 2.5 does not include the optimisation problem faced by operators when sourcing their material from arboricultural arisings. Following the teaching of the formal forestry models, the sparsely distributed sources of tree surgeons will make the terminal more important. An illustration of this is the Croydon Tree Station currently operating with material mainly collected throughout the borough and engaged in fuel supply (Mayor of London, 2005).
Figure 2.5: Woodfuel supply chain (basic diagram)

Ever since the early models, optimising woodfuel production has equated to minimising transport costs (Eriksson and Björheden, 1989). For a Swedish region, mobile chippers were found to be more expensive to run than fixed devices located at a terminal. However, direct woodchip loads of processed material from the forest for delivery did reduce re-loads and necessary handling costs if realised through a terminal. Although the model would not account for risks, it was acknowledged in the discussion that woodfuel suppliers would keep higher inventories\(^8\) at the terminal in order to buffer against the risk of not being able to access the material at source when most needed at the peak of the heating season (Eriksson and Björheden, 1989; Gunnarsson et al., 2004). More recent models such as developed by Kanzian et al. (2009) for an Austrian region confirmed the conclusion that chipping at terminal tends to be more expensive than if done directly before delivery from the source but has also confirmed the need to consider security of supply particularly when dealing with higher ground forests. These models were not concerned with arboricultural arisings but should not be overlooked as it has been the single largest potential source of wood material in England as highlighted by McKay et al. (2003) and presented in Section 2.3.2 even if it is not the most used by far today.

### 2.4.2 Geography and the (transaction) costs of procurement.

**Transport**

A fundamental constraint to the optimization objective in woodfuel supply chain is transport, both in its own and in relation to the remaining logistical priorities particularly when aiming at sustainable operations. On its own, the mobilisation of low density and bulky material has great influence on transport costs. Transport is faced with a technical trade-off between stable fuel with high moisture content and drier but unstable material, particularly under the form of woodchips.

Concerning transport, the radius of the “catchment area for the biomass resource” (Allen et al., 1998: p. 469) is decisive. The estimates for forestry material are within a maximum of 100 km (approx. 60 miles) radius around processing or user location (Asikainen et al., 2002) and an average 55 km for Scandinavia (Anderson et al., 2002). The central importance of transport is also clear in the mind of UK forest contractors as voiced by the Forestry Contracting Association (1997 in Hudson and Hudson, 2000: p. 97) as “a major cost in the supply of wood fuel is the transport from point of production to the end user plant”. Although the “point of production” can be somehow ambiguous in

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\(^8\)Apparently beyond optimal volumes, according to the model.
this case; either referring to the woodland or a processing yard/plant, it is acknowledged that woodfuel operations tend to be geographically dispersed making transport costs an important share of total costs, thus placing spatial aspects at the centre of solid biofuel market development (Asikainen et al., 2002; Roos et al., 2000). As seen, Eriksson and Björheden (1989) simply summarised it as “optimising forest-fuel production essentially means minimising transportation costs by prudent location of the conversion plants in relation to the sources of wood fuel”.

This characteristic of woodfuel has not only very clear implications in terms of transport costs, and thus production costs but also influences how transactions may be carried out in the most efficient way. The literature has identified this possibility through the concept of “site specificity”, as presented in Chapter 3.

**Geography and transaction costs**

Although transport costs are not transaction costs as such, the structure of the market shaped by a logic of reducing transaction costs, can contribute to “reduce the cost for geographically distant (suppliers) and consumers to execute trade” (Wang, 1999).

In their study of the Swedish woodfuel market for district heating, Roos et al. (2000) showed, with an explicitly geographical emphasis, that woodfuel use was positively related to local availability and negatively so, by competition to access the material from other users\(^9\) within a 100 km radius\(^10\). These conclusions did not apply to systems close to ports as they were not significantly affected by those factors, probably because of their easy access to cheap and large volume fuels (either biomass or fossil) from abroad or shipped by sea from other parts of the country.

When looking at the above summarised Swedish case for inland (or rather landlocked) wood-fired district heating systems, studied by Roos et al. (2000), the majority of heating systems experienced retrofitting processes from fossil-based to wood-based boilers and therefore it can be inferred that their original installation was not related to the presence of woodland within the 100 km radius, opening the possibility of some site-specific transaction costs beyond transport costs. Although not analysed in the later study, the hypothesis of site-specific transaction costs is explicit in this thesis and explored in Chapters 7 and 8.

\(^9\)These two variables could have been partially synthesized into the variable of woodfuel price but such information was not available and the authors assumed that “strategic decisions about woodfuel procurement are influenced by information about woodfuel availability and competition rather than by prices for one season” (Roos et al., 2000: p. 115).

\(^10\)Technical note from Roos et al., (2000): Availability was calculated as the estimated total forested area within a 100 km radius from the user multiplied by the mean annual forest growth in the county concerned.
2.5 Consumption of woodfuel and energy

Woodfuel is not a completely generic commodity as it takes different forms with several uses and different users. Uses of wood as energy varies greatly across the world (FAO, 2008). In this sense, demand is expected to be segmented, influencing the market structure and diversifying the wood supply chain. Building upon Steierer and Fischer-Ankern (2007) the four main categories of uses are:

- Traditional domestic use (main source and/or recreational purposes in open fires and stoves)
- Modern domestic use (wood powered boilers)
- Industrial (space heating, heat processes and waste treatment)
- Power, heat, combined heat and power (CHP) generation

Given the scope of this project, the attention of the thesis will mainly focus on domestic (both traditional and modern) and industrial heat generation. Electricity generation is touched upon as some examples are related to heat and power but only marginally.

2.5.1 European trends

The aftermath of the Second World War in Western Europe was characterized by a steady replacement of woodfuel by other fuels up to the consecutive oil shocks of 1973-79. Woodfuel consumption continuously declined from around 60 million $m^3$ in 1961 to 33 million $m^3$ in 1975. Since 1975, annual consumption has been very stable around 30 million $m^3$ (UNECE and FAO, 2005), as Figure 2.6 depicts the historical trend.

Nevertheless, it is important to point out that the “quality of statistics about woodfuel production and consumption in Europe is generally quite poor” (UNECE and FAO, 2005: p. 92)\textsuperscript{11} with ambiguities concerning the figures. The records can be inaccurate but there are also questions about what material they include as woodfuel. As such, branches, hedges, waste wood might or might not have been accounted for therefore making comparisons difficult if not meaningless.

Actually it is acknowledged that FAO’s model to estimate missing woodfuel statistics was very simplistic until recently (UNECE and FAO, 2005). However, previous documents might have captured some trends of significance that were not accurate in absolute terms but highlighted some implications of the oil shocks on woodfuel use.

\textsuperscript{11}As shown in Section 2.5.2, this was and is still the case in the UK.
Figure 2.6: Trends of the production and consumption of woodfuel in Europe (1960-2000)

Note: Figures for Eastern Europe and the CIS sub-regions before 1992 have been estimated from statistics for the USSR.
European Forest Sector Outlook Studies (The EFSOS Region, includes Western and Eastern Europe and the CIS countries)
Commonwealth of Independent States (CIS)
(UNECE and FAO, 1986). Although the events had probably stabilised woodfuel use, at the time the trend was interpreted as a rise in its use. In the initial stages of the recovery in woodfuel use, many users returned to old burning equipment that was not completely abandoned in the period of woodfuel decline (these were generally inefficient, though). It is also notable that the time lag inherent in fuel price changes and the actual change in fuel use is linked to the change of equipment. This translated into users installing flexible equipment which could be rapidly converted from burning oil to burning solid fuels (coal and wood) and vice versa (UNECE and FAO, 2005). Following the first oil shock, woodfuel use was promoted from the 1970s onwards by certain countries, notably Sweden (Hillring, 2000) and later Austria (Rakos, 2005; Wörgetter et al., 2002) but not decisively by the UK.

Industrialisation increased fossil fuel dependency and the “generalized view has been that countries climb the energy ladder that leaves biomass behind in favour of more efficient fuels and technologies” which are often fossil-based (Silveira, 2005: p.4). This has tended to create the image in the relationship between developed and developing regions that biomass for energy purposes was linked to pre-industrialisation and by extension, to poverty. However, such a link is now loosening, favoured by climate change, energy security and even trade balance concerns (Silveira, 2005). Bauen interprets it as a “rediscovery of bioenergy in industrialized nations with access to biomass resources” (Bauen, 2005: p.19).

Recent estimates for sources and uses of wood as energy, gathering the most recent national data suggested that the European average displays a heavy reliance on direct and indirect sources for woodfuel with a very small component of recovered material (Steierer and Fischer-Ankern, 2007). Also, direct heat use by domestic and industrial agents is the more common use. Less than a quarter of the material is allocated for CHP generation. However, the average is influenced by outliers such as France regarding large direct source for domestic use and tends to hide discrepancies between countries, particularly regarding uses, less so for the relative importance of each source. Figure 2.7 illustrates this aggregated data and trend.

Although biomass is primarily used in solid form for heat, recent global trends have showed that biomass liquid and gas fuels use have grown faster. Actually, solid biomass, basically woody biomass, has experienced the slowest growth since 1990 of all renewable energy sources. In the EU, a similar trend has been observed. Biomass use as heat has been developing but has been slow compared to its energetic contribution to electricity and transport in the Union. It is estimated that the latter grew three times faster between 2000 and 2004 than the use for heat generation, despite having the most promising technical potential of all three uses (Kopetz, 2007).
Figure 2.7: Estimates of sources of woodfuel and uses of wood energy in Europe in 2005

S1 Direct supply - essentially wood directly from the forest.

S2 Indirect supply - (processed and unprocessed) co-products (residues) from wood processing industries (sawdust pellets, black liquor).

S3 Recovered wood supply- post consumer recovered wood products having served their purpose for at least one life-cycle (e.g. pallets, construction wood, furniture), which are then used for energy.

U1 Power and heat - the generation of electric power for the grid and heat for sale, outside the producing (forest) companies (industries).

U2 Industrial - wood energy used internally by the forest industries.

U3 Private households - wood volumes used for energy generation in private households.

Table 2.4: Estimates of quantities of woodfuel from UK sourced roundwood compared to total deliveries for soft and hardwood (000’s green tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>Softwood for woodfuel</th>
<th>Hardwood for woodfuel</th>
<th>Total all Softwood</th>
<th>Total all Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>100</td>
<td>150</td>
<td>7 213</td>
<td>818</td>
</tr>
<tr>
<td>1998</td>
<td>100</td>
<td>150</td>
<td>7 057</td>
<td>717</td>
</tr>
<tr>
<td>1999</td>
<td>100</td>
<td>150</td>
<td>7 285</td>
<td>676</td>
</tr>
<tr>
<td>2000</td>
<td>100</td>
<td>150</td>
<td>7 344</td>
<td>655</td>
</tr>
<tr>
<td>2001</td>
<td>100</td>
<td>150</td>
<td>7 471</td>
<td>641</td>
</tr>
<tr>
<td>2002</td>
<td>100</td>
<td>150</td>
<td>7 360</td>
<td>621</td>
</tr>
<tr>
<td>2003</td>
<td>100</td>
<td>150</td>
<td>7 692</td>
<td>563</td>
</tr>
<tr>
<td>2004</td>
<td>100</td>
<td>150</td>
<td>7 987</td>
<td>514</td>
</tr>
<tr>
<td>2005</td>
<td>100</td>
<td>250</td>
<td>8 109</td>
<td>594</td>
</tr>
<tr>
<td>2006</td>
<td>100</td>
<td>250</td>
<td>8 168</td>
<td>439</td>
</tr>
</tbody>
</table>


2.5.2 UK woodfuel use and relation to general energy use

The availability of specific and reliable statistics on woodfuel is scarce in the UK (FAO and ECE, 2004), strongly echoing the general European trend mentioned earlier (UNECE and FAO, 2005). The UK has no systematic annual statistical source on woodfuel use and has almost exclusively relied upon estimates provided by an expert group. Such estimates were not updated between the 1990s and 2004. Only hardwood roundwood destined for fuel uses was updated from 2005 onwards (FAO and ECE, 2004; Forestry Commission, 2007). Table 2.4 is presented to illustrate the lack of actual data regarding roundwood.

Recent steps have been taken to improve records about woodfuel to feed the main Forestry Statistics of the Forestry Commission (2007b; 2009b; 2010) by improving the data from sawmills and round fencing manufacturers and a specific survey conducted in 2009. However, the recording system is not definitive and has yet to be established\(^\text{12}\). The estimates for woodfuel supplied in the UK for 2008 are presented in Table 2.5. As an overview, and excluding imported pellets, about 2 million odt of woodfuel was supplied in the UK in 2008 (Forestry Commission, 2010). To give this an order of magnitude,

\(^\text{12}\)This was the most important attempt to tackle the lack of reliable information on woodfuel in UK but the reliability of the results from the survey is limited. The exercise did not provide enough data to construct an accurate picture of the sector’s importance and had to rely on additional sources, mainly secondary and experts’ judgments to publish an estimate (Forestry Commission, 2009b). Detailed results for the the South West Region were requested in the framework of this thesis but were not shared by the public body, after all. The quality of the data gathered in the 2009 on-off survey was not deemed to be of enough quality as to be made available. An indicator of this was that comparisons were made with the thesis primary data collected at the same time and they had nothing to envy from the official survey, according to informal accounts.
Table 2.5: Woodfuel supply by sawmills and round fencing manufacturers, 2006-2009 (000’s green tonnes)

<table>
<thead>
<tr>
<th>Woodfuel type</th>
<th>000s odt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs for stoves and open fires</td>
<td>122</td>
</tr>
<tr>
<td>Woodchips from recycled wood</td>
<td>278</td>
</tr>
<tr>
<td>Woodchip from other sources</td>
<td>495</td>
</tr>
<tr>
<td>(Total woodchips)</td>
<td>(772)</td>
</tr>
<tr>
<td>Wood pellets</td>
<td>90</td>
</tr>
<tr>
<td>Other</td>
<td>78</td>
</tr>
</tbody>
</table>

*Although indicated in the Forestry Commission glossary, bioenergy defined as “Energy from any fuel that is derived from biomass” should be here understood as excluding logs. Logs are registered as “firewood”


this woodfuel volume represents about 0.4% of all UK primary energy needs in the same year.

In addition to these aggregated volumes, some independent information exists as to the importance given by British homes to woodfuel. The main basis to estimate behaviour of households regarding the use of wood as an energy source are a few surveys of varying sample size and quality. The most recent general survey results are illustrated in Figure 2.8. For the national surveys, the Forestry Commission requested a “Use of firewood” survey in 1997 (RSGB, 1997). This research suggested that 9% of the 1900 households surveyed used such a fuel on a more or less regular basis. This has been corroborated as a stable average given that England had a similar percentage of households (8%) using firewood as a heating energy (either systematic or occasional) according to the latest, larger but similar survey 13 “UK Public Opinion of forestry 2007” (Forestry Commission, 2007b; Forestry Commission, 2007c).

However, important disparities remain between use intensities. Use of wood as the main energy resource is very rare (RSGB, 1997). Figure 2.8 shows the result of different surveys on woodfuel use and indicates that use had continued to decline throughout the country between 1997 and 2007. It is striking to see that the relatively wood-rich Scotland (Forestry Commission, 2007b) is a modest domestic woodfuel user (only around 4-5% of households) compared to England. Despite more wood availability in

13This more recent survey also included the same questions as the 1997 survey conducted by the RSGB.
Scotland and accounting for the relatively more urban Scots, of whom only 19% are rural (Scottish Executive, 2004), a comparable weighted proportion of users in Scotland would still only be the same proportion of households as England\textsuperscript{14}. This could relate to the nature, structure and exploitation systems of the Scottish forests. Woodlands in England are probably more accessible for this use. However, the 1997 data suggests that 76% of the Scottish households that did use woodfuel at the time were self-gathering the resource against a maximum of 68% in the Northern English regions which would contradict the accessibility hypothesis. However, according to a small 2002 survey of suppliers of wood burning appliances, more woodfuel burning units as primary heat source\textsuperscript{15} were sold in Northern England and Scotland (Dagnall, 2004), hinting at a current more dynamic development of the sector despite a lower initial level inherited from traditional use in the rest of the country.

**South West consumption estimates**

National information on woodfuel is not very developed and this trend is mirrored at a regional scale. Three existing strands of information exist and provide some indication of the volumes and the energy importance of woodfuel in the region. The first source is the RSGB 1997 and Forestry Commission 2007 surveys about woodfuel usage. The results show that in the South West, woodfuel was more widely used as a main source of heat (RSGB, 1997). However, according to a small industry 2002 survey of suppliers of wood burning appliances, new appliances purchased were mainly destined for holiday properties (Dagnall, 2004). Regional details are presented for information in Figure 2.9 and present the South West as more used to handling woodfuel as a heat source than other regions, potentially making it more favourable to its development through modern woodfuel powered heat systems.

The second source estimating the potential volume of material used the census of existing modern (and recently installed) woodfuel boilers. Although this source is naturally biased it provides information on the largest volumes traded formally in contrast to traditional woodfuel material (i.e. logs) of which an important share tends to be exchanged informally, hence the associated poor statistics as demonstrated by the previous sections. By looking at the boiler installation records, Rawson (2010) estimated that woodchips and woodpellets used in medium to large installations (100 kW- 1MW and totaling 34MW in the region) provided about 0.12% of the heat supply in 2009. These installations mobilised about 20000 tonnes of material from the region. This material

\textsuperscript{14}An estimate of 31-34% of rural population for the East and the South West according to the National Statistics (2007).

\textsuperscript{15}These are only absolute numbers.
Figure 2.8: Proportion of respondents who use wood as fuel in their home by surveys and country between 1997-2007 (%)

Source: Formatted from Forestry Commission (2007a, 2007c)
being mainly heterogeneous woodchips, it is not possible to provide an accurate account of its conversion into odt, but it probably lies between 10000-15000 odt. An additional 5000 tonnes were also imported from outside the region. These are very conservative estimates as they only provide traceable users and pale in comparison to the national estimates from the Forestry Commission and the expected 24% share of the national supply from its identified potential (McKay et al., 2003).

Finally, and in aggregated terms, woodfuel only provides about 8% of the regional bioenergy mix, mainly for heating, as it is less financially viable for electricity generation (Hammond et al., 2008).

2.6 Problem statement: Approaches to woodfuel development

2.6.1 Innovation and woodfuel

The thesis deals with a rapidly changing phenomenon. As such, a focus on institutional arrangements cannot ignore the engineering dimension of energy conversion technologies linked to technological innovation and innovation in general including innovations in governance. The innovation literature places woodfuel market development dynamically, within a context. In turn, the Transaction Cost Economics literature examines where management innovation arises and provides some prediction on its direction.

To offer a brief articulated insight into the dimension of innovation as part of the context for woodfuel market development, we choose an evolutionary perspective, namely Innovation Systems. Such systems gather "the elements and relationships which interact in the production, diffusion and the use of new, and economically useful knowledge" (Lundvall, 1992 in Foxon et al., 2005; p. 2124). We acknowledge that innovation is a nonlinear process and follow the historical approach of Freeman and Soete (1997) by understanding it as a process "that involves imaginative combinations of new technological possibilities and markets possibilities" (1997; p. 201). Because both evolve through time, "there is a Kaleidoscopic succession of new possible combinations" and gives to the process an "apparently random, accidental and arbitrary character" (1997; p. 202). Freeman and Soete colourfully encapsulate the non-linearity of the process by asserting that "unexpected turn of events may give new life to long-forgotten speculations or make today’s successful chemical process as dead as a dodo". The renewed interest in wood as energy is clearly in line with the "unexpected turn of events" scenario, after having being displaced as the primary source of heat by the 1650s in the UK (Fouquet and Pearson,
Figure 2.9: Proportion of respondents who use wood as fuel in their home, by region (%)

Source: Formatted from RSGB (1997) and Forestry Commission (2007a; 2007c)
2003) and later for other advanced economies such as the USA, where it remained the primary source of energy until about 1885 (Solomon and Johnson, 2009).16

For analytical purposes, the process can be divided into categories of distinctive stages of "commercial maturity of a technology". Such technological maturity can be seen as a continuum from "blue sky" concepts of Research and Development (R&D) to broad commercial availability where information feedback from one stage to another. Efforts from the supply of the technology and increased adoption by demand can either be enhanced or hindered by the policy environment and the availability of venture capital (ICEPT and E4Tech, 2003).

The model permits linking the design maturity of a given technology and its actual intake to the potential users (i.e. market penetration). The relationship is based on an underlying S-shaped curve adapting a model first formalised by Rogers (1962, 1995) as in Figure 2.10. Such maturity understood as the design functionality linked to its market intake has implications for the institutional arrangements. At the most basic level, the degree of technology maturity will influence the nature of the transaction and associated costs, with likely influence of information costs at the early stages. As the intake develops, we expect changes in the governance structures used to govern this market.

Following the results drawn for the UK’s innovation systems analysis for renewable energy technologies of Foxon et al. (2005), different energy technologies can be placed within this simple and stylised model of innovation. However, the high level of design maturity of biomass-based combustion is not reflected by their market penetration for the UK. For Foxon et al. (2005) institutional barriers are at the root of this unexpectedly low intake of such technology. This is in line with previous analysis of the barriers to the development of alternative energy technologies (Roos et al., 1999, Rösch and Kaltenschmitt, 1999, McCormick and Kübler, 2007). Although the proposed conversion technologies can be qualified as mature or well performing, most barriers tend to "appear at the later stages of the implementation chain" (Roos et al. 1999: p.113). Even if in certain cases, both technological issues and non-technical ones interact as barriers, as highlighted by Margolis and Zuboy (2006) in their selected review of non-technical barriers to solar energy use, akin to what can be experienced by biomass energy with respect to the cost of certain high-tech components. As a concluding remark, design and technical factors are taken as given and mechanically proven, although basic adaptation is expected locally, along with limitations associated with storage availability, particularly acute for potential urban users as recorded for the UK by Jablonski et al.

16In the early 19th century, the growth of the US population and the move West sparked "occasional shortages [...] reminiscent of past experiences in Europe" (Perlin, 1991 in Solomon and Johnson, 2009), contributing to rising prices and the search for alternatives.
Figure 2.10: The commercial maturity of new and renewable energy technologies relative to market penetration.

Source: Reproduced from Foxon et al. (2005; p. 2128), highlight added.
(2008). With such local adaptation also recorded for mature markets for woodfuel, such as Austria (Rakos, 2005). However, the model of development and market penetration of biomass-based energy conversion technologies is based on the assumptions that market penetration is mature when the conversion technology is fully commercial "given environmental taxation, regulation or trading" (Foxon et al., 2005: p. 2134). This state of the world assumes an effective internalisation of any major positive externality offered by the renewable technology such as being low-carbon, conversely to the negative externalities linked to high emitting fossil-based alternatives. This is expected to be realised through a mechanism acknowledging such internalisation, following basic environmental economics principles, now well publicised following Lord Stern’s review on climate change for HM Treasury (2006). But for very recent developments (i.e. the Renewable Heat Incentive), the general set of measures has come short of the assumed level of commitment, demanding the exploration of second or third best alternatives. Following Allen et al. (2008), we highlight that such alternatives, mainly from regulation and subsidies remain vital to bioenergy development and also partially explain the apparent paradox emerging from the assessment linking technological maturity and (the low) uptake of biomass energy as illustrated in Figure 2.10.

The main body of literature on innovation tends to focus on the development of devices and services that are then delivered into the market. Foxon et al. (2005) follow this pattern although acknowledging the need to adapt to a variety of biomass feedstock, there are no further insights provided in how the heterogeneity of feedstock generates organisational needs. One of the challenges of bioenergy requires both the deployment of new technology but also structuring its feedstock supply chain. Many new technologies are developed but they generally rely on existing feedstock or do not concretely require one as it is only associated with direct opportunity cost of land surface (solar, wind, tidal, heat pumps). Bioenergy is based on a great variety of sources, placing the management, the governance of heterogeneity at the heart of its challenge. In the case of small-to medium combustion devices, even gasifier based ones, we can follow the conclusion that "combustion is a commercially mature technology with little scope for innovation. However technical issues remain to be addressed in relation to the combustion of biomass, these relate mainly to adapting combustion technologies to deal with specific physical properties of biomass fuels" (ICEPT and E4Tech, 2003: 59). As we focus on combustion of solid biomass fuels, the technology of interest is then assumed to be mature. Where organisational innovation is required is at the intermediate level of feedstock production and supply. This push will enhance the demand pull as it will

\[\text{Box 1 in Section 4.4.}\]
generate more confidence in the potential usage of biomass-based combustion devices. Following the critique of demand-pull theories of innovation (Mowery and Rosenberg 1979 in Freeman and Soete, 1997) that showed that a market cannot (necessarily) grasp a new product in which it has no knowledge, we could extend this insight to markets that require transactions on which there are great uncertainties linked to heterogeneous feedstock. As presented in Chapters 6, 7 and 8, data tends to confirm the need to strengthen the support not only of the demand but also of the supply chain, away from the support to technological innovation of combustion devices only, which has attracted past government efforts, some of which have been well publicised bioenergy failures\textsuperscript{18} such as the ARBRE project (Forestry Commission, 2005; Piterou et al., 2008; van der Horst, 2005).

### 2.6.2 Background on critical factors to bio-energy market development

Several “critical factors” have been identified as key determinants in implementing bio-energy technology and woodfuel systems in particular (McCormick and Käberger, 2007; Roos et al., 1999)\textsuperscript{19}. These “critical factors” can be divided into technical and non-technical driver and barrier types. Before engaging in a more detailed review of such factors, a brief exposition of the terminology used is undertaken.

- **Technical**: Design and engineering challenges in energy efficiency conversion with practical implications for industrial and domestic use.

- **Non-technical and Institutional**: Encompasses the i) legal framework and policy (“rules of the game”), ii) production cost and profitability options and iii) market-related issues such as market failures and competition.

- Also, to avoid confusion, the difference between woodfuel systems and supply chains is also briefly presented as:

- **Woodfuel systems**: Such systems depict the technical/engineering stages of woodfuel handling such as harvesting, processing, and combustion when used in general. Additionally, in the context of a specific use, the term will be used to denote an installation combining a boiler and storage facilities.

\textsuperscript{18}Only 7 wood-fuelled plants of the 22 originally awarded became operational under the NFFO (van der Horst, 2005).

\textsuperscript{19}Roos et al. (1999) only use it explicitly as related to non-technical barriers but the use of the concept in this context is compatible with the inclusion of technical factors.
• Woodfuel supply chain: The managerial integration of the engineering stages composing general woodfuel systems

TECHNICAL BARRIERS The technical or engineering challenges of fuel supply are covered by the specialised literature (Mitchell et al., 1990; Richardson et al., 2002) and the responses developed have proven creative not only with increasingly efficient processing devices to generate energy from biomass, and in particular of ligneous origin. Such technological improvements also concern harvesting, processing, storing and transporting of biomass. Processing here is focused on comminution, understood as the reduction of forest biomass by mechanical means into a higher valued and relatively uniform bulk material (Hakkila, 1989 in Hudson and Mitchell, 1993).

Optimal technical combination of woodfuel production system stages have been subject to evaluation in most OECD countries including the UK (Hakkila, 2004; Hudson and Mitchell, 1993; Mitchell et al., 1990). Some studies combine engineering and financial evaluation of the options available with mixed results on the feasibility of woodfuel systems development.

NON-TECHNICAL The principally investigated factor is the profitability of the activity derived through a financial cost benefit analysis (Bullard et al., 2004; DTI and DEFRA, 2007; Okkonen, 2008). Akin to this kind of study lie efforts in comparative financial performance of alternative heat or power generating devices using competing fuels (DTI, 2007). Under this category, we also choose to include studies that focus on the physical availability of wood material including forestry and arboricultural arisings, thinnings, traditional firewood, agricultural waste and post-consumer waste (i.e. pallets, packaging). This inclusion in the non-technical drivers derives from the fact that availability tends to be estimated against potential demand. Such aspects will be reviewed with a specific focus on the UK (DEFRA, 2008; DTI and DEFRA, 2007; Forest Research and RDI, 2009; GOSW and SWRDA, 2005; McKay, 2006)

Of the non-technical factors, contracts and other governance mechanisms were identified as important and necessary conditions to the development of bioenergy supply chains (McCormick and Käberger, 2007), emphasis tended to remain on finding ways of solving the “chicken and egg” problem. Following the announcement of early but not particularly successful initiatives, government support to woodfuel in the UK, this vicious circle was defined for woodfuel, as “for the first time there is a prospect of breaking the no market no crop, no crop no market cycle associated for so long with the supply and use of wood fuel” (Booth, 1994: p. 42 in Maryan, 1993)

The emphasis is on reaching a certain level of volume to be transacted but the way these transactions were governed but has not been a focus of analysis, nor of policy. This
has not even been the case for the more advanced countries, as concluded by Helby et al. (2004) in their review of a supply crisis that occurred during the early development of pellets in Sweden in the early 2000s. They equated a pellet supply crisis to market governance weakness, rather to a technical issue.

The concept of “critical factors” then used by Roos et al. (1999) is versatile as it encapsulates both constraints and drivers and offers a less deterministic impression than only using the concept of barriers to bioenergy development. The identification and analysis of the critical factors is indebted to economic theory and accounts for both production and market structure approaches. In their review of critical factors, and focusing on what were the barriers, McCormick and Kåberger (2007) identified three dimensions susceptible to hindering the development of bioenergy in Europe:

- Economic conditions;
- Know-how and institutional capacity;
- Supply chain co-ordination.

Economic conditions cover the issue of the lack of competitiveness of woodfuel because of pervasive externalities, already touched upon in section 2.6.1. In turn, the know-how and institutional capacity is related to RBV at the different levels of the supply chain, including for example the lack of exposure of the financial analysts to bioenergy systems when assessing credit and investment opportunities. Finally, supply chain coordination is touching central issues of the analysis of the thesis by looking at the organisational dimension of the critical factors. Moreover, McCormick and Kåberger (2007) concluded there are no definitive barriers to bioenergy development in Europe, something supported by the evidence from the case studies reviewed, even when not successful. An example of very relevant failed project is the planned biomass gasifier plant in Winkleigh, Devon, South West of England (McCormick and Kåberger, 2007; Upham and Shackley, 2006). The project failed but although it faced some technological challenges, it was the local opposition to the project that brought it to a halt. Such opposition is related to organisation and institutional factors, not technical ones. However, it is also important to point out that potentially, sustainability limitations do exist. This is particularly so for energy crops fostered by the “new environmentalism” of climate change, as described by Lobley and Winter (2009). Although less controversial than agriculture biofuels, wood energy development also entails potential environmental sustainability issues, even in tightly regulated forestry environments such as the UK.\textsuperscript{20}

\textsuperscript{20}For more details on general social and environmental sustainability aspects of woodfuel, please refer to Röser et al. (2008); Thornley et al. (2009); Upham and Shackley (2006). For a specific reference to wood ash management, please refer to Pitman (2006).
2.6.3 Policy responses in the UK and the South West

Targets for the UK

It is a shared view that the UK is not positioned on how it will meet all the new EU 2020 renewable energy targets (DTI and DEFRA, 2007). A general change is perceivable but “it will take years to work out how the (energy) objectives might be achieved” (Helm, 2005: p. 9). One of the challenges consists in conjugating the “new” objectives with the existing liberalized framework. According to BERR (2008), the current level of national public support and local level engagement for the development of renewables is expected to only generate 5% of all the region’s energy needs, far behind the 15% targeted by the UK as a whole. Although enough regional woodfuel resource has been identified (RegenSW, 2008a), it has to be highlighted that the scenarios for the development of bioheat are pessimistic because a critical level of risk is associated with their supply chain deficiencies (RegenSW, 2008a; 2008b).

The responses

Although having developed a variety of mechanisms to promote renewable energy in the last 20 years, the UK has focused on electricity generation21, thereby ignoring the importance of heat in the country’s primary energy needs and its related contribution to greenhouse gas emissions. This is changing and heat is acknowledged, most relevantly in the Woodfuel Strategy for England (Forestry Commission, 2007d) and was integrated into the law through the Renewable Heat Incentive (RHI) in early 2011.

Such an approach has translated into two practices, one consisting of promoting renewable electricity generation and the other promoting the development of a more structured supply chain for renewable feedstock, mainly biomass (Forestry Commission, 2005; Forestry Commission, 2007d).

The last decade witnessed various initiatives to stimulate and strengthen woodfuel supply nationwide from the FC and DEFRA, however, “the slow development of wood as a biofuel has been frustrating with uncertainties, delays and some high profile failures” (Glynn, 2006). The commitment to renewables has been varied but its importance relative to public spending and the size of the UK economy has been very limited. Moreover, Bauen (2005) acknowledges the initiatives developed in the UK by different sector policies to promote bioenergy, but as poorly integrated, particularly with respect

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21 The Renewables Obligation (RO), the main policy instrument for renewable energy generation, is briefly discussed for reference in Annex F.
to the relationship between short- and long-term considerations and the levels of implementation. This was reiterated by the House of Commons’ Committee of Public Accounts (House of Commons, 2010).

In the framework of the submission of the National Renewable Energy Action Plan for the United Kingdom to the European Union, DECC (2010a) presented a fairly complete overview of the different mechanisms in place for supporting renewable energy in the country in the last decade. They can be classified as regulatory, economic and policy instruments.

The economic instruments basically provided subsidies for either supporting demand (e.g. Bioenergy Capital Grants Scheme 2002-2010) or supply through capital investments (e.g. Bioenergy Infrastructure Scheme, the Rural Development Programme for England 2007-2013 (RDPE), partially responding to the “economic conditions” identified among the three main barriers summarised by McCormick and Käberger (2007). More directly answering the incentive problem related to externalities; two important mechanisms were developed, the Renewable Obligations (RO), a regulatory instrument and Feed-in tariffs which are an economic instrument. These systems focus on electricity generation, but are only of marginal interest in this thesis. However, a discussion of the RO is presented in Annex F for reference.

A novel economic instrument to be introduced specifically for promoting the generation of renewable heat by businesses and domestic users is the Renewable Heat Incentive (RHI) which is expected to significantly stimulate renewable heat in the country through an annual payment made to any renewable heat system installed since 2009 during their estimated lifespan (i.e. 15 years for biomass boilers). Although it is expected to be implemented very soon, a high degree of uncertainty still covers its details. Finally, policy instruments such as the Woodfuel Strategy for England were published and are expected to be complemented by an associated Implementation Plan but this has been delayed. Given its direct importance to the topic of the thesis, this document is presented and discussed below.

Focus: The Woodfuel Strategy for England

This document is the result of a process to identify the priorities for biomass and has been well received by the commercial forestry community\textsuperscript{22} (ConFor, 2007). This specific strategy aims at mobilising an extra 2 million green tonnes of wood by 2020,

\textsuperscript{22}\textit{Stuart Goodall, Executive Director Policy and Research at the Confederation of Forest Industries (ConFor), said: “ConFor has lobbied hard for this strategy and for a focus on local, heat generation” (ConFor, 2007).}
representing about half of the currently unharvested wood material grown each year (Forestry Commission, 2007d). Meeting this goal would enable wood to provide 16% of all renewable energy sources from its current 10% (Forestry Commission, 2007d). Overall, this increase would approximately provide 0.2% of all UK primary energy needs.

The strategy has three main dimensions that are expected to tackle the main barriers to develop woodfuel in the country:

- Engaging the end user: creating awareness and access through capital support providing confidence in the supply chain;
- Sourcing and extracting the material: engaging with woodland owners and develop incentives for them to manage their forests;
- Stimulating the supply chain: supporting the simplification and mainstreaming the chain to reach viable margins for all agents involved (i.e. grower to final retailers).

Although not fully integrated within renewable energy policy and legal frameworks, heat was acknowledged in this strategy as playing a major role with woodfuel. The “most economic use biomass”, an idea of optimum energy use, is expected to be realised by medium-scale local heat (Forestry Commission, 2007d: p. 14), probably in the range comprising large domestic boilers of 30kW to district / industrial units of 1-2 MW (Leslie, 2007). Small and medium CHP installations are also seen as important contributors. Although larger installation like dedicated power plants and co-firing plants are not excluded, they are less likely to offer development opportunities to UK grown material because of both the limited local availability of large quantities of suitable material and the fact that industrial quantities have already been absorbed by existing plants. No specific action is aimed at small domestic appliances because of their lesser efficiency and, it is expected that their related woodfuel market will develop spontaneously.

To achieve such goals, the government is aiming at providing capital support and awareness alongside the acquisition of fundamental skills to the central actors involved. However, the strategy acknowledged the need to provide heat generators with a clear and stable long-term incentive through a “revenue support mechanism for renewable heat (such as a renewable heat obligation)” (Forestry Commission, 2007d: p. 18). An Implementation Plan was attached to the Strategy and planned for 2009, rescheduled for 2010 but has yet to be launched23.

23Still the case in September 2011.
2.6.4 Diversification of actors and levels in UK energy policy design and implementation

Traditionally energy policy has been centrally governed with little or no participation by regional or local actors (DTI, 2007a: p. 280) although more room for Devolved Administrations and local authorities is deemed necessary (DECC, 2010a). The need to integrate regional actors by aligning their activities to national ones contributing to climate and energy goals was explicit in the previous Energy White Paper (Roberts, 2008: p. 6) and reaffirmed in the current Energy White Paper as: “The RDAs in England will” (or now their replacement24):

- continue to set regional energy priorities and take forward initiatives to support national energy policy, for example by committing to publish carbon saving projections from regional measures and prioritise support for energy technologies.

Local authorities in England will:

- have a strengthened role to play in tackling climate change through measures in the new Local Government Performance Framework; and be able to use the new self-assessment tools to evaluate their own performance and provide guidance for improvement on tackling climate change. (2007: p. 6267)

However, such integration is fragile and requires development. Exploratory25 research has been commissioned to identify such needs. It concluded that, there is limited understanding of the potential of regional contribution to national goals. Moreover, despite working examples of coordination (i.e. planning), there is “reticence to provide tightly defined input from the centre to the regions”, probably because of the general policy to self-determination (Smith, 2007). The report also noted that many working channels depend on focal points and single experienced individuals, making coordination vulnerable to simple posting changes.

Experiences of devolution, reforms of institutions such as the Forestry Commission and decentralization have brought about a diversification of the actors involved in policy design, and in particular of renewable energy strategies. However, beyond government and its formal structure, there are also hints at the emergence of multi-level governance

24In May 2010, the RDAs were replaced by Local Enterprise Partnerships (LEPs) and will cease to exist by 2012.
25The national government officials interviewed had some experience in working with the region, possibly biasing conclusions to a more positive trend than it is actually the case across the State agencies (Roberts, 2008).

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around renewable energy with initiatives “distributed across levels and actors” (Walker et al., 2007). Important questions around hierarchy, autonomy and accountability arise in the negotiation between the “partners” of this type of governance when dealing with the specifics of developing renewables (2007: p. 66), enriching implementation options but also complicating them. For example, formalised experiences\textsuperscript{26} of integrating local communities to such developments have exposed the challenges, as an agreed and effective governance framework has proved elusive because of tensions between stakeholders and short and long-term objectives. However, since May 2010, the mechanism for decentralised energy policy has entered into a period of uncertainty with the replacement of the RDAs by the Local Enterprise Partnerships (LEPs).

2.7 Summary

The chapter presented what is understood as woodfuel, its different forms and possible energy conversion processes. Although the focus is on solid forms such as simple logs, processed woodchips and manufactured wood pellets, other forms exist. For example the future development of this resource as cellulosic ethanol has great prospects as a second-generation biofuel, without the problems surrounding maize or biodiesel from oil palm. In terms of its conversion we focused on combustion and gasification for the production of heat, although it can also power steam turbines to generate electricity.

Then, the potential of woodfuel was explored for the UK and the South West, as a region. Source of wood can be either the forest and the forest industries or come back as waste after being used. Although robust statistics have yet to be developed on the resource (both as potential resource and as used resource), some estimates have been published and provide some idea of its potential. An important fact is that with approximately 212,000 ha of woodland (Forestry Commission, 2002), the South West could hold about 24% of the woodfuel potential of the country (McKay et al., 2003).

The chapter reviewed some of the critical factors for this market development and the current policy response mobilised to foster it. The first aspect to highlight is that policy will influence woodfuel through the adoption of heat as a subject of policy. This is accompanied by a shift from support mainly spearheaded through grants towards an incentive-based system being set up to specifically foster the development of renewable heat with the Renewable Heat Incentive (RHI). This new policy instrument is expected to steer support more in line with the spirit of the internalisations of the benefits of renewable energy. This initiative was not yet a reality when this thesis was conceived.

\textsuperscript{26}The Community Action for Energy (CAFE) and the Community Renewables Initiative (CRI), among others.
and the fieldwork undertaken. In the meantime, and following a General Election with a change of government, the RHI has now been approved. However, the evidence gathered for the thesis captured the effects that is was still standing as a promise, effectively acting as a factor of uncertainty characterising transactions in the sector with various implications for its governance. Now that this economic policy instrument is adopted and it is expected to enhance demand, it is important to identify that it does not respond to all the challenges identified and suggest possible avenues for additional measures that would.
Part II

Approach
Chapter 3

Theory and philosophy of the approach

3.1 Introduction and rationale

The focus of research on biomass for energy under the form of chips, logs or pellets, has concentrated on feasibility studies with “engineering-economic” approaches comparing its performance to both established and other emerging energy technologies such as wind and solar energy.

Forestry studies have developed optimisation logistics models along the supply chain of wood as fuel. A common conclusion of such developments is the need for coordination and planning among stakeholders to reach a shared main objective which is to ensure that the biomass fuel, often seasonal, is delivered on time, in the right quantity and expected specifications to the user. Such analyses provide a clear picture of the specificity of biomass logistical challenges. However, the organisational costs are not developed upon by feasibility nor optimisation studies, although they may be implicit in some of the trade-offs along the supply chain logistics. Feasibility studies tend to assume that exchange is seamless, ignoring friction and other barriers.

However, there are barriers and if they are to be surmounted, it is critical to be able to offer some analysis of organisational change and prescription for adaptation towards a more established market. A New-Institutional Economics (NIE) approach provides insights to analyse friction and barriers to exchange and enables dialogue between economics, law and direct business decision-making about organisation. The costs associated with exchange both observable and non-observable are known as transaction costs (Coase, 1937; Klein et al., 1978; Williamson, 1985).
The existence of barriers to exchange or transaction costs has been identified as an important non-technical barrier to the development of renewable energy technology implementation (Altman et al., 2007; Bohlin, 2001; McCormick and Kååberger, 2007; Roos et al., 1999) but only with limited application to the specific case of woodfuel and only focusing on industrial scale cases (Bohlin, 2001; McCormick and Kååberger, 2007). A major weakness identified by the accounts covering the untapped potential of woodfuel is linked to its weak supply chain. Moreover, the Woodfuel Strategy for England (Forestry Commission, 2007) depicts the current situation of the woodfuel market as one where exchange is limited, constrained by the “complexity of supply chain” (2007: p. 14). This is where barriers to exchange need to be identified along with their implications. This was also echoed by regional initiatives. Woodfuel potential as a renewable energy option is plagued with uncertainty because of the risks associated with its delivery as concluded by the Road to 2020: An analysis of renewable energy options in the South West of England report (RegenSW, 2008a). As such, of all the renewable energy options at the regional level, the report asserted that “the biggest supply chain risk relates to heat retrofit deployment where the small size of the current market means that supply could be a major short-term constraint to the rapid growth of the sector” (RegenSW, 2008a: p. 17)\(^1\). This offers a particularly fertile ground for analysis of transaction costs and how they could be lowered to create incentives for regional woodfuel market growth. The type and degree of coordination of the woodfuel supply chain, in the light of transaction costs and their origin, is central to this research. This could imply the thesis is only concerned with a supply-side analysis, at the expense of analysis of demand, a criticism raised by Jablonski et al. (2008) with respect to the dominant research on biomass energy in the UK as a whole. However, a neo-institutionalist approach reduces this risk. Although mainly grounded on evidence from supplying businesses, the focus on transaction places the analysis at the interface between supply and demand. There is a clear need to focus on the nature and management of relationships along the woodfuel supply chain.

To respond to this need, insights provided by NIE, and particularly by an extended version of Transaction Costs Economics (TCE) are presented as a framework for approaching the woodfuel supply chain in the South West. The TCE approach followed here is extended and complemented with contributions from the Resource/Competence-Based View (RBV) of the firm as it offers a reading of change in the emerging and changing bioenergy sector analysed.

The chapter unfolds by first presenting the theoretical origins of the main approach

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\(^1\) *Heat retrofit deployment* refers to the replacement of existing heating systems, in contrast to the installation of wood fired boilers and systems in new buildings where the needs of such energy conversion devices can be accounted for in the early planning phases of a building.
developed by Coase (1937) and then, by locating the analysis in the broader NIE research programme on institutions, including TCE. Subsequently, the assumptions relied upon by TCE are explored along with the diversity of transaction costs and their operational dimensions. The implications of transaction costs for structures governing exchange (i.e. *spot markets, hybrid structures and hierarchies*) are presented, followed by the main testable hypothesis and brief review of the evidence from general empirical applications. This basic framework is then combined with a set of factors which allow for its application in a dynamic and changing sector; mainly drawn from RBV. The chapter ends by opening the way for Chapter 4 which develops a discussion on empirical undertakings directly relevant to woodfuel to establish the implications of transaction costs for the sector.

### 3.2 Theoretical origins

The formal acknowledgment of the existence and relevance of what would come to be known as transaction costs was introduced by Coase in his seminal article on the nature of the firm (1937) and with further developments, in his reflections on social cost (1960). The first article asked why firms emerge as organisations; when, in theory, neoclassical economics would assume that exchange develops smoothly through the market. Although prices are the established coordinating mechanism of exchange, it is acknowledged that, in some contexts, conscious coordination is undertaken by “entrepreneurs” (Coase, 1937: p. 389). The answer put forward, was that *marketing costs* (i.e. transaction costs) existed; basically that “*there is a cost of using the price mechanism*” (Coase, 1937: p. 390) mainly due to searching and information costs along with negotiation cost attached to contracting during each transaction. Interestingly, he also mentioned that the emergence of firms was more likely when “*short term contracts would be unsatisfactory*” (Coase, 1937: p. 392). This “unsatisfactory” situation would be pointing out shortcomings of the price mechanism to allocate certain resources in a given order, hence the need for a (more) conscious organisation, the firm. This situation faces entrepreneurs with the question “*will it pay to bring an extra exchange transaction under the organising authority*” instead of leaving it to the market, leading to the paradigmatic problem of the “*make or buy decision*” of firms. By answering these questions, managers acknowledge that each organisational option (i.e. the market or the firm) has transaction costs to be accounted for, as a realistic analysis of the market mechanism. Shortcomings of the market will be dealt with within a firm, if the con-

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2 This term has been standardised as “transaction costs”, although not necessarily with the same scope in definition (Allen and Lueck, 2002; Langlois, 2006), as developed in Section 3.4.
sequent increase in administrative costs is lower than the transaction costs associated with only relying on the market mechanism for part of the production process. This qualification of “realistic” deserves some explanation, as it is pervasive in what Transaction Costs Economics, and by extension, Neo-Institutional Economics, stand for in relation to other frameworks such as the Neo-Classical one (Allen and Lueck, 2002; Wang, 2003a). The approach has proclaimed itself as truly “applied economics” (Allen and Lueck, 2002: p. 200).

In his article on social costs and externalities, Coase (1960) introduced the implication of transaction costs to institutions in general. When transaction costs are zero, as in the hypothetical world of neoclassical models, the efficient allocation of resources is detached from the distribution of property rights. That is organisational structure does not matter in resource allocation. Whatever the organisation configuration, wealth will be produced efficiently. However, the very existence of transaction costs justifies organisations. Under such conditions, different organisations will have different impact on wealth creation, making necessary a comparative appreciation of the options such as the market, an integrated firm or any structures that could lie in-between.

### 3.3 Neo-Institutional Economics and TCE in perspective, institutions and levels of analysis

Neo-Institutional Economics (NIE) has mainly developed in two directions (Ménard, 2004). One strand has followed the works of North (1991) on the relationship of economic agents, institutions and economic growth at the macro-level. In turn, and following Coase (1937), micro-analytical research programmes also developed as a second strand. Williamson (1985) provided insights on governance mechanisms from TCE, as developed in the following sections. Additional micro-analytical developments have focused on the formalisation of models for incomplete contracts such as the “property-right approach” (Grossman and Hart, 1986; Hart, 1995). Although inspired by the “intuitive” propositions from TCE, its latest developments relaxed the assumption of bounded rationality so central to TCE (Fares and Saussier, 2002; Williamson, 2000). The interest in keeping bounded rationality as a valid assumption and the fact that woodfuel is not a mature market does not make this current of analysis very applicable and it will not be analysed further for this purpose.

Recently the two main levels of analysis have started to construct a more coherent

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3Very detailed appraisals of the contributions of this strand can be found in Hart and Moore (1999), Lyons (2001) and Tirole (1999).
ensemble (Joskow, 2008) despite the great diversity of insights and origins (Brousseau and Glachant, 2008). To illustrate this, a mapping of institutional levels representing the different NIE research programmes to integrate their different levels of enquiry, is presented. In his review of the contributions of Neo-Institutional Economics and, to properly locate its level of scrutiny, Williamson (2000) presents social analysis as divided into four levels of examination. Such analysis is based on the assumption that institutions govern economic relations and that “contrary to earlier conceptions – where the economic institutions of capitalism are explained by reference to class interests, technology, and/or monopoly power – the transaction-cost approach maintains that these institutions have the main purpose and effect of economizing on transaction costs” (Williamson, 1985: p. 1). This integrates with the general objective of institutions formulated by macro-analysis as “to create order and reduce uncertainty in exchange” (North, 1991: p. 97).

To map the locus of analysis, it is useful to reproduce the diagram presented by Williamson (2000: p. 597) in Figure 3.1 indicating the levels of analysis, time and theoretical frames used to analyse such levels. The solid arrows imply constraints from the higher to the lower levels and the dotted ones are related to feedback from lower to higher layers.

The higher layer (L1) is concerned with “embedded” informal institutions, customs and norms and are generally taken as given by NIE because of their degree of inertia (Granovetter, 1985; North, 1991: p. 97; Smelser and Swenberg, 1994 in Williamson, 2000: p. 597). For perspective, their evolution is assumed to be within several centuries or millennial time frames.

Once these spontaneous foundations are established in the background, “formal rules (constitutions, laws and property rights)” are formulated (North, 1991: p. 97). These can be seen as an intentional first effort to bring order at a first-order economising level (L2) to provide a propitious general environment for resource allocation under the rule of law. This public ordering through formulation of “the rules of the game” is a progression of a cumulative kind and rarely prone to overhauls but in the case of social upheavals such as revolutions (Coase, 1994; North, 1994; Levy and Spiller, 1994; Olson, 1996; Henisz, 1998 in Williamson, 2000). The establishment of property rights and their enforcement by a public body is a primary but slow construction that spans over decades and centuries. Such rules of the game lay the foundations for the development of private enterprise and the efficient allocation of resources. With chaos or uncertainty on property rights resolved, incentives are in place to guide decision makers toward efficiency (Coase, 1959). Defining and enforcing such property rights that allow for the theoretical dynamics of the perfect market are assumed to be smooth or costless
Figure 3.1: Economics of institutions

Source: Reproduced from Williamson (2000: p. 597)

Such structure is both coherent and supported by a precise identification of institutions more relevant to transactions such as property rights and law of contracts (Ménard, 2001). However, law enforcement or property rights definitions are seldom costless
(Coase, 1960). Much “contract management and dispute settlement” is directly internalised by the interested parties through “private ordering” (Williamson, 2000: p. 599). Although property rights from public ordering are supporting such transactions, contract enforcement is not the result of costless court ordering. To account for this phenomenon, an additional level of analysis is required (L3), which, in turn focuses on the “governance of contractual relations” or “the play of the game” (Williamson, 2000: p. 599). The thesis is located at this level to understand private governance in the woodfuel supply market.

Finally, and at a fourth level (L4), day to day economising exercises are the realm of marginal analysis and adaptations of firms to price and quantities as production functions, following the neoclassical framework (Williamson, 2000).

As a concluding remark, it is important to stress that one of the main theoretical weaknesses of the construct lies in the lack of understanding of the mechanism by which the institutional environment (L2) influences the organisation of transaction through governance structures at L3, as highlighted by Ménard (2001), offering a rich research agenda.

### 3.4 What are transaction costs?

#### 3.4.1 Introduction to transactions.

Transaction costs are a variety of costs that influence and that can hinder exchange, making it more difficult to occur. Williamson (1985) uses the analogy of friction in physics to describe this phenomenon.

Exchange can be hindered by market failure but “it is better to consider a broader category, that of transaction costs, which in general impede and in particular cases completely block the formation of markets” and such costs are “the cost of running the economic system” (Arrow, 1969: p. 48 in Williamson, 2005: p. 4). Such costs need to be distinguished from production costs (Williamson, 1985) but, at times are also related to transport costs because of their frictious nature (Coase, 1937; Langlois, 2006).

Before continuing with the dynamics of transaction costs, the use of the transaction as a basic unit of analysis requires a definition of the transaction as such. Williamson identifies a transaction “when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins” (Williamson, 1985: p. 1). However, a more complete definition insisting on the social aspect of the transaction would focus on the transfer of property rights, comprehensive enough
to encompass physical transfers and opening the concept to uses that go beyond the "separable interface". Conceptually, and following Ramstad (1996), this comprehensive characterisation of transactions is more in line with Williamson’s own inspiration from Commons (1934 in Ramstad, 1996) explicit in the need for "value-preserving governance structures to infuse order, thereby to mitigate conflict and realize mutual gain” (Williamson, 2002b: p. 176). Explicitly formulating the transaction as both a production activity and as a transfer of rights reinforces the transaction as exchange (Verhaegen and Van Huylensbroeck, 2002). The exchange can relate to two production processes (e.g. harvest and comminution of forest residues) within a single organisation but also a sale that entails change in ownership of woodfuel to a user (e.g. procurement). Thus, a great variety of transactions exist but also at different scales (Verhaegen and Van Huylensbroeck, 2002). A study may focus on a single operation such as transport of woodfuel from the harvesting site to storage facility yet another one may describe a series of operations (i.e. the whole processing of woodfuel before storage).

For the purposes of this research we will combine the definition of Williamson, given the very physical nature of commodity transactions with that of transfer of rights, particularly with respect to procurement.4

3.4.2 Identifying transaction costs.

Despite the apparent coherence of the concept vis-à-vis production costs, there are various definitions and taxonomies of transaction costs, starting with the initial formulation of Coase (1937) focusing on searching and information costs along with negotiation costs attached to contracting at each transaction.

Two main strands of transaction cost analysis have developed from Coase’s formulation. One focuses on measurement and evaluation challenges of quality, standards and sometimes quantities of goods and services transacted (Barzel, 1982). The second focuses on asset-specificity, creating potential hold-ups after the commissioning of a contract (Williamson, 1985). However, a third, independent, current has also developed from neo-classical analysis that focuses on frictions.

The measurement branch During exchange, goods and services are advertised or expected to possess certain properties that require evaluation. When accurate evaluation is challenged, transaction costs arise. “Measurement” problems create the potential

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4Not only the property rights dimension requires attention for sales of woodfuel, but given the both positive and negative externalities that the development of woodfuel as energy may imply, it requires to be explicit. This is developed in Chapter 2.

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for moral hazard and ask the question about the organisation better suited to deal with such moral hazard. Barzel, building on Cheung (1969) opens the questioning by asserting that: “Virtually no commodity offered for sale is free from the cost of measuring its attributes [...] "Market signaling" and "adverse selection" are seemingly instances of the general case. In both cases, the costs of measuring the attributes of individuals are high, and the resulting errors permit people to transfer wealth to themselves at a resource cost. Costly measurement is a factor common to these and various other instances where individual and joint maximization do not coincide. [...] Of concern here are the effects of such behavior and the market arrangements that emerge to reduce the losses from the exploitation of the inaccuracies.” (1982: p. 28)

Higher costs of sorting products from a buyer’s perspective are expected to lower the actual price she is prepared to pay. When measurement costs are high (e.g. not possible to simply assess them visually), there is an incentive for a seller to internalise such costs by sorting the products and offering potential buyers a guarantee of the characteristics of the goods exchanged. The existence of standards and certification schemes offer this possibility to the seller if it is not able to create some brand name or as a mechanism to reinforce its reputation.

Asset specificity

Williamson’s (1985) understanding relates to costs of contractual hazard, because of potential opportunistic behaviour facing transactions with asset specificity. This could be defined as the potential harm that each agent engaged in the exchange or “transactor” can do to each other (Baldwin, 2008). However, we fully share the appreciation with Langlois (2006) that such kinds of cost are not obviously a friction as initially presented by Williamson and as in Coase’s original acceptance, although the process to deal with such asset specificity is related to more “frictious” costs (Williamson, 1991).

Friction In addition to the “measurement” and “asset-specificity” currents, a less debated understanding of friction has also developed for analysing the stock exchange (Demsetz, 1968; Van Vactor, 2004; Stoll and Whaley, 1983 in Wang 2003). In this context, “friction” is the actual term used to describe costs to exchange related to the price concession paid to a broker to provide immediate transaction (Demsetz, 1968; Stoll, 2000). Such developments have tended to evolve independently from the rest of the TCE literature although they share the same roots (Wang, 2003b). Nevertheless, as Van Vactor notes: “The observations concerning financial markets are helpful in interpreting market institutions in the broader economy. Fundamentally, there are two
types of marketing arrangements—brokers and marketers. Brokers, such as real estate agents, auctioneers, etc., do not take title to the goods and services they sell. Marketers (most retail outlets, for example) do take title and manage inventories; they organize the distribution of goods and services temporally and geographically. These two aspects of a market go beyond simple arbitrage, which is the usual function attributed to middlemen; they reduce transaction costs and provide benefits and services to producers and consumers” (2004: p. 29). The main service to satisfy being the demand for immediacy.

Another manifestation of friction can be expressed as whether the market is thick or not. In thin markets, information is underprovided generating trading costs related to search but also negotiation costs. In turn, thick markets are populated by a large number of middlemen that lower such cost as the number of similar transactions conducted increases (Stavins, 1995 in Liski, 2001). As such, the thickness of markets as influencing contract choice has been established for maritime contracting by Pirrong (1993). Thin markets are more likely to be governed by long-term contracts whereas thick ones are traded under spot markets. Lyons (1994, in Lafontaine and Slade, 2012, forthcoming) studied engineering sub-contractors in the UK and identified a higher probability of developing formal contracts when the customer tended to have a larger share of the contractor’s output combined with asset specificity. Internal market thinness tended to be associated with more formal contracts.

3.4.3 Transaction costs as a family

Given the various strands of transaction-costs and to contextualise the somehow restricted definition of transaction costs developed by Williamson, it is beneficial to present broader typologies (Allen and Lueck, 2002; Baldwin, 2008; Langlois, 2006; Van Vactor, 2004). A summary review of the classified transactions costs is presented in Table 3.1. In line with the social aspect of a transaction focusing on the transfer of rights, Langlois (2006), building upon Allen and Lueck (2002) proposes a distinction between transaction costs related to the “transfer of property rights” and the transaction costs associated with “enforcing and maintaining property rights”. Transaction costs can be i) fixed, ii) variable as a function of time and, iii) variable as a function of volume of trade or number of transactions. These categories allow transaction costs to be more comparable to traditional production costs. Transaction costs can also occur before or in preparation of a transaction (i.e. ex-ante) and others will tend to manifest or realise during or after the transaction (i.e. ex-post). To reflect this the ex-ante and ex-post dimensions were also introduced. Finally not all transactions costs are accounted for by different economic theories and in this case, these can be either Classical, Neo-classical
or TCE. A fundamental difference between TCE and a basic neo-classical approach, is that the orthodox approach tends to assume that property rights are clearly defined and the cost of enforcing those rights by the means of knowledgeable courts is negligible (Williamson, 1983), whereas TCE treats “property rights and contracts as problematic” (Williamson, 1996), costly and therefore with implications as to how a transaction may or may not be conducted. By the way of illustration, this is why ex-post enforcement costs are only associated with TCE and not with the Neo-classical framework, at least not in its textbook or “straw-man” version in the words of Williamson (1996) in Table 3.1.

Although neither is in the spotlight of classical or neoclassical economics (Arrow, 1969 in Williamson, 2005) the measurement of such costs is theoretically compatible with traditional economic analysis (Rao, 2003) that focuses on the choices of agents, rather than contractual and relationships between agents. Williamson asserts that this analysis “is less a substitute for than a complement of the orthodox lens of choice” (2002a: p.440). This is so because their management has an economising objective akin to the neoclassical production costs (Williamson, 1985).

However, assuming that costs of production and cost of transaction are separable has been identified as a weakness of the framework. Such conceptual independence is not straightforward because total costs are generally not the simple sum of them (Milgrom and Roberts, 1992; Platteau, 2008). Although transaction costs can be singled out, their complementarity to traditional production costs is not always well interpreted. This is the case with understandings of independent minimisation of TC, rather than the whole process (Rao, 2003). In the same vein, and after highlighting the shortcomings of focusing on asset specificity transaction costs only, Langlois insists that the analysis should focus at the interface between production costs and transaction costs; and among transaction costs themselves: “Keep in mind that, since the goal is to minimize the sum of production costs and all three kinds of transaction costs, the result may not be one that minimizes transaction costs, since one may well want to increase transaction costs (of one kind or another) if that will more than proportionally reduce production costs or other kinds of transaction costs” (2006: p. 1397)\(^5\). It could be expected that transport costs, among others, play a pivotal role in this dialogue and trade-off, even more so in the context of this specific research. The technical literature on bioenergy is unanimous in stressing transport cost as central (Asikainen et al., 2002; Eriksson and Björheden, 1989; Roos et al., 2000), rarely interpreting governance implications, however. The question of non-separability has important consequences to account for

\(^{5}\) 1) Fixed Costs, 2) Costs that are a function of time and 3) Costs that are a function of volume traded, as in Table 3.1.
<table>
<thead>
<tr>
<th>Type of costs</th>
<th>Relation to property rights</th>
<th>Fixed or variable</th>
<th>Timing</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production asset protection</td>
<td>Enforcing and maintaining</td>
<td>Fixed</td>
<td>ex-ante and-post</td>
<td>Classical</td>
</tr>
<tr>
<td>Search</td>
<td>Transferring</td>
<td>Variable</td>
<td>ex-ante</td>
<td>Neo-classical</td>
</tr>
<tr>
<td>Information and measurement</td>
<td>Transferring</td>
<td>Variable and Fixed</td>
<td>ex-ante</td>
<td>Neo-classical</td>
</tr>
<tr>
<td>Bargaining</td>
<td>Transferring</td>
<td>Variable</td>
<td>ex-ante</td>
<td>Neo-classical</td>
</tr>
<tr>
<td>Decision</td>
<td>Transferring</td>
<td>Variable</td>
<td>ex-ante</td>
<td>Neo-classical</td>
</tr>
<tr>
<td>Policing</td>
<td>Enforcing and maintaining</td>
<td>Variable</td>
<td>ex-ante and-post</td>
<td>TCE</td>
</tr>
<tr>
<td>Asset specificity (i.e. hold-up)</td>
<td>Enforcing and maintaining</td>
<td>Fixed</td>
<td>ex-ante and-post</td>
<td>TCE</td>
</tr>
<tr>
<td>Enforcement</td>
<td>Enforcing and maintaining</td>
<td>Variable</td>
<td>ex-post</td>
<td>TCE</td>
</tr>
<tr>
<td>Re-negotiation and adaptation</td>
<td>Enforcing and maintaining</td>
<td>Variable</td>
<td>ex-post</td>
<td>TCE</td>
</tr>
<tr>
<td>Breach of contract</td>
<td>Enforcing and maintaining</td>
<td>Variable</td>
<td>ex-post</td>
<td>TCE</td>
</tr>
</tbody>
</table>

Table 3.1: Typologies of transaction costs

Source: Various, please refer to table for specific references.

(Barzel, 1982; Coase, 1937; Downs and Mui, 1998; Rao, 2003; Williamson, 1985; Allen and Lueck, 2002; Langlois, 2006; Williamson, 1985)
in the framework, as there may not be one but several different institutional solutions to a cost-economising problem (Platteau, 2008).

3.5 The assumptions of TCE

The neoclassical economics’ assumption of a fully rational economic agent or “maximizing man” (Williamson, 1996) is adapted in TCE by agents gifted with a bounded or limited rationality, in an attempt to make more realistic assumptions of decision-makers, than the traditional one. This approach understands economic agents to be “intendendly rational, but only limitedly so” (Simon, 1957: p. xxiv, emphasis in the original). Langlois and Robertson insist on understanding “bounded rationality” as the “limits to an agent’s knowledge and decision-making skills” rather than “imperfections in the agent’s rationality” (1995). As such, rationality also encompasses the skill of foresight (Coase, 1937; Williamson, 2000; Williamson, 2008b) opening the way for ex-ante mechanisms to deal with “unanticipated disturbances” (Williamson, 2008b: p. 6). One of the implications of this assumption is the need for organisations to be developed to offset such limitations (Simon, 1957; Williamson, 1985).

In addition to this vision, however, the idealised agent is seen as being able to be opportunistic through a “self-interest-seeking assumption that makes allowance for guile” (Williamson, 1996: p. 56). This will tend to manifest in the strategic use and withholding of information by agents creating the potential for moral hazard and therefore a greater need of the ex-ante mechanisms as mentioned before, to limit ex-post opportunism (Williamson, 1985, 1996).

3.5.1 Operational study of transactions and their dimensions

For TCE, firms are not “black boxes” (Arrow, 1999 in Williamson, 2000) of production functions that transform inputs into goods but rather governance structures that ensure the supply of their input and that reach their consumers (Vannoni, 2002). It is expected that TC will shape the governance structure when transactions or a business relationship are influenced by:

---

As demand for goods and services of a sector analysed is not bound to any specific structure in TCE (Nickerson, Hamilton, and Wada, 2001), TCE can be combined with other theoretical frameworks. For example this makes it compatible with other approaches that do so, but in turn that have no behavioural assumptions of their own such as the Strategic Positioning Framework of Porter (1985), as highlighted by Nickerson et al. (2001).

Dating back to the early 20th century organisation practitioner and theorist, Chester Barnard with his 1938 The Functions of the Executive (Simon, 1957; Williamson, 1985).
• Asset specificity
• Uncertainty
• Frequency of transactions

The combination of these three dimensions in a transaction influences the degree of contractual hazard of such a relationship when, undertaken between rationally bounded but opportunistic decision makers. Transactions with such a profile need to be framed by adapted governance structures that will reduce contractual hazard.

Asset specificity

An asset is defined as specific when it cannot be generic to any transaction by being restricted in use to a certain transaction in particular. It can be defined as “idiosyncratic” in contrast to “generic”. Although such assets tend to generate rent, they also are more attractive and vulnerable to opportunistic behaviour than generic ones (Klein et al., 1978). The forced redeployment of such assets would entail a significant, if not total loss in its extreme manifestation. This position of dependence of the investor to their partner makes them vulnerable to a “hold-up” by the latter who could exert pressure to re-negotiate previous arrangements and capture part of the rent generated. Such phenomenon will tend to affect the willingness to invest unless certain guarantees are provided.

Different kinds of asset specificity have been identified by the literature and we present the summarised version by Vannoni (2002: p. 117) in the following Table 3.2.
Table 3.2: Asset specificity manifestations

<table>
<thead>
<tr>
<th>Asset specificity</th>
<th>General examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical capital specificity</td>
<td>when some particular machinery, used to produce components specific to the buyer, cannot be converted without costs to manufacture inputs for alternative buyers</td>
</tr>
<tr>
<td>Human capital specificity</td>
<td>when some workers of the upstream firms obtain a specific knowledge of the technology and of the productive process of the buyer</td>
</tr>
<tr>
<td>Site specificity</td>
<td>when downstream plants are located close to upstream plants for lowering transportation costs or improving technical efficiency</td>
</tr>
<tr>
<td>Dedicated assets</td>
<td>when some non-specific investments, made in view of the relationship, lead to excess capacity after the latter has been broken</td>
</tr>
<tr>
<td>Brand name capital</td>
<td>when expensive investments are made in order to promote a brand characterised by vertical relationships with other firms</td>
</tr>
<tr>
<td>Design specificity</td>
<td>when inputs are specifically designed for the particular manufactures of the downstream firm</td>
</tr>
<tr>
<td>Temporal specificity</td>
<td>when timely performance is critical, and the failure to supply a particular input on schedule can cause interruptions of the production process</td>
</tr>
</tbody>
</table>


Uncertainty

The importance of uncertainty is influenced by the assumptions regarding bounded rationality and the potential for opportunism (Williamson, 1996). The first case is “innocent” and can be linked to external factors, beyond the control of agents. The second is strategic in nature and introduces hazard in contracts. Note that this is different from the uncertainty derived from measurement problems although they can interact with strategic behaviour.

Frequency of transactions

Transactions can occur once in lifetime, be casual or be frequent. The more frequent the transaction in combination with the two previous dimensions, the less likely the operation will use spot markets.
General context

Although this section is integrated under the section of assumptions, not all elements characterising the context under which transaction cost should be economised or minimised are expected to be assumptions as such. Some can also be the result of practice which focused on certain cases and industries that offered good data.

Economising is expected to become a necessity when the transactions and the characteristics of the transaction are non-trivial. By extension if the activity is of marginal importance but faces complex transaction, it is less likely that the existing governance mode is adapted. Methodologically, Transaction Costs Economics has primarily been concerned with groups of individuals, single organisations and organisation dyads as exposed by Douma and SchreuderÔs typology (1992: p.174). TCE generally analyses population of organisations or systems as wholes and focuses on relationships between two agents. More importantly the sectors analysed have generally been established and mature sectors (i.e. ocean shipping, oil, car manufacturing, etc.) which provide good bases in terms of data and work on documented experiences, even if, bespoke databases are also necessary as developed in Chapter 5 on methodology. That said more recent sectors have also been the object of analysis (i.e. software open source) but may offer large samples on which to test hypothesis (Demil and Lecocq, 2006). Evolving sectors are probably better covered by the concept of “dynamic transactions costs” (Langlois, 1992). Taking stock of the competence view, Langlois (1992) proposed the inclusion of “dynamic transaction costs” that account for frictions that push for vertical integration when goods and services are not adequately provided through spot market transactions. When such costs exist, firms may integrate activities otherwise outsourced because they are the “costs of persuading, negotiating, coordinating and teaching outside suppliers. Another—if perhaps fast and loose—way to look at these transaction costs is as the costs of not having the capabilities you need when you need them” (1992: p. 113).

These particular costs associated with innovation and emerging markets add a valuable explanation for the need for conscious coordination of the transactions.

Finally, an additional dimension which should be highlighted in this section is that as demand for goods and services of a sector analysed is not bound to any specific structure in TCE (Nickerson, Hamilton, and Wada, 2001), TCE can be combined with other theoretical frameworks. For example this makes it compatible with other approaches that do so, but in turn that have no behavioural assumptions of their own such as the Strategic Positioning Framework of Porter (1985), as highlighted by Nickerson et al. (2001).
3.6 Transaction costs and the governance approach

The tension in a given transaction appears through the “Fundamental Transformation” (Williamson, 1985). This process refers to the transformation of a market from a large pool of qualified bidders to a small number of supply relations through contract. This is significant if such contract is related to non-trivial investments in transaction specific assets. In the framework of the assumed conditions of bounded rationality and opportunism, it creates relationships that face contractual hazard that are managed through governance options as depicted in the simple contractual diagram in Figure 3.2.

The governance options were identified as instruments to analyse the paradigmatic problem of the “make or buy decision” of firms (Williamson, 1985) identified by Coase (1937). In the context of intermediate goods, the question of the firm is if it should produce the input itself by controlling the means to do it, or rather buy it from another firm in the market.

The importance of this phenomenon is that transactions along with organisations are the key to “take advantage of division of labour or of innovative technologies” (Ménard, 2001: p. 86), basic for economic development. With transaction costs, such advantages (i.e. resource allocation and technology) are dependent on existing governance structures, understood as modes for organising transactions (Ménard, 2001). The very existence of transaction costs implies the need for institutions to manage them.

The central contribution of transaction cost analysis is understanding that transactions will be managed in such a way as to minimise their importance (cost) through alternative governance modes or structures (Williamson, 2000) such as:

- spot markets,
- hierarchies or bureaucracies (i.e. vertically integrated private/public firms)
- hybrids (i.e. collaborative platforms between players)

New theoretical contributions have also identified emerging governance modes such as the bazaar, that came into view from the analysis of open-sourced software development (Demil and Lecocq, 2006), confirming the compatibility between transaction cost analysis, governance structures and technological change (Williamson, 1988). Hierarchies have also been revised in the light of the implications derived from electronic technology in how pertinent it is to integrate or de-integrate in such new technological contexts (Lajili and Mahoney, 2006).
The concept of a continuum of governance structures is, according to Williamson (1991: p. 271), analogous to von Clausewitz’s understanding of war as a continuation of policy by other means, by maintaining that “hierarchy is not merely a contractual act but it is also a contractual instrument, a continuation of market relations by other means”. Although this is the mainstream interpretation of the “hybrid” phenomenon, the existence of a continuum between firms and markets through hybrids is contested by Hodgson (2002) first, as developed in Sub-section 3.7.2 on page 97, on the grounds of a clear legal distinction of firms from markets and vice versa. More importantly, he defines them as completely distinct manifestations of “non-market contractual exchange” (Hodgson, 2002: p. 45). Although retaining Williamson’s continuum assumption in this analysis, such continuum should be expected to go beyond market relations. The practical implications of this are that, in the words of Ostrom (2005), we need to embrace “institutional diversity” reflecting the heterogeneity of transactions characteristics of nature-related goods and services. Such diversity is not directly apparent in the basic TCE but is present under the “hybrid” category, and very much so (Hagedorn 2008)\(^8\).

Please note that measurement of a transaction cost also affects the governance structure of the transaction. When measurements of a product quality are required several times throughout a processing chain between several independent firms, the cost of repeated and costly efforts may be alleviated by vertically integrating the whole process into one firm or hierarchy. Less serious problems can be solved through contracting and the development of warranties. Transactions undertaken under some sort of quality assurance scheme that reduce quality variability can also be fostered.

The more relevant attributes that differentiate governance structures or modes are i) the type of contractual relations they are governed by, ii) their incentive intensity, iii) control intensity, iv) autonomy of adaptation and v) degree of adapted coordination. The different attributes for each main governance structure are presented in Table 3.3 on the next page.

### 3.6.1 Spot markets

The spot market mode corresponds to the natural “market” of economics, although without its direct implication for efficiency. To operate, this platform only requires information which is communicated by the price of the good or service exchanged.

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\(^8\)Besides the direct commercial transactions, other transactions, not necessarily voluntary are involved when trading biomass. These can be related to the environmental economics concept of externalities (Beckmann, 2002). In order to be able to better answer the specific needs of nature-based transactions. (Hagedorn, Arzt, and Peters, 2002) have developed the framework of “Institutions of Sustainability” (IoS) to analyse costs associated with transactions involving environmental goods and services.
Table 3.3: Comparative attributes of governance structures

<table>
<thead>
<tr>
<th>Contractual framework</th>
<th>Spot market</th>
<th>Hierarchy or Vertical integration</th>
<th>Hybrid</th>
<th>Bazaar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classical (Short to very short term. Full independence of players, no special commitments)</td>
<td>Employment/Subordination</td>
<td>Neo-Classical (More long-term, incomplete but keeping independence between players)</td>
<td>Open Source</td>
</tr>
<tr>
<td>Incentives intensity</td>
<td>High</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Control intensity</td>
<td>Low</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Autonomy of adaptation</td>
<td>High</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>Degree of coordinated adaptation</td>
<td>Low</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

Source: Adapted from Williamson (1991) and Demil and Lecocq (2006)
Although it tends to be lead by short-term contracts, future activities can be easily be established ex-ante and any litigious issues can be resolved by public courts, as in the classical contractual framework. This is an autonomous situation for firms where coordination is decentralised and spontaneous (Williamson 1996). The high incentive intensity is the natural result of direct competition in the market.

3.6.2 Hierarchies

At the other end of the spectrum, we find hierarchy (Williamson, 1985). Coordination of activities follows a hierarchical structure based on the subordination of the different agents of production. The contract is therefore clearly of a subordinate / employment type. Integrating firms are faced with a trade-off because without the incentives of the market it is necessary to raise control intensity at a cost that needs to be internalised through bureaucracy. Hierarchy will be defined by various degrees of vertical integration of activities, depending on the specificity of the transaction they depend on when faced with bounded rationality and uncertainty. Adaptation of the production chain is not spontaneous, as in the spot market, but intentional without needing to renegotiate or depend on others’ decisions.

Building upon the insights of Hayek (1945) and Barnard, (1938), Williamson (1991) insists that the fundamental problem facing economic organisation is adaptation. The question is “properly posed not as markets or hierarchies, but rather as markets and hierarchies” (Williamson, 2002b: p. 175, emphasis in the original). It transpires that both spontaneous and coordinated adaptation mechanisms are properties needed for well functioning complex economies.

Moreover, as hinted at by Klien et al. (1978) and noted by Hennart (1993) and Ménard (2004), most organisations evolve in duality regarding their governance structure as they combine both the spontaneous and coordinated instruments. This is now part of the theoretical model in its own right.

3.6.3 Hybrids

Hybrids are an eclectic group of arrangements that border the two paradigm extremes of markets and hierarchies and extend from loose clusters to quasi-integrated partners (Ménard, 2004: p. 345). As a distinctive group of governance forms, hybrids can be defined as consisting of “agreements among legally autonomous entities doing business together, mutually adjusting with little help from the price system, and sharing or ex-
changing technologies, capital, products and services, but without unified ownership” (Ménard, 2004: p. 348).

Again, according to Ménard (2004), this hybrid option manifests itself in various archetypal forms with specific objectives, degrees and inherent trade-offs, in coherence with the TCE framework as follows:

1. subcontracting
2. network of firms, including supply-chain systems and distribution channels
3. franchising
4. collective trademarks
5. partnerships
6. cooperatives
7. alliances

In turn, Ménard (2004) identifies three main characteristics of the above set of organisation responses to the inability of markets to join the relevant resources and capabilities to ensure production (Teece and Pisano, 1994 in Ménard 2004). The identified patterns include i) pooling resources, ii) contracting activities, and iii) a degree of competition among partners.

Pooling resources is the most common feature, along with contracting activities, but always maintaining space for competition as partners keep their autonomy. Such autonomy translates as keeping the possibility of making unilateral decisions.
### Table 3.4: Comparative attributes of governance structures

<table>
<thead>
<tr>
<th></th>
<th>Spot market</th>
<th>Hierarchy or Vertical integration</th>
<th>Hybrid</th>
<th>Bazaar</th>
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</thead>
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<td>High</td>
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<td>Degree of coordinated adaptation</td>
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<td>Intermediate</td>
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</tr>
</tbody>
</table>

Source: Adapted from Williamson (1991) and Demil and Lecocq (2006)

Finally, the more recent proposal of the bazaar as a governance structure, although not directly relevant to this research, is presented for the sake of completeness and more importantly to stress the fact that emerging governance structures are developing and can be incorporated into the original framework. This is illustrated by the influence of technology and other external factors, that can be institutional of level L2 (Williamson, 2000) or others types (Williamson, 1991). Such external factors are expected to be additional influencing parameters in the choice of governance structures, along with the frequency of transactions, uncertainty and asset specificity.

**Relevant manifestation of hybrids**

**Contracts and incomplete contracts** Contracts offer a specific way of governing relationships and for some; they are not only at the heart of TCE despite the much publicised central make-or-buy paradigm, but also of economics as “economics comes closer to being a science of contract than a science of choice” (Buchanan, 1975: p. 229 in Gibbons, 2010).

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9This structure is based on the recently developed Open Source contractual framework, where all actors in the sector have access to the software codes, and can freely adapt them to their convenience, to create new products for profit or not. This governance structure does not allow for the source code to be appropriated but only used as a base for development.
Contracts can be seen as very comprehensive and include all agreements, however here we follow Macneil in restricting the concept to “legally bonding promises” (1974, p. 693 in Ménard 2004). Such promises have the additional characteristic of also being relational contracts, in contrast to transactional contracts which are only based on repeated business. The difference lies in that transactional contracts only govern the transfer of a good whereas, the relational ones frame long-term relationships (Brousseau 2008).

The fundamental characteristics of contracts are determined by whether they are complete or not. Saussier (2000) in Table 3.5 presents the basic characteristics that a complete procurement contract should possess. The general aspects were also adapted for woodfuel, hence the reference to a regional initiative to develop woodfuel supply contracts (RegenSW, 2008c).

Table 3.5: Characteristics of fuel contracts

<table>
<thead>
<tr>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum quantities that have to be purchased / sold</td>
</tr>
<tr>
<td>Minimum quantities that partner must provide</td>
</tr>
<tr>
<td>Standards of the fuel</td>
</tr>
<tr>
<td>Location / Origin of Source</td>
</tr>
<tr>
<td>Penalties in case of default</td>
</tr>
<tr>
<td>Penalties in case of default of partner</td>
</tr>
<tr>
<td>Price indexation mechanism</td>
</tr>
<tr>
<td>Terms of payments</td>
</tr>
<tr>
<td>Provisions for negotiations in the event of conflict</td>
</tr>
</tbody>
</table>

Source: Adapted from Saussier (2000) and RegenSW (2008c).

However, contracts evolve in a context that may or may not favour enforcement of such contracts. Moreover, enforcement is a costly process. As Williamson reminds us that “Most studies of exchange assume that efficacious rules of law regarding contract disputes are in place and that these are applied by the courts in an informed, sophisticated and low-cost way. These assumptions are convenient, in that lawyers and economists are relieved of the need to examine the variety of ways by which individual parties to exchange “contract out of or away” from the governance structures of the state by devising private orderings” 1983: p. 520, emphasis in the original).

Supply Chain Management (SCM) TCE has been categorised as more concerned with content than process (Douma and Schreuder, 1992) compared to other approaches to organisations such as Strategic Positioning Framework (Nickerson et al., 2001; Porter, 2000). However, as part of the NIE approach, it allows for the integration of a richer
background when identifying barriers to market development as a context to the study of governance modes shaping this market.

A supply chain can technically be defined as “a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” (Mentzer, 2001: p. 4).

Supply Chain Management (SCM) is different from a good practice in logistics management by integrating a strategic dimension of management into the efficient flux of material and information (Cooper et al., 1997; Lambert and Cooper, 2000). Or, more precisely, following the enquiry by Mentzer et al., SCM is the “systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole” (2001: p.18). However, as Lietke and Boslau (2007) remind us, this is an ideal and; real attempts to manage such platforms are only a partial reflection of such a definition.

Although SCM lacks an a priori theory (Cox, 1997 in Croom et al., 2000; Hobbs, 1996) it is widely represented in empirical studies. The question of its actual “general problem domain” (Croom et al., 2000: p. 67) is reflected in the debate on its definition (Cooper et al., 1997; Croom et al., 2000; Mentzer et al., 2001). Moreover, the questions and comments issued by Williamson (2008b) with respect to its behavioural assumptions; level and unit of analysis and actual predictive power support such views on its theoretical paucity to date.

Nevertheless, SCM can be usefully integrated in a study informed by TCE. SCM can be seen as one type of “hybrid” alternative to hierarchies and spot markets (Ellram, 1991; Ménard, 2004; Peterson, 2002; Williamson, 1991). This, along with a less coordinated version of Hybrids (Ménard, 2004), such as the work of Högnäs (2001) on a partnership for coordinating harvesting and transportation of material from state-managed forests in Finland. More specifically, Ellram (1991) proposes that SCM should be adopted as the most appropriate mode of governance for certain types of transactions, directly echoing the core testable hypothesis of TCE.

A more recent use of TCE to understand SCM variations by Lietke and Boslau (2007), identified a correlation between increasing degrees of asset specificity and higher integration into SCM, although with certain weaknesses in testing for causality as their sample was small and having some uncertainty as to how SCM was understood by interviewed firms. Finally, another level of analysis is highlighted by Christopher by asserting that “leading-edge companies have realized that the real competition is not company against
company, but rather supply chain against supply chain” (2005: p.18). Such emphasis at
the level of analysis of supply chain rather than at individual firms (and entrepreneurs)
is complementary in the case of nascent bio-energy markets. This understanding is
present, although implicitly in the vision that actors involved in such young markets
face high, and to a certain degree disloyal, competition from competing established
fossil-fuel alternatives currently dominating the market (Beck and Martinot, 2004) and
may favour cooperation before competition among themselves (Roos et al., 1999) to
stand a better chance to sustainably establish both their position in the energy market
in general and the boundaries of their bio-energy market. Such insights can also be
fruitfully integrated within a TCE framework as an economising mode of governance.
However, TCE would not favour cooperation as the best option per se but in relation
to other options.

3.6.4 Conclusion on governance

To conclude this section on organisation structure alternatives, it is illustrative to quote
the introduction by Brousseau and Glachant (2008: p. xliii) to their recently edited
“New Institutional Economics: A Guidebook” at some length: “Everything depends
on the fact that organizations and markets are at the same time both substitutes and
complements. First, the firm is sometimes an alternative mode of coordination that
enable the same activity as markets — that is enabling transactions among individual
agents providing/benefiting of services as proven by the divestiture of large firms and
permanent movement of mergers and acquisition. However it is sometimes an inherently
different mode of coordination, as proven by the need to separate certain collections of
resources (physical assets, financial means and knowledge) from markets in order to
generate new activities, build new capabilities, (e.g. the internalization of start-ups,
the movement of alliances, and these large innovations often linked to the emergence
of large firms). Second, hierarchical coordination is a way to avoid the drawbacks of
independent decision makers driven by their individual interests.”

3.7 Transaction costs in real time\textsuperscript{10}

The common analysis of transaction costs provides useful and powerful snapshots of
“possible institutional responses to a momentary situation [...] but they do not place
those responses in the context of the passage of time” (Langlois and Robertson, 1995: p.

\textsuperscript{10}Following the title used by Robert N. Langlois (1992). Transaction-cost economics in real time.
Ind Corp Change, 1(1), 99-127.
They do not account for rapid changes either of technology or more general business environment. As such this static dimension of the analysis weakens the explanatory power of asset specificity when innovation and rapid changes are introduced. This was acknowledged by Williamson in that “the introduction of innovation plainly complicates the earlier-described assignment of transactions to markets or hierarchies based entirely on an examination of their asset specificity qualities. Indeed, the study of economic organization in a regime of rapid innovation poses much more difficult issues than those addressed here” (1985: p.143). Responding to this critique, Williamson (1999) rejected the static nature of TCE by highlighting the intertemporal dimension of the approach mainly focusing on the so-called Fundamental Transformation\(^{11}\) that takes place when the market goes from a large pool of qualified bidders to a small number supply relation through contract. Although on the onset, there was a competitive market, contracting creates, in the case of high asset specificity, “intertemporal contractual complications” (Williamson, 1999: p. 1101). Also, as highlighted in Section 3.6 on page 85, new governance types can be integrated within the framework following technological change and innovation (e.g. the bazaar, derived from the open source software development arrangements). Despite these clarifications, the issue of a lack of dynamism does remain relevant. Important questions about which transactions and what modes of organising them “are most favourable to the development of capabilities and to the dynamics of innovation” remain open (Ménard, 2001: p. 86). Moreover, Ménard does not hesitate to be self-critical by concluding that “innovation is a black hole that neo-institutionalists share with other economists and other social scientists, and one that they have tended to underestimate” (Ménard, 2001: p. 86).

In an attempt to contribute to the integration of change in the analysis, beyond characterising TCE as static, Langlois (1992) takes the view that transaction cost analysis is anchored in the short-run. Please note that this run is an economic one rather than a calendar one and the long-run may be achieved in a few weeks in certain sectors but centuries in others. In this sense, he insists that as the long-run is reached, transaction costs lose their importance and diminish with learning. This is valid for both strands of transaction costs, namely the “measurement” and the “asset-specificity” or Williamsonian one, including incomplete contracts theory. With time, “contracting parties gain information about one another’s behaviour” and “parties will develop or hit upon arrangements that mitigate the sources of transaction costs” (1992: p. 104). Two aspects are expected to change with an increasingly stable environment. Reputation effects will make contracts self-enforcing and hold-up or moral-hazard issues are expected to be “attenuated by the effects of the evolution of norms of reciprocity and cooperation” (1992:

\(^{11}\)See Section 3.6.
p. 104). This perspective could imply that in the long-run there is full dis-integration, but this is not necessarily the case. If transaction costs in the short-run had pushed for vertical integration, the learning process would have developed within a hierarchical context with potential consequences for future learning because of “lock-in” effects\(^\text{12}\). Lock-in is an important phenomenon raised by the innovation literature. The crux is that specific technological systems "exhibit increasing returns, similar types of increasing returns accrue to the framing of institutional structures" (ICEPT and E4Tech, 2003. p: 12). Please note that in his response, Williamson (1999) does acknowledge the need to highlight the importance of learning processes, including its biases and sees it as a clear research opportunity. This in turn could be interpreted as an implicit acknowledgment of the need of more dynamics to the framework after having rejected the claim made by Langlois (1992).

Connecting the well developed short-run perspective offered by TCE to the long-run, requires the introduction of organisational learning which is central to the complementary, though sometimes competing, view of the firm and its boundaries embodied by RBV. TCE and RBV differences lie mainly around the definition of 1) what is a firm and 2) what is their unit of analysis: the firm itself as an entity or transactions.

The question of what is a firm requires a comprehensive theory of the firm capable of answering three questions (Garroute and Saussier, 2005). The first delineates the nature and boundaries of the firm by defining why some transactions need to be fully or partially internalised, or exclusively left to the market. The second focuses on internal characteristics such as the organisation of production, incentives and the structure hierarchy, although not of traditional interest to economics (Garroute and Saussier, 2005). Finally, the relationship between firms and markets requires analysis to identify the extent of their mutual substitutability. Since Coase’s contribution with The Nature of the Firm (1937), several theories have developed. The main dimensions mentioned above have been partially tackled but with high degrees of competitiveness between the models forwarded; even if hypothetically joined together, they could sketch a solid definition of what a firm is, as shown in the reviews of Garroute and Saussier (2005) and Gibbons (2005). However and despite the interest and energy devoted, particularly since the 1970s, the question of what is a firm “remains an empirical as well as a theoretical challenge” (Garroute and Saussier, 2005: p.178). In his co-edited Handbook on New Institutional Economics, Ménard joins the choir by asserting that “we still miss an integrated theory” (2005: p.281).

We can identify two broad families partially answering the three main dimensions pre-

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\(^{12}\)Concept famously illustrated by the permanence of the QWERTY keyboard system, despite not having kept any function in electronic keyboards. (David. 1985 in Langlois. 1992).
viously introduced namely the i) Contractual with TCE, and the ii) Competence or Resource-based approaches. On the one hand, the first gathers analyses that are clearly focusing on the exchange and transactional dimension of firms. On the other hand, the second category is more grounded on the issues of production, internal structures, routines, knowledge.

### 3.7.1 The “contractual” or TCE perspective

Three main approaches form the contractual perspective. First there was TCE that focuses on the diversity and nature of governance modes and the trade-offs between them. Then, there is Property right theory that focuses “on ownership and the related allocation of decision rights as a determinant for understanding relation-specific investments” (Ménard, 2005: p. 281). Finally, there is Agency theory which focuses on incentives issues in the principal-agent problem.

Coase’s initial understanding of the nature of the firm, later developed upon by Williamson, distinguishes it from the market as a hierarchy of one agent over another, basically defined through a labour contract. The firm is defined as the entrepreneur’s authority to coordinate the action of their employees. Moreover, firms replace “contracts for products with employment contracts, effectively substituting a factor market for a product market” (Langlois, 2007: p. 1109). This is the core contractual foundation of the firm. However, Coase (1937) does not specify why the firm is about command in opposition to market’s spontaneous coordination (Khalil, 1996; Pitelis, 1998). The implications of this aspect are heavily debated (Ménard, 2005) such as the degree and nature of control as the result of a symmetric contract (i.e. TCE crowd) or of predatory nature (Pitelis, 1996). Accordingly, the degree of cooperation between employers and employees is analysed through, among others, the approach of Agency Theory. Such a firm can be qualified as the “capitalist firm” and critics of this narrow definition such as Hodgson (2002) and Pitelis (1996), assert that other types such as “partnerships without employees, workers cooperatives or enterprises with slaves” could also be defined as firms (Hodgson, 2002: p. 53).

According to the original definition, self-employed entrepreneurs working alone would not necessarily be regarded as firms as they would be agents operating in spot markets. Nevertheless, the expanded framework developed by TCE is more comprehensive as it includes hybrids where agents would enter specific relationships (i.e. “firms” with self-employed agents or self-employed agents among themselves with a myriad of combinations).

The firm is also negatively defined as what it is not: it is not the market (Khalil,
1996). To support the definition of the firm it is important to briefly define the concept of “market” as it has two complementary meanings that can be confusing. One use, labelled as “spot market”, refers to a specific way or mode of conducting exchange, as opposed to an exchange organised within a firm (Ménard, 2005: p. 282). The second but more common use will describe the institution that embraces all modes of organisations engaged in production, exchange and consumption of a market economy. Additionally, we can include the concept of the market as the aggregated demand for a specific product or service.

Coase’s insight covers the first dimension of what is a firm by introducing the concept of transaction costs as an explanation of why the black box exists. However, as widely acknowledged (Khalil, 1996; Pitelis, 2007), the arguments put forward do not provide a theory of the firm that answers the second issue, which is the internal attributes and structure of the firm. The fundamental reason is that the focus on the exchange and transactional dimension of firms limits insights into internal appraisals, particularly regarding production. However, theories of the firm related to TCE do not ignore production by starting with transactions (and the market). Here the focus lies on the problem of the boundaries of the firm as understood by the degree and direction of diversification (i.e. vertical and horizontal) (Foss, 1996; Khalil, 1996). The size of the firm is defined by the relation between costs of internal administration and transaction costs associated when relying on markets. This trade-off delineates the boundaries of firms. In that sense, the approach is a tool to “assess the comparative efficacy of alternative economic and organizational instruments” (Williamson, 1990: p. 3). If the interest lies on price or effective factor ratio the conventional production function approach is more suitable.

3.7.2 The “competence based” / “evolutionary approach” views

In parallel to the “contractual” approach we found the RBV which is grounded on the internal specificities of the firm and focuses on the problems of production. This approach could be summarised, following (Ménard, 2005), as efforts to understand how organisations develop internal characteristics to deal with the external environment. Also, the approach defines the role of firms as “repositories of productive knowledge” (Foss, 1996: p. 8).

As in the case of the “contractual” approach, several currents feed this family but with less cohesion as the origins are more varied with no single founding father such as Ronald Coase. However, two origins can be identified in the seminal works of Edith Penrose’s The Theory of the Growth of the Firm (1959) and Joseph Shumpeter’s The Theory
of Economic Development (1934). More recent formative works can be traced back to Richard Nelson and Sidney Winter’s An Evolutionary Theory of Economic Change (1982) that explicitly formulates the process of firm development as an evolutionary one. For rich details on the origins of this approach, please refer to Foss (1996) and Pitelis (2007).

According to RBV, a firm’s resources can be tangible or intangible and their combination will define their competitiveness in a business environment. The tangible resources are related to geographical location, raw material access, availability of a trained workforce, characteristics of productive plant and machinery, and financial capital. With respect to the intangibles, firms are seen as “repositories of productive knowledge”. These include human capabilities and know-how, organisational capital and routines, technological assets and designs and "relational capital" based on reputation and certifications. This versatility in adapting skills in new activities follows Teece as "externally, these competencies may be perceived as a firm’s skill in a particular product area. However, a competence is the ability of a firm to solve organisational technical problems, and thus it is not limited to a specific set of products" (2008: p. 58).

A basic difference with TCE is that it is the competences of an organisation that are expected to shape their boundaries and not only transaction cost implications as illustrated in the empirical work of Argyres (1996) or the comparative literature reviews of Carter (2001) and Langlois (2006) between TCE and alternative interpretations. In that sense and conversely to TCE, the basic unit of analysis is the firm and not the transaction. However, smaller analytical units can be the “routines” and more recently “modules”, overlapping but not necessarily the same as transactions (Langlois, 2006).

Hodgson (2002) insists that the profusion of analyses and thereby confusion is the product of the modern theories having neglected or explicitly abandoned the legal dimension of the firm in their respective analyses. Although the Neo-classics clearly distinguished the market, where demand and supply meet, from the “firm”, they opened the way to confusion by disconnecting the legal entity from the functional locus of production with the concept of the production function (Hodgson, 2002). Such a dimension is also important when talking about the market as it contains “legal and other rules and structures that pattern [...] exchange negotiations and transactions” (Hodgson, 2002: p. 44). He indicates that such blurring has deepened when introducing the concept of a continuum between firm and markets in the Williamsonian tradition. This is also the case with alternative propositions of Marxian inspiration in line with Pitelis (1996) that focus on the existence of pervasive “extra-legal notion of power” (Hodgson, 2002: p. 51) and, therefore, ignore legal and contractual realities. Nevertheless Hodgson’s critique, the need to establish the legal reality of firms is explicit with the introduction of the
concept of “hybrid structures” in the TCE framework where the legal aspect is unavoidable for their analysis\textsuperscript{13}. This is the case for the well-established and acknowledged definition of Ménard (2004), presented in subsection 3.6.3, dedicated to this pivotal set of governance structures. For these cases, Ménard (2004) clearly stipulates that firms interact as legally autonomous entities.

3.8 The main refutable propositions empirically testable of TCE

3.8.1 The discriminating alignment hypothesis

Following the exposition of the main dimension of transaction costs (i.e. asset specificity, uncertainty, and the frequency of transactions), the implications of their combination for governance structures are the testable proposition of TCE theory.

David and Han (2004: p. 41-42) used a strict definition of the propositions in their review of the empirical testing for the main tenets of TCE, mentioned below. As a guiding reference such a set of hypothesis is reproduced at some length:

- “As asset specificity increases, the transaction costs associated with market governance increase.
- As asset specificity increases, hybrids and hierarchies become preferred over markets; at high levels of asset specificity, hierarchy becomes the preferred governance form.
- When asset specificity is present to a nontrivial degree, uncertainty raises the transaction costs associated with market governance.
- When asset specificity is present to a nontrivial degree, increasing uncertainty renders markets preferable to hybrids, and hierarchies preferable to both hybrids and markets.
- When both asset specificity and uncertainty are high, hierarchy is the most cost-effective governance mode.”

In turn, governance modes that are aligned with transaction characteristics should display performance advantages over other modes; for example, when both asset specificity and uncertainty are high, hierarchy should display performance advantages over markets and hybrids

\textsuperscript{13}Partially acknowledged by himself (Hodgson, 2002: p. 50).
Figure 3.2: Simple contractual diagram: The Discriminating Alignment Hypothesis

The schema of Figure 3.2 represents the possible alignments of governance according to the dimensions of the transaction where $k$ represents the degree of asset specificity and $s$ the level of safeguards. The schema summarises the Discriminating Alignment Hypothesis which develop as “transactions, which differ in their attributes, are aligned with governance structures, which differ in their adaptive strengths and weaknesses, so as to accomplish a transaction cost economizing result” (Williamson, 2008b: p. 9). When $k$ rises, more of $s$ is sought after, up to reaching an acceptable solution. As spot markets do not provide much safeguards for transaction specific assets, the prediction postulated by David and Han (2004: p. 41) above as: “As asset specificity increases, hybrids and hierarchies become preferred over markets; at high levels of asset specificity, hierarchy becomes the preferred governance form” is expected to follow the path of the simple contractual schema of Figure 3.2. The same applies for the other postulates relating asset specificity and governance modes.

Source: Reproduced from Williamson (2007: p. 22)
3.8.2 Empirical evidence and support to theoretical expectations of TCE

An increasingly large body of empirical literature has develop since the operationalisation of Coase’s original ideas by Williamson (1975; 1985). Some do not hesitate to define TCE as an empirical “success story” (Whinston 2001: p.185) following literature surveys that corroborate TCE (Shelanski and Klein 1995). Additional all-encompassing surveys have also reported general support for the theory (Boerner and Macher, 2001; Macher and Richman, 2008). Such developments have invited Williamson (2000; 2002) to also state that it has been a success.

However, more targeted and selective reviews of empirical literature focusing on the central tenets of the theory have put forward more mixed results\(^\text{14}\) (Carter, 2001; 2006; David and Han, 2004). They concluded that the main efforts concentrated on testing asset specificity with good results and, to some extent, tested uncertainty. Far less effort has been invested in testing frequency and performance (David and Han, 2004). More generally, in the absence of direct measures of transaction costs, “even where the results from the studies are consistent with the predictions of TCE, it would not demonstrate that the outcomes are necessarily associated with transaction cost minimizing behaviors. The identified correlations could actually be consistent with an alternative theoretical explanation” (Carter and Hodgson, 2006: p. 474). A reading of this lack of coherence could be traced to problems of construct validity\(^\text{15}\) in the classical TCE applied literature when operationalising key transaction cost predictions, as suggested by Mayer (2009).

The main competitor would be embodied by the RBV understood as an ensemble of efforts that define the firm, its boundaries and organisation structure as the result of their competence, resources and assets, be they physical, informational or human (Teece et al., 1997).

Although these well documented critiques do not provide the final word on TCE and invite the research community to develop additional research agendas, their conclusions point to the need to consider alternative explanations of organisations structure. This has to be accounted for, as it has fundamental implications for the normative dimensions derived from the analysis of constraints of exchange and the potential of each firm. However, the approach followed here is to understand both the RBV and TCE as complementary when suggested so by evidence and as advanced by Silverman (1999 in Rao, 2003).

\(^{14}\text{Only 47\% of the 63 peer-reviewed papers specifically testing TCE selected by David and Han (2004) were supportive of the theory in general.}\)

\(^{15}\text{Please refer to Section 5.2.3.}\)
3.9 Summary

The aim of this chapter was to present an overview of the New Institutional Economics approaches along with historical origins and limitations. Although strongly anchored on TCE tradition, the analysis also draws from complementary, although sometimes competing, theories of industrial organisation such as the Resource-Based View (RBV).

Starting with the seminal article by Coase (1937) asking the question of why firms come to be, the Chapter located the analysis within the broader economics of institutions focusing on “the governance of contractual relations” (Williamson, 2000: p. 599). This level of analysis lies between the higher order institutions (i.e. customs and the formal rules, including property rights) and day to day decision making related to production functions. The analysis is centred on the transactions and their characteristics in order to identify to which extent such characteristics influence the way the studied transactions are to be governed. The characteristics of the transaction may generate transaction costs. In a nutshell, these costs can be related to information problems, bargaining difficulties, nature of goods and services traded which are associated with asset specificity and costs of renegotiation. Asset specificity can take different forms and is important as it induces what Williamson (1985) calls the “Fundamental Transformation”. This process refers to the transformation of a market from a large pool of qualified bidders to a small number of supply relations by contract. This is significant if such a contract is related to non-trivial investments in transaction specific assets. In the framework of the assumed conditions of bounded rationality and opportunism it creates relationships that face contractual hazard that are managed through governance options.

There are several options to govern this level of relations and possible transaction costs. Governing complex transactions is realised through transaction cost economising. Spot markets can be enough in many cases but, as said, certain transactions have complexities that make this solution unsatisfactory, requiring the establishment of more stable platforms such as contracts and partnerships of some sort. Sometimes, the only functional transaction is done internally, under a hierarchical system such as a firm or administration which is better positioned to economise (i.e. control for) transaction costs. If such costs are unaccounted for, the theory predicts difficulties in trading and, in some cases, even grinding it to a halt. As the TCE framework is a base for the analysis and interpretation of the project, ensuing chapters first review the existing TCE and related approaches’ empirical applications to the relevant forestry and bioenergy sectors. This provides the foundations to identify relevant transaction costs and their empirical relations to existing governance of woodfuel markets, particularly for heat.
Chapter 4

Implication of an institutional approach the woodfuel supply chain

4.1 Introduction

The acknowledgment of friction in exchange whether it regards labour, stocks or woodfuel is fundamental in how we appreciate the development of a market. For the different levels of the woodfuel supply chain, such development is linked to the establishment of the boundaries of the firms and actors involved. However, some have raised their concern when using the TCE paradigm in nascent markets (Santos and Eisenhardt, 2006) on the grounds that this basic framework assumes that suppliers are known and the transaction structure is pre-determined in the industry. Despite such limitations when dealing with new products and markets, TCE is appropriate given the nature of the lack of maturity of the woodfuel market differs from the lack of precedence implied for the new technologies they base their analysis on. Although nascent, the woodfuel market is not without precedent and has some references in the more developed markets in continental Europe and other bioenergy pioneering countries. The extended framework designed by Langlois (1992) and discussed as Transaction Costs in real time, accommodates emerging sectors in transaction cost analysis.

The analysis of emerging markets, such as the woodfuel sector directly benefit from dynamic insights. Following Langlois’ (1992) framework in his case study of the development of biomass district heating development in Sweden, Bohlin understands that the transaction in TCE is “by its attributes merely a definer; the actual cost carrier is accrued through the governance form (or lack of it). It may be constructed that, for emerging markets, the transaction attributes evolve dynamically over time via learning and repeated interactions between buyers and seller and users” (2001: p. 5).
The first step to identify the (possible) implications of an institutional perspective requires establishing the type of transactions involved across the woodfuel supply chain. To do so, we illustrate the analysis with transactions throughout the woodfuel supply. This approach also presents opportunities not visible under other frameworks, particularly with respect to forward integration of fuel suppliers into heat production. Then, the following section identifies transaction costs expected from such transactions before characterising the governance options. To develop such central features that eventually are formulated into hypotheses and, in addition to the existing general empirical literature (Boerner and Macher, 2001; Carter and Hodgson, 2006; David and Han, 2004), earlier studies relevant to bio-energy are highlighted as starting points to this thesis. Given the focus of this project, two sectors are under scrutiny, namely forestry and bioenergy. Finally, and before engaging with the methodological Chapter 5, the final section of this chapter develops the main hypotheses guiding the thesis.

4.2 Forestry

There are a few classical cases of transaction cost analysis related to forestry, namely Globerman and Schwindt (1986) on Canadian forestry and paper industries and Leffler and Rucker (1991) along with a related study by Leffler et al. (2000) on the choice of timber-harvesting contracts. We will present them in the light of more recent research as they will provide both methodological clues and interpretation avenues for the woodfuel sector.

Globerman and Schwindt (1986) focused on the organisation of the Canadian forestry and paper industries without measuring costs themselves but using, in their terms a “more pragmatic inductive approach” (1986: p. 201). Given the transaction characteristics identified along the timber supply chain, they compared their evidence to the prediction of classical TCE to identify anomalies. Only one of the major forest product companies was not vertically integrated into controlling harvesting rights. They explained this by the fact that sawmills were highly dedicated assets and potentially targeted by post-contractual opportunism. They also applied the same approach to newsprint producers and reckoned that virtually all were integrated into pulp production. A strong ownership link from newspaper firms to newsprint producers was also identified, but on asymmetrical terms where newspaper firms were more vulnerable to opportunism from paper producers than vice-versa. When looking at more recent accounts, the highly integrated structure of this industry and particularly the pulp industry is documented worldwide because of site-specificity (i.e. remote and with poor infrastructure areas) and the risk-sharing explanations about business cycles associ-
ated with large sunk investments (Jantunen et al., 2009). A historical study of the US pulp industry ranging from the mid 19th to the mid 20th centuries also pointed at the integrated feature of this sector throughout time (Ohanian, 1994). However, given increased competition and recurrent overcapacity problems, the structure is now changing towards a more vertically disintegrated form (Siitonen, 2003 in Jantunen et al., 2009). The organisational drivers identified depended on what was understood as “core” activities and some of their dynamics have been captured by extended versions of TCE incorporating dynamic transaction costs and RVB in the spirit of Langlois (1992) and Jacobides and Winter (2005). As such, classical TCE is more relevant to core activities than to supporting ones in influencing governance options. Looking back at the basic theory, these observations reinforce TCE, as only significant transaction costs are expected to influence governance structures.

Leffer and Rucker (1991) used the measurement branch of TCE (Barzel, 1982) as their base to interpret the choice of timber-harvesting contracts and characteristics. Comparing their approach to the more traditional risk-sharing view, they identified that measurement costs in the form of search, information and monitoring costs were more significant than risk-sharing in explaining the choice of contract by woodland owners in the State of North Carolina, USA. Private woodland owners are understood to face two decision moments with respect to harvesting. The first is to decide whether to employ harvesting companies to harvest and then sell the material to sawmills; or to sell rights to harvesting companies or sawmills directly. Although both options have their respective transaction costs, given the internal incentives associated with labour hiring, the minimizing option favoured by Leffer and Rucker is to sell rights to contractors instead of carrying out the operation through employment. The second step defines the way the first arrangement is ordered either through per unit sales or lump-sum. Lump-sum options do not require monitoring but are associated with higher measurement by the seller to provide more information to the buyer. Per unit sales were identified to be more probable when i) presale measurement costs were higher because of uneven terrain or quality, when there is paucity in the information given by the seller, and ii) when monitoring costs are cheap for the seller. With a different data set but in the same vein, Leffer et al. (2000) undertook a thorough analysis of how, at an auction, presale measurement by the buyer to assess quality of timber and harvesting conditions can significantly affect the way the sale is conducted by the seller. Under the conditions identified in Leffer and Rucker (1991), per unit sales remain the preferred option for the buyer as it would lower uncertainty and reduce incentives to engage in costly presale inspection.
4.3 Bioenergy

We can also highlight a few studies of biomass energy with attention to governance, dynamics of transaction and organisational costs.

Liquid fuels, such as ethanol and biodiesel, have been studied, particularly ethanol in Brazil. Although exploratory, the thesis of Rosenthal (2006) was able to show a positive relationship between vertical integration of five major ethanol companies\(^1\) and their performance. Although not definitive, mainly because the indicators of performance chosen did not include direct cost information, the exercise offered clues about this sector’s success when operating with integrated firms.

It is important to note that this study describes a mature industry that has been developing under the auspices of fuel import-substitution policies launched in the 1970s by the Brazilian state. Conversely, Western Europe and the USA have been the subject of a few studies accounting for their more nascent bioenergy sector (e.g. Altman et al., 2007; Ferchichi and Sauvée, 2010).

Altman et al., (2007) studied the US biopower industry focusing on the effect of scale on the choice of organisational form. This sector does not rely on agro-energy crops but rather on forestry, wood and food waste. Several variables such as physical asset specificity, spatial asset specificity and scale of generation were regressed in a multinomial logit model against the choice of organisational form. There are three general organisational alternatives: i) vertically integrated systems that typically involve the biomass producer integrating forward into biopower production and in more rare cases power producers integrating backward into biomass production; ii) external procurement which involves independent power producers purchasing biomass as fuel for their generation needs from independent biomass producers (i.e. spot markets, formal contracts or informal contracts); and iii) arrangements involving both internal and external procurements when firms use in-house sources but also purchases some fuel externally. This provides an historical account that non-utility biopower producers which have integrated forward into generation, have not integrated into transmission and distribution. Conversely, traditional utilities using wood have not tended to integrate backward into woodfuel production. Although early accounts of the sector structure have highlighted\(^2\) its dependence on spot markets for bioenergy feedstock (Overend, 1993), Altman et al. (2007) found that about half of their sample\(^3\) were vertically integrated, 20% used some

\(^1\)Representing 60% of all ethanol exports and 44% of the domestic market.

\(^2\)Or rather lamented by Overend (1993), although this was not clearly identified by Altman et al. (2007) and Ferchichi and Sauvée (2010). We could speculate that the 1993 world of Overend was only functioning on very limited governance structures that later diversified with long-term contracts and vertical integration.

\(^3\)The sample was 53 operating plants, out of 210 registered of which not all were operational at the
kind of contract and 5% relied solely on spot markets. The remaining 25% both procured externally and internally to make up for a growth not matched by their own resources. While the authors did not say whether such arrangements were developed through contracts or spot markets, it means that almost 75% have some degree of vertical coordination if not outright integration. To assess asset specificity, they used a proxy regarding the flexibility of plants in the type of fuel provided without incurring large costs (i.e. how easy would it be for them to take in the more readily available fossil fuels instead). External and bi-sourcing were found to be related to larger scale and higher haulage distances and such association was statistically significant. Only a probable influence was detected from their degree in fuel flexibility but was not statistically significant. When Altman and Johnson (2008, 2009) completed the picture they identified a positive association between internal procurement and less flexibility. A final characteristic of this sector is that the share of biomass feedstock used by plants was directly related to their degree of vertical coordination. The more dependent on biomass, the more likely the plant is to be vertically coordinated if not integrated into feedstock supply. This aspect resonates with the idea that “core” activities are more likely to be vertically coordinated than marginal ones (Jantunen et al., 2009). This provides a template for future biomass-based development such as cellulosic ethanol which should expect a high degree of integration during its development. Based on their evidence, Altman and Johnson invite future investors hoping to rely on spot markets for their biomass to “consider alternative external procurement methods such as short term and long term contracting [...] along with vertical integration through strategic alliances and joint ownership” (2009: p. 784). A similar study by Ferchichi and Sauvée (2010), following the template set by Altman et al. (2007), assessed vertical coordination in the nascent bioethanol sector in the EU. In this case, vertical integration is nonexistent so there are only two organisational alternatives, either hybrids and contracts or spot markets. 85% of the 41 plants studied relied on contracts, the remainder only used spot markets. Interestingly, the spot market-based plants only operated in Spain and Germany. Ferchichi and Sauvée (2010) explored the relevance of fuel flexibility, haulage distance and frequency of transaction to establish the determinants of the organisational structure of this new sector. When testing the likelihood of spot market procurement with both probit and logit models, large scale operations were found to be significant in favouring spot procurement. The same effect was found from the degree of flexibility of processing plants. The plants able to take in a variety crops were more likely to use spot markets, as compared to those only relying on sugar beet. Haulage distance may have some influence but was not statistically significant in their model.

\footnote{time of the survey.}

\footnote{Although in cases supply was also increased through external procurement.}
In parallel, we can contrast another study developed to explain the structuring of the nascent biofuel industry in nine of the EU-15 by Wubben and Karamichas (2009) which looked at the architecture of the sector and its evolution. This more ambitious, although only exploratory, undertaking identified the main aspect of the biofuel industry as being “converged industry that rises from the linking up of the Agricultural industry (AI, upstream) and the Petrochemical industry (PI, downstream)” (Wubben and Karamichas, 2009: p. 5). They based their analysis on the Institutional Structure of Production framework advocated by Jacobides and Winter which “provides a theoretical framework that explains how capabilities co-evolve with transaction costs to set the menu of available choices that firms face in an industry” (2005: p. 396). Based on documents and 19 interviews, they conclude that the sector started with both sides (PI and AI) as highly specialised but these developed into a bioethanol integrated sector, particularly as they developed second generation biofuels where asset specificity seems more present.

More dynamically, Choinière (2004) formally showed that underinvestment in the US agro-biopower industry was pervasive on both sides of the chain (producers and users). Such sectors are connected by limited-liability contracts in the context of dedicated assets, site specificity and uncertainty, all of which create hazards and significantly reduce the incentives to invest. This seems particularly the case when influencing investment in learning by doing by the growers of the energy crops, leading to higher than expected production costs, less interest in the crop and ultimately underinvestment. The formal model shows that organisation and contract forms are fundamental incentives for this sector’s development, recommending explicit government support of vertically coordinated if not integrated structures. This conclusion was also reached by McCormick and Käberger (2007) through their selected case studies of successful bioenergy developments when systematising the experience of the CHP plant in the pioneering town of Enköping, Sweden. As woodfuel was deemed too unpredictable because of wide price fluctuations, energy crops were considered and developed by the company managing the CHP plant. However, the conditions expected from farmers to plant salix spp. (willow family) were not successfully developed through contract, so the energy companies resorted to renting land and running the fuel production operations themselves. Although not done so by McCormick and Käberger (2007), this case could be formulated as economising on transaction costs through vertical integration but also requires the approach of the extended model as dynamic transaction costs. Paraphrasing and adapting Langlois (1992) for this case, the CHP plant is internalising fuel production because the complementary capabilities that this stage represents are not offered by the market (i.e. farmers) or are still too expensive.

Woodfuel for heat in Sweden was analysed by Böhlin (2001) through an extended TCE
approach with dynamic capabilities in the spirit of Langlois (1992). Through an historical approach, three district heating companies that switched to wood and one that did not were studied to capture the institutional dimensions of change. Two levels of analysis were undertaken, one at the level of policy and regulation and the other at firm level. Bohlin’s approach can be associated with the levels of institutions mapped out by Williamson (2000) as L2 and L3 respectively presented in Chapter 3. Translating it, and given the L2 conditions, the switch to wood was for the majority a two stage process that followed policy and subsidies to first reduce dependence from oil, favouring other fuels such as coal and peat. At the time and until 1993 there were legal limits to woodfuel use. Subsidies were initially focused on district heating providers tied to a particular fuel for a certain period of time but there was no consistency in the length of such contracts. Later initiatives fostering woodfuel use (1991-96) were more precise requiring 85% of wood feedstock over five years. However, stability of the environment proved elusive with the liberalisation of the electricity sector, which led to unexpected diminished returns for CHP investments. On the measurement side, the state has been more systematic and crucial in providing specification standards as well as reliable price statistics to protect against opportunism and reduce uncertainty. Changes in public policy and regulation meant that individual companies’ development depended on when they switched to wood. At the L3 level of firms, we find the development of “common interest organisations to disseminate knowledge and further the common cause” (Bohlin, 2001: p.19) and the choice of vertical scope of each company. From the evidence provided, both TCE and capability arguments shape the governance of the sector through time. All wood-using heat companies developed some vertical scope through backward integration into fuel production. Some secured full woodfuel processing chains. Looking back at the conditions in the early days of development and assessing the strategies followed at the time, the company managers concluded that such early strategies would be too expensive if implemented in the current market because the feedstock market is reliable now. The initial change to solid fuel provided valuable experience before going for wood, although all faced technical problems mainly related to feeding, ash melting and auto-combustion in storage when switching to biomass. Bohlin clearly asserts that TCE is a useful tool in identifying the initial obstacles to trade and development of this market. However, the reduction of transaction costs was more linked to a “general institutional development”, not only at the firm level. Uncertainty and asset specificity problems were changed by public action, firm-level initiatives and collaboration within the sector. Although the signal of public support was unstable and at times contradictory, it did provide standards and reliable statistics. Firms looked for new solutions, built knowledge, and developed new ways of interacting

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5From the year 2000 onwards.
with suppliers which is related to RBV. In turn, association in the sector provided the platform to share experiences, develop and frequently update important tools such as standard contracts for fuel trade.

As seen, there have been few attempts to analyse woodfuel for heat with TCE although other bioenergy sectors have attracted a bit more attention, particularly bioethanol and wood for electricity generation. This is probably due to the greater interest in liquid fuels and power generation in general but also because they can be more easily captured with the basic TCE framework. However, a more active stream of literature has developed around the idea of business models based on mature wood energy markets for heat. This wood for heat literature documents a variety of organisations and arrangements following “business models” (Alankangas, 2003; Kokkonen, 2005; Okkonen and Suhonen, 2010). Some cover the entire supply chain and others only segments of it. The models are identified according to the size of the venture with some options successfully developed for small-scale ventures and others to larger volume settings. Ownership considerations are also used as a classifying factor. Although such categories provide indications to specific actors they do not provide a systematic overview of how the supply chain is coordinated. These works provide a spectrum of governance options that enrich the TCE and related works.

4.4 From business model to governance

Theoretically, the concept of a business model is still much debated and tends to “focus on taxonomic issues” (Rasmussen, 2007: p. 3) and as such can be limited to a list of characteristics. However, it is generally understood as an architecture (Amit and Zott, 2000 in Okkonen and Suhonen, 2010) or “a construct that mediates the value creation process” between the technical and economic domains by selecting “technologies and packaging into particular configurations” (Chesbrough and Rosenbloom, 2002: p. 553).

A fundamental part is that such architecture is accompanied by a formulation of the earning logic of the process. It is relevant to stress that the concept was originally developed for new or emerging activities where almost no precedent on actual performance was documented and therefore not readily available to investors (Rasmussen, 2007).

However, looking at governance also answers more directly the question of what happens between each business model, even if they account for their external relations, other actors and the business environment in general. To offer a clearer picture of their characteristics and how they respond to exchange hazards and to various transaction costs we analyse (i.e. translate) from the different “business models” and “supply models” to identify their respective implications in terms of an extended TCE framework.
Three main families of models can be identified for wood energy supply, namely i) a fully integrated organisation, ii) the “network model” and iii) “heat entrepreneurship”. The first possibility encompasses a fully integrated or hierarchic model of self harvesting, processing and energy conversion developed by certain actors. This can describe several scales from a simple household with woodland, a farm or estate. It can also be applicable for processing industries that use wood to fuel heating processes from owned woodland, a common practice in wood processing industries that require drying material.

The “Network model” is based around a diversified processor and broker that, through agreements, manages its relationship upstream (i.e. producers of wood by-products and harvesting contractors) and downstream to the user, be it a public authority, industry or domestic. Its main objective is to sell large quantities of standardised material (Kokkonen, 2005). This matches the definition of a broker that takes title and manages inventories being what Van Vactor calls a marketer (2004)\(^6\). As such, marketers reduced transaction costs. This is expected to satisfy the demand for immediacy from a reliable and credible supply chain. As such, “the main objective of the networking is to be able to adapt to the ever-changing circumstances (and the partners) operate in close cooperation” (Kokkonen, 2005: p. 3). Although some of the different options and degree of coordination possible are mentioned in this definition, there is no specific study of the transactions that require more conscious coordination. Sub-contracts and integrated activities are mentioned but not as answers to specific requirements of wood energy supply. This supply model is what Alakangas (2003) defines as the “conventional wood heating” model. Whether the supplier sells wood energy by the volume or by its estimated heat content, they only sell fuel.

In contrast, “heat entrepreneurship” allows a supplier to sell a specific energy service, namely heat and in some cases electricity when operating a CHP plant. Following the study of the phenomenon in Finland, a heat entrepreneur or enterprise is defined by Okkonen and Suhonen as a “single entrepreneur, entrepreneur consortium, company or cooperative providing heating for a community” (2010: p. 3443). These experiences are that of woodfuel Energy Service Companies (ESCo). This type of organisation offers energy services to businesses and individuals and can sell heat to customers. This option has thrived following a wave of privatization of municipal heating services throughout the country since the 1990s (Okkonen et al., 2005) offering the opportunity for various arrangements, including Public-Private Partnerships (PPP). It is important to point out that ownership of the energy conversion system and, when relevant, of the heat network, does not necessarily imply its direct operation or maintenance. From their Finnish experience, Okkonen and Suhonen highlight heat provision services distinctive-

\(^6\)Please refer to the subsection 3.4.2 in Chapter 3 for details on the definition.
ness as it “differs from many other businesses because in many cases, it is an external
actor or customer who has invested in the unit of entrepreneurship, and therefore var-
ious ownership relations and overlapping responsibilities are possible” (2010: p. 3444).
Although it is said that this definition excludes the business models of fuel supply,
such as the “Network model”, it only partially excludes them, depending on the degree
of integration with upstream activities (i.e. harvesting, woodland management and
ownership).

An example of “heat entrepreneurship” can also be found in the Austrian experience and
the development of woodfuel powered district heating (DH). According to the Biomass
Energy Centre, district heating “is the use of a centralized boiler installation to provide
heat for a number of buildings. This can use a heat only boiler, or the heat from a
combined heat and power (CHP) plant” (Biomass Energy Centre, 2011). The boiler is
connected to a heat network which distributes the hot water to the connected users.
The Austrian experience of Biomass District Heating Plants (BMDH) as illustrated in
Box 1, below.
Box 1. Biomass District Heating Plant development in Austria (BMDH)

Biomass District Heating Plants aim at reducing fuel handling at individual level, ensure continuity of heat and reduce emissions. However, introducing BMDH has been a process of “technology dissemination” in Austria that was far from easy (Rakos, 2005: p. 47).

The systems only developed in four of the nine existing states in Austria and the initiatives’ leaders evolved through time. The early period (1980-1984) was dominated by private companies installing BMDH. This was followed by municipalities and farmers’ cooperatives which are now running the majority of installations to this day. Utilities have integrated the movement in the 1990s but cautiously with partnerships and joint ventures with farmers’ cooperatives. Utilities tended to provide technical and managerial capabilities to the agreements and farmers would operate and “arrange for the fuel supply”. Rakos (2005: p. 48) attributes the dominance of farmers’ organisations to their preferential access to subsidies. However, when using our theoretical framework, other factors such as basic transaction costs may have also played a role in inducing them to take over or develop the systems themselves. Once installed, the major technical problems of operations were generally handled directly by operators of the BMDH through a learning process that can be traced with the lowering of major issues reported throughout the studied period (1980-1992). This process was achieved thanks to the support provided by “technology introduction managers” that were dedicated institutions or focal points created by public authorities (Rakos, 2005: p. 56). Such dedicated organisations have been identified as key to the implementation of the technology because it did not develop in the states that have not introduced them. However, the main technical weakness remained the connection of the boiler to the grid of users which depended on non-specialised plumbers that did not benefit from the learning process.

\[\text{With respect to the financial viability of the project, it is vital that potential users are actually committed to connect to the grid and “pay a somewhat higher price than for individual heating” (Rakos, 2005: p. 53) because heat sales and prices are defining aspects of each project. This attitude was achieved because the BMDH provided a more reliable service compared to poor functioning individual systems in rural areas. However, it is noted that managing resistance by potential users and stakeholders is crucial and this aspect tended to be marginal in the efforts to introduce the technology, leading to many introduction opportunities being missed because of conflicts around installation. It is important not to limit introduction efforts to a “simplistic economic and technical focus” (Rakos, 2005: p. 57).}\]

In turn, an institutional perspective looking at the continuum of arrangements in terms of the coordination of activities allows for linking different business models along a supply chain. Refining the analysis from a transaction costs perspective, privatization does not mean the end of public ownership but rather the possibility of singling out transactions that can be either integrated or de-integrated, according to emerging cost economizing opportunities. In such an open context, the “conventional wood heating”
supply model can evolve through forward integration by providing heating provision. At the same time de-integration of heat operations by the user would occur. Conversely, backward integration by the user is also possible, particularly through quasi-integration with partnerships and long-term contracts.

The possibility of disintegrating energy conversion into heat from a user’s transactions has a fundamental advantage when this accompanies a conversion from low-maintenance systems of heat provision to high-maintenance ones linked to biomass. For example, having to (re)educate maintenance staff about solid fuel handling requires a change of culture within the organisation with implications for the cost structure, including transaction costs. The illustrative regional experience at the Royal Cornwall Hospital in Treliske conveys these dimensions in Box 2.

<table>
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<th>Box 2. Royal Cornwall Hospital at Treliske</th>
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<td>The former maintenance manager of the hospital shared his recent experience about a newly installed woodchip boiler and highlighted a clear change from their routine with gas and oil boilers. With the woodchip boiler, they have returned to &quot;a high maintenance system&quot;, after years of &quot;low maintenance system&quot;. Maintenance tasks include ash management (both bottom and fly ashes), a ten minutes daily check, and twenty minutes weekly checks including ash removal along with a check of the woodchip stock. Before the introduction of low maintenance systems, there was always a person in charge such as the &quot;former steamship seaman in charge of the boiler&quot; that managed coal fired devices. Change to oil and gas brought a &quot;de-skilling and a loss of organisation for systems that require maintenance&quot;. This implies a learning curve for the technical / maintenance team in charge of the new biomass boiler. He stated that the key to a successful conversion was “somebody (in the maintenance team) taking ownership of the boiler.”</td>
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If outsourcing heat conversion operations lowers internal production and transactions costs, it is expected to make biomass heating systems more attractive to potential new users.
4.5 Beyond activities: Exploring transactions along the supply chain

Presenting the supply chain of woodfuel as in Figure 4.1 opens the possibility of a wider variety of arrangements and degrees of integration across all possible transactions. Traditional supply chain diagrams only detail the fuel supply from source to user, presenting a series of processes and activities. They also assume the user as a homogeneous self contained agent, failing to open the “black box” actually composed of Williamson’s technologically separable interfaces: the transactions (1985). This may also be the case for landowners upstream. Given the theoretical basis of the analysis in Chapter 3 and some directly relevant applications above, it is possible to establish which transaction costs are faced by woodfuel development.

From the start, a dynamic look at how transaction costs are expected to develop follows the line of Bohlin (2001). The early, although not necessarily ephemeral, transaction costs are search and information costs. This is expected from all current and potential agents operating in the sector and not only from main users and specialised suppliers as documented by Bohlin (2001). Searching for potential commercial partners is expected to be more difficult at the beginning as well as accessing reliable information on prices, available volumes, size of the market and estimated potential growth. Not having reliable information opens the door to opportunistic behaviour, as we are reminded by Bohlin (2001). However, because of the uncertainty we should also expect speculative behaviour to hinder the construction of stable relationships between potential suppliers and users of wood for energy. This environment is expected to invite parties to develop safeguards through the creation of governance instruments such as long-term contracts or closer relationships, when deemed necessary. However measurement related transaction costs may persist in this context because of the heterogeneity of biomass and its variability. Assessing its properties requires efforts in standardisation and costs at each exchange. Moreover, ex-post measurements are necessary, such as heat actually produced from a determined volume of raw material. The success of the relationship will be based on such estimates and again is expected to be taken into account when drawing longer-term commitments. Vertical coordination mechanisms are expected to have developed and to continue to do so.
Figure 4.1: The supply chain as web of transactions

Source: Adapted from Okkonen and Suhonen (2010)
4.6 Before the characteristic of the transaction, the characteristics of the fuel

Echoing asset specificity, the physical characteristics of woodfuel, understood as a commodity, influences the nature and quantity of transaction costs. The lively narrative of Frankel (1946), in his classic Essentials of Petroleum: A Key to Oil Economics, illustrates how intrinsic properties of a commodity influence the structure of its related industry. We may extend this influence to how exchange is undertaken in the market in general, following Black (1986 in Van Vactor, 2004) when analyzing the futures market for commodities in the modern financial markets.

As Van Vactor (2004) reminds us, such acknowledgment of the effects of physical properties on industry structures, pre-dates the formalisation of TCE. Moreover, Frankel (1946) makes reference to the dominant structure of the oil industry at the time. He emphasized that “cartels”, monopolistic in nature, were not related to simple market power exploitation but rather derived from the nature of the commodity, also introducing an implication for how non-market governance structures could be seen, beyond the traditional suspicion from neoclassical economics and early antitrust laws questioned first by Coase (1972 in Williamson, 1996) and Williamson (1985). Building upon Black (1986) and Frankel (1946), Van Vactor (2004) compared the three main energy commodities to each other: oil (crude, heating and gasoline) with gas and electricity to translate technical differences into transaction costs in the financial market. He concludes, “whether or not the commodity is homogeneous, divisible, transportable, durable, composed of hazardous material, has “non-rival” characteristics, or is a component requiring use with other products may affect industry configuration. Commodities vary significantly in their combination of characteristics. Thus, it should not be surprising that transaction costs and market institutions vary widely from one industry to another, and the more complex the commodity, the more complex the market” (Van Vactor, 2004: p. 4).

In the same vein, Table 4.1 presents an overview of the characteristics of woodfuel that can translate into transaction costs comparing them to the major energy commodities. Although the present research does not expand on the futures market as developed in financial markets, such comparisons are very instructive. The need for stability for future prices and quantities is inherent to the development of contracts around supply and use of wood as an energy commodity.

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7Definition of futures market: “An auction market in which participants buy and sell commodity/future contracts for delivery on a specified future date” (Investopedia, 2011).
In Table 4.1, as detailed by Van Vactor (2004), heterogeneity is understood as the various forms and qualities the commodity can take. In the case of woodfuel, this would be logs, chips and compressed material such as pellets. It would also involve their quality standards.

In turn, a high divisibility of a product will entail the increase of transaction costs per unit, the smaller the volume purchased due to measuring, packaging, and handling costs. Divisibility is a characteristic of commodities, thus transaction costs will depend on volumes traded. However, even physically indivisibles can be divided by a market that allows uses by different agents through time, like hotel rooms.

Mobility – The mobility of a product has implications for search, enforcement, and negotiation costs.

Durability – Some commodities decay if not used and others depreciate with use. Uncertainty about depreciation can increase information and measurement costs.

Hazard – Dangerous products impact enforcement costs, requiring special packaging and warnings, and the assumption of liability risks.

Rivalry – Enforcement costs arise in excluding free riders if non-rival and by prohibiting or limiting secondary markets. Rival commodities are by nature exclusive to one consumer.

In turn, Table 4.2 offers an appreciation of the main types of woodfuel, namely logs, woodchips and pellets following the framework of Van Vactor (2004). Please note that the classification is relative to woodfuel only and it translates the description of the fuels in Chapter 2, mainly based on Richardson et al. (2002). Heterogeneity is expected to influence transactions of logs and woodchips. Although pellets could be heterogeneous in terms of their chemical properties, the degree of their mechanical properties is limited and more standardised than less processed fuels. Fuels have very different mobility as their degree of processing and density is different. The denser the fuel, the more likely it
is to be transported as each load is more valuable. Logs are more durable than processed fuels and this introduces time constraints to the transaction as chipped material tends to decay and pellets are sensitive to heavy handling and atmospheric conditions. In general, the material is not hazardous although green woodchip is prone to self ignition because of the decomposition process that increases the temperature of a given load.

Although the combination of characteristics of different types of woodfuel is expected to play some role in predicting how transactions are governed, other larger contextual factors are also expected to influence their governance structure, as detailed in Chapter 2 as well as the characteristics of the transaction itself, as developed in Chapter 3 and adapted in Section 4.7 on the following page.

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<th>Logs</th>
<th>Woodchips</th>
<th>Pellets</th>
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<tr>
<td>Heterogeneity</td>
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<tr>
<td>Divisibility</td>
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<tr>
<td>Mobility</td>
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<td>Hazard</td>
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<tr>
<td>Rivalry</td>
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Source: Developed by author for woodfuel types, based on Van Vactor (2004).

However, energy sectors may have asset specific investments, they “*also have another complexity in that virtually all energy commodities are component products, i.e., their production and use requires substantial capital expense by both the buyer and the seller in equipment necessitating compatibility and, thus, continuing interdependence. Conceptually this is similar to, but not the same as, the problem of asset specificity analyzed in transaction cost literature. It is different from the problem of asset specificity because ex-post the market may still be competitive, i.e., buyers and sellers are locked into a technology, but not to each other*” (Van Vactor, 2004: p. 30). Asset specificity could be classified as an extreme case of component product, according to Van Vactor (2004). A complementary possibility is that, when energy-related transactions are developed, the combination of any other type of specificity other than physical investment with component product (or asset specialty) makes the need for conscious governance more likely in the same way as expected from a physical asset-specific relationship.
4.7 Implications of assets specificity for woodfuel development

Although TCE and related analyses have focused on intermediate goods and not generally dealt with transactions involving end-users, energy from wood has to be transformed before use through energy conversion technology. It is not the end product. The end product is an energy service, as illustrated by Figure 4.1 on page 116 and the potential configuration of heat entrepreneurship developed by Alankangas (2003) and Ökkonen and Suhonen (2010) and presented in Section 4.3. As such, it requires investments, as clearly identified in Section 4.6 on page 117 that have the potential to be characterised by different asset specificities even when dealing with end-users.

Expanding and adapting from the review of cases, the types of asset specificity likely to be relevant are:

- Dedicated asset specificity of users particularly if a conversion/retrofitting from fossil based boilers requires space-related opportunity costs to ensure storage. This is also the case for new buildings. Note that a modern boiler could be seen as capital asset specific, although it is only special as it does not depend on a specific transaction to be functional.

- Physical asset specificity of biomass suppliers.

- Spatial asset specificity of biomass suppliers

- Dedicated assets in the creation of a storage space and the constitution of inventories that require seasoning.

- Process specificity of biomass producers (i.e. contractors) if adopting integrated harvesting methods described for their UK potential by Hudson and Mitchell (1993) and Mitchell (1992).

Actors having more mobility and versatility are less likely to be exposed to such transaction costs in the exchange.

4.8 Uncertainty

Uncertainty is expected to be at play in influencing woodfuel transactions. Transactions are influenced at two levels. At the institutional level (L2, in Williamson’s framework
developed in Chapter 3 and illustrated by Figure 3.1 on page 74) through the type and stability of renewable energy and forestry policy. The second aspect likely to impact transactions relates to strategic behaviour from the parties as well as measurement costs associated with quality standards, echoing the characteristics of the fuels themselves as summarised by table 4.2 on page 119.

Uncertainty linked to the institutional environment has testable consequences for the development of contracts as developed in Chapter 3.

4.9 Conclusion: Drawing hypotheses

Along with the empirical context drawn from Chapter 2, the theoretical underpinnings of the body of research presented above suggest a series of causal avenues and hypothesis that provide insight into regional woodfuel market development. The main hypotheses explored are formulated as the following causal statements.

HYPOTHESIS 1: Transaction costs are defining factors structuring the woodfuel supply chain, by both shaping its modes of governance and by hindering its development when friction is present.

HYPOTHESIS 2A: To develop the woodfuel market, economic agents need to shape it into a purposely structured platform such as “value-preserving governance structures to infuse order, thereby to mitigate conflict and realize mutual gain” (Williamson, 2002: p. 176).

HYPOTHESIS 2B: The regional stakeholders need to embrace “institutional diversity” (Ostrom, 2005) to develop wood-based bioenergy.

HYPOTHESIS 3: Apparently misaligned transactions with governance structures (i.e. apparently inefficient solutions) persist because of a combination of “lock in” effects of past organisational culture, learning costs and the underrated influence of the uncertainty about public support.
Chapter 5

Methods

5.1 Introduction

The aim of the thesis is to undertake a study of the transaction costs and critical factors shaping the development of the woodfuel supply chain in the South West of England. As such, it faced several methodological challenges both implied by the subject of analysis and by the approach followed.

The subject can be described as a young, small and changing renewable energy sector involving actors not assumed to routinely contribute to research\(^1\). This required primary data and an adapted data collection strategy. Given its evolving character, the subject is difficult to fully separate from its context, defined as a *diffuse*\(^2\) topic by Gerring (2007). Given the subject of the study, a small sample of observations was gathered preventing the development of a quantitative model. The NIE approach followed through an extended version of TCE also pointed at to mainly quantitative methodology for this study. The type of information required is rarely available for established sectors and nonexistent for an emerging and unrecorded one such as woodfuel. Therefore, there was a need for a detailed and bespoke data base.

This chapter is articulated to develop and answer the methodological challenges faced by the subject and approach of the study. First, it presents the rationale of choosing a mainly qualitative approach to analyse the dynamics at play and follows good social science practice formulated in methodological work on case study research, mainly by Gerring (2007) and Yin (2003). The methodology chosen is presented with its particular advantages and shortcomings, particularly compared with quantitative methodological alternatives.

\(^1\)In contrast to farmers

\(^2\)This is the case when the boundaries between phenomenon and context are not clearly evident.
The chapter unfolds by first justifying the choice of case study as a methodology to guide the enquiry of the structure of the woodfuel sector in the region of interest. The procedure involves a brief review of the characteristics of the methodology and, more importantly, the presentation and discussion of the strategies followed to ensure a successful, yet rigorous development of data gathering and interpretation.

The interpretation of the evidence followed an analytical narrative strategy. This strategy involved developing a narrative based on a theoretical framework using various sources of quantitative and qualitative data, including historical records. Following the framework offered by an extended version of Transaction Cost Economics (TCE), the exercise was supported by the identification of dependent and independent variables linked to the governance and transaction characteristics respectively. These were derived from the literature review of quantitative and qualitative empirical studies presented in Chapters 3 and 4.

The main source of data was developed through in-depth interviews with actors in the sector with 42 participants formally contacted during the course of the project along with others informally engaged. This source of information was complemented by contractual documents shared with commercial participants. The rationale for using interviews as the primary evidence for this project, along with the actual outcomes is sustained following previous studies.

The final part of the chapter shares the process and experience of the field work involving the meeting of business owners and managers. The protocol followed to contact participants and use the information gathered through recorded interviews and documents is also presented.

5.2 The study

5.2.1 Rationale

The study mainly focuses on transaction costs as a critical factor to the development of a woodfuel supply chain. Wood energy, in its modern form in the South West of England, is a new development and can be classified as an emerging and unrecorded sector and only a small sample of actors could be gathered, excluding a quantitative approach to the problem.

In turn, the choice of a Neo-Institutional Economics (NIE) framework implies that much of the analysis of this project is inspired by economics but not exclusively. However, the discipline as a whole has difficulties in fully integrating mainly qualitative studies
in their own right. Mainly qualitative case studies have tended to be seen as exploring narratives without the possibility of providing evidence for generalisation (Alston, 2008).

The challenge for this kind of study is that there is no common norm for “*economically disciplined*” empirical stories in NIE, other than econometrics (Acheson, 2000; Ménard, 2001). Sample sizes in any given field tend to be limited by the cost of tailor made data collection efforts, and therefore “*preclude effective use of most of the econometric techniques*” (Sykuta, 2008: p. 135). Despite the reduced generalisation capacity and the inherent risk of ex-post rationalization, case studies are an important contribution to the literature. Although case studies are not able to disprove the validity of a theory they can demonstrate its shortcomings (Masten and Saussier, 2002).

However, despite the scarcity of readily usable data, case studies have flourished to test TCE postulates and related theories (Boerner and Macher, 2001; Carter and Hodgson, 2006; David and Han, 2004)⁳. Many have developed case studies as “*analytic narratives*” in the sense of using a theoretical framework in a narrative using historical evidence and data (Alston, 2008; Bates et al., 1998). These examples are very different from simple descriptive narratives (Ménard, 2003), as they are sometime caricaturised.

In the same vein, and this time looking at future research on contracts with inherent requirements for in-depth interaction with the parties involved in a studied transaction, Sykura anticipates that “*the most insightful research to be conducted will; not be achieved by the best econometric tools, but by case study research*” (2008: p. 136). It is important to note that because transaction costs tend to be difficult to quantify in a systematic way, assessments in absolute terms are rarely to the advantage of comparative analysis. Operationally, TCE estimates “*the difference in transaction costs rather than the absolute amount of transaction costs*”, favouring qualitative applications (Verhaegen and van Huylenbroeck, 2002: p. 38). Although case studies can be associated methodologically with quantitative research, it is important to highlight that this is only an “*affinity*” and not a definition (Gerring, 2007) as they can rely on a combination of both quantitative and qualitative evidence (Gerring, 2007; Yin, 2003).

This case study of woodfuel in the South West of the UK combines a theoretically driven analysis of the evidence on transaction costs with a narrative based on the direct experience conveyed by stakeholders, primary and secondary source documents and policy publications. To achieve this, the project combines quantitative data from both secondary and primary sources along with the qualitative details about processes in relation to the construction of the woodfuel market, as developed below in the second body of the thesis Part II Evidence. After identifying the dimensions of a case study,

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³For more details, please refer to Chapter 3.
clear criteria need to be adopted to achieve its sound development. The criteria and strategies followed contribute to the rigorous development of the analysis, as developed in Subsection 5.2.3.

5.2.2 General traits of the study

Although widely used, defining a mainly qualitative case study has been the subject of debate. Several complementary but sometimes rival definitions have been formulated to orient social research in developing case studies. We can highlight seven potential attributes that shape what is understood by a case study from the literature survey conducted by Gerring (2007). These range from their methodology, sample size, type of evidence and definition of the research topic. Table 5.1 provides a brief review of these attributes generally associated with a case study.

<table>
<thead>
<tr>
<th>Dimensions / Attributes</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Its method is qualitative</td>
<td>Small-N sample</td>
</tr>
<tr>
<td>It is holistic, thick research</td>
<td>More or less comprehensive examination of a phenomenon)</td>
</tr>
<tr>
<td>It utilises a particular type of evidence</td>
<td>Ethnographic, non-experimental, non-survey based, process-tracing,</td>
</tr>
<tr>
<td></td>
<td>historical, textual, or field research</td>
</tr>
<tr>
<td>Its method of evidence is naturalistic</td>
<td>Real-life context</td>
</tr>
<tr>
<td>Its topic is diffuse</td>
<td>Case and context are difficult to distinguish</td>
</tr>
<tr>
<td>It employs triangulation</td>
<td>Multiple sources of evidence</td>
</tr>
</tbody>
</table>

Source: Adapted from Gerring (2007: p. 17)

Individually, each attribute listed in Table 5.1 does not provide a comprehensive definition. In some cases they simply represent rigorous protocols such as triangulation when faced with small-N. To respond to this diversity, Gerring defines it as the “intensive study of a case for the purpose of understanding a larger class of similar units (a population of cases)” (2007: p. 20).

A case study looks at only a few cases but with a large breadth of dimensions, contrasting with operationally statistical studies which consider a large number of cases but with only a small number of dimensions as evidence (Gerring, 2007). This is also related to the fact that there are more variables of interest than observations (nonexistence of a large N) when analysing the main transactions of interest, making statistical inference inapplicable. However, it is also possible to lower the level of analysis to a sub-unit of
a case or cases selected, allowing for a larger N at this lower level of observation and therefore providing more solid support for inference. For example, if a sector is the case study, the lower level will be firm managers and a finer level phenomenon could be the numerous transactions within a firm.

Finally, a distinctive feature of the properly designed case study is the deliberate interest in the contextual environment of the phenomenon studied. This is even more important when boundaries between phenomenon and context are not clearly evident (Yin, 2003), defined by Gerring as a topic which is “diffuse” (2007: p. 17). In this sense, the current research, by aiming at answering specific questions by practitioners, requires a rich contextualisation of the phenomenon to develop policy and decision-maker relevant recommendations.

5.2.3 Following best practice

To follow best practice in social sciences, Yin (2003) highlighted several criteria required to provide solid foundations when engaging with a case study. There are both internal and external aspects of the analysis to be accounted for. Internally, the study has to show both construct validity and internal validity. These have to be completed by external validity and reliability as shown in Table 5.2.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>Establish relevant operational measures for the</td>
</tr>
<tr>
<td></td>
<td>concepts studied</td>
</tr>
<tr>
<td>Internal validity</td>
<td>When relevant, establish causal relationships in a</td>
</tr>
<tr>
<td></td>
<td>controlled fashion sorting out spurious ones</td>
</tr>
<tr>
<td>External validity</td>
<td>Establishing the domain to which the study findings</td>
</tr>
<tr>
<td></td>
<td>can be generalised</td>
</tr>
<tr>
<td>Reliability</td>
<td>Demonstrating that the operations of the study can</td>
</tr>
<tr>
<td></td>
<td>be repeated with same results</td>
</tr>
</tbody>
</table>

Source: Yin (2003)

The most important message from Yin (2003) is that the criteria have not only to be designed ex-ante at some research design stage but also have to be applied throughout the analysis. The criteria have to be in dialogue with the process. Given the constraints emanating from the subject and approach, which are developed in Section 5.2.1, each good practice criterion from Table 5.2 is addressed through the following strategies.
CONSTRUCT VALIDITY. As the case study is theoretically driven, construct validity is particularly important and challenging. Although strongly based on a critical assessment of the quantitative TCE literature, Mayer (2009) asserts that identified lack of coherence in the findings when operationalising key transaction cost predictions could be traced to problems of construct validity. "Construct validity is then the degree to which the original constructs in the theory section and the variables in the empirical section align. If these two elements are strongly matched, then the study is considered to have high construct validity. If, however, the story being told in the front end of the paper is disconnected from the data analysis, then the construct validity is low. This issue is very important because studies with low construct validity are not actually testing the theoretical relationships that they purport to examine." Not to mention "lacking complete understanding of the theory itself" by testing variables in isolation, such as focusing on uncertainty without accounting for asset specificity (Mayer, 2009: p. 215). To respond to this challenge, the questionnaires use proxies for the dimensions of transactions to record the relevant data. These were drawn from both the qualitative and quantitative literature with the sources detailed below, in Section 5.3.2. The details of the proxies chosen can be found in Annex C.

Additional support to ensure validity was to base the study on multiple sources of evidence through triangulation. Secondary literature, statistics and in-depth interviews with both sides of important transactions surrounding woodfuel form the core of the evidence. Similarly to Palay’s (1984) experience, in order to stick to the commitment to confidentiality of interviews, it was inappropriate to tell suppliers that the researcher talked to woodland owners or customers about a specific transaction. Using his own words, “nevertheless, by choosing the interviews carefully I was fortunate enough to have many interviewees discuss transactions with the appropriate (suppliers), in some instances, relate their answers to precisely the same transaction (a producer or customer) had described” (1984: p. 267). This outcome provided triangulation of several transactions discussed independently.

INTERNAL VALIDITY. This is ensured by following a particular theory, being an extended version of TCE. In addition, some space is also provided in the data collection mechanisms to account for competing hypotheses and rival theories. In this case several options were open to the competence theory of the firm (RBV).

RELIABILITY This was strengthened by three consecutive and complementary procedures. As the main source of evidence was interviews, the first step consisted in developing clear and comprehensive interview guides⁴. The second ensured a record of the data-collcting phase through tape/digital recording of interviews when authorised and

⁴Please refer to Appendices D and E
notes if not, followed by an accurate complete transcript of the exchanges, accounting for additional supportive material provided by participants (e.g. contracts). The final step consisted of organising the evidence so as to support its interpretation through grouping themes and subsequent coding. The last phase was carried out using SPSS for the quantitative data and the Computer Assisted Qualitative Data Software Analysis (CAQDAS) NVivo. The use of CAQDAS was mainly pursued so as to ensure a systematic grouping of evidence in a flexible and reliable environment. Besides flexibility and accessibility of data it offered transparency\(^5\) when later analysing material, supporting efforts in meeting the criteria of reliability.

**EXTERNAL VALIDITY.** Finally, the external validity of the study has to be tested. The degree of generalisation possible, as exposed earlier is defined by the case study approach. Although it is not possible to make direct statistical inference, the detail of the analysis on governance structures for woodfuel in an English Region is to suggest similar explanatory mechanisms in the UK and across other biomass renewable energy sectors. The study's contributions to generalisation are threefold. First, it aims to frame theoretically non-technical barriers to the development of bio-energy markets that have been listed or only weakly related to *a priori* models. Then, it focuses the analysis on the modes of governance (spot markets, hybrids, vertically integrated firms) developed in other geographical and/or institutional settings as economizing alternatives for exchange in a woodfuel market. Finally, the thesis is an adaptation of a TCE framework generally used at firm level in established markets to inform the construction of bio-energy markets as an effort to circumvent and economize on transaction costs.

Although this study regarding the development of market structure is firmly theoretically driven and does not aim to build on grounded theory, the small number of cases and the type of evidence gathered required support from design criteria of best practice to provide a reliable analysis. Throughout the study several strategies are used so as to answer the challenges of using a case study methodology. To ensure rigorous gathering and use of the evidence three main steps were undertaken. First, questionnaires were devised including a selection of proxies for the transaction characteristics identified by the literature as potentially relevant. Then, the data set mainly composed of full transcripts was coded and stored. Finally, an attempt at identifying the contribution to generalisation was been made and this is developed in Chapter 9.

\(^5\)Although this research is not based on grounded theory, it interesting to highlight that this type of software has been identified as a tool to significantly enhance transparency in the development studies based on the sometimes challenged grounded theory. However, its use and the enhanced transparency derived should not be confused with the actual use of a framework (Bringer et al., 2004).
5.3 Levels and units of analysis

5.3.1 Levels of analysis and time span

The focus of the enquiry and data collection is contemporaneous. Such immediacy with our object of analysis generates a tension between privileged access to actors engaged in woodfuel development and the difficulties faced when disentangling the main object of analysis from its evolving context (Gerring, 2007). The protocol described above aims at easing such tension through a systematic enquiry. However, the context is drawn from research and experience in the field over the last 20 years, but not exclusively, including data from earlier experiences with firewood.

The general enquiry is focusing on transactions as units of analysis and it does so at the level of the supply chain\(^6\). Methodologically, Transaction Costs Economics has primarily been concerned with groups of individuals, single organisations and organisation dyads as exposed by Douma and Schreuder’s typology (1992: p.174). TCE generally analyses population of organisations or systems as wholes and focuses on relationships between two agents. However, following Chapter 3, this does not imply incompatibility with the analysis of a supply chain, when understanding its directed coordination as a manifestation of various governance structures within the TCE framework, one being Supply Chain Management (Ellram, 1991).

For this purpose, the empirical work will focus on three specific dyadic relationships that are linked to each other along the supply chain. The categories of stakeholders of the supply chain are developed in Section 5.5. The relationships represented in Figure 5.1, are expected to be the most defining transactions in the construction of the woodfuel market through procurement contracts. Please note that the relationship between energy conversion devices (i.e. boilers and heating systems) is not the focus of this study.

The following three different vertical relationships were the centre of focus and guided the data collection phase:

1) Land owner ↔ Forest Contractor OR\(^7\) Land Owner ↔ Broker / Aggregator
2) Forest contractor ↔ Broker / Aggregator
3) Broker / Aggregator ↔ User OR Land owner ↔ User OR Forest contractor ↔ User

All the relationships illustrated in solid lines are vertical or following a hierarchy as in the basic TCE model. However, the introduction of the hybrid governance modes

\(^{\text{Please refer to the paragraph 3.6.3 on page 91 in Chapter 3 for a definition of a supply chain.}}\)
\(^{\text{Where Or is understood as a setting where transactions with similar characteristics develop.}}\)
allows for the interpretation of more horizontal relationships between organisations such as cooperatives, joint ventures along the lines analysed by Ménard (2004). Examples of this are represented in Figure 5.1 by the dashed line.

### 5.3.2 Independent and dependent variables.

As developed by Williamson (1985), the basic unit of analysis is the transaction. This also holds true for all categories of transaction costs to be analysed. Although this is a clear starting point, many, including Williamson, have acknowledged that the dimensions of transactions are difficult to measure and therefore to collect relevant and adequate data is a significant challenge (Acheson, 2000; Hobbs, 1997; Hobbs and Young, 2000; Ménard, 2001; Rao, 2003). Adequate proxies need to be identified to analyse contracts, measuring the degree of specificity of assets and the degree of uncertainty surrounding transactions (Ménard, 2001).

In broad terms, the thesis is divided into a positive or analytic section and a normative part. The first and main part analyses the determinants of the current development of the woodfuel market in the South West by focusing on the dynamics of transaction costs within its general policy context and regional initiatives. Based on the conclusions of the institutional analysis, the second part formulates recommendations for mainly local private and public actors. However given the initial stages of the development of
bioenergy, some recommendations with respect to governance structures are also expected to be applicable in the national and EU settings, as developed in the concluding Chapter 9.

With respect to the main body or positive part of the thesis, four lines of investigation are developed, with their respective dependent variables. Although not fully applicable throughout this study, using the concept of a dependent variable keeps a degree of control on the phenomenon studied.

The first analysis aims at providing an explanation for the current level of development of woodfuel as an energy sector in the region with special attention to the implications of transaction costs. Other factors already identified in the literature covering renewable energy development were also included. They were accounted for through confirmation or identified within the context of the South West of England.

The first assessment is followed by a focus on the governance structure ruling the transaction(s) studies, in line with TCE analysis. Adapting from Verhaegen and van Huylenbroeck’s (2002) summary, applying this framework required four steps:

- Characterisation of transactions
- Description of governance structures
- Cross-reference of transaction characteristics’ proxies with the governance structure through a comparative analysis (i.e. alignment). The procedure was associated with the type of “business models” developed in the sector, as introduced in Chapter 4, and reflecting various degrees of integration, away from the simple and spontaneous coordination mechanism of the market (i.e. spot market).
- Exploration of misalignments between what is to be expected theoretically between existing governance structures and the nature of transactions related to woodfuel.

*An additional line of research was planned to identify the influence of (mis)alignments to performance in terms of woodfuel development. Given the lack of traceability of the issue and despite its weaknesses (Sykuta, 2008), we followed Poppo and Zenger (1998) by simply measuring performance of the organisations with respect to their targets, in this case for woodfuel transactions. In more mature sectors, more refined measures of performance such profit would be appropriate but given the youth of the woodfuel market, there was a better case for using expectations to measure performance. This cross-reference is compatible to Williamson position to evaluate remediable inefficiency “in relation to feasible and implementable alternatives” (Emphasis in the original, 2008a: p. xxxvi). Otherwise, an evaluation against an ideal efficiency would not provide much insight as it would inevitably under-perform (Dixit, 1996 in Williamson, 2008). However, given the very recent and short experience of most participants to this sector, the results from this aspect were not applicable to the majority of cases and did not produced complete responses. As such the specific value of the evidence of the relationship between (expected) performance and governance is not presented in this thesis and deserve future investigation, once the sector is more established.

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The theoretically driven development of proxies is inspired from several empirical studies dealing with the governance implications of transaction costs and alternative understanding of the boundaries of the firm.

For the Coasean and friction transaction costs, we are directly in debt to the work of Hobbs (1997) on cattle supply chains. Williamsonian costs, linked to asset specificity were drawn from Altman and Johnson (2008), Joskow (1985), and Palay (1984) which provided the main inspiration for questions and proxies. Competence-based approaches to firms and market performances provided the backdrop for identifying proxies of competing theories to contrast with TCE.

The proxies for transaction costs and associated questions on contracts are presented in detail in the Annex C.

5.4 Data requirements and instruments to gather evidence

The choice of Neo-Institutional Economics as a theoretical framework required analysis to be conducted at the transaction level. However, information of this nature is collected by neither national nor sector statistics, therefore demanding the collection of original primary information. Although this is a common challenge facing institutional analysis research, this project also faced poor data on basic dimensions generally available for established sectors such as traded volumes because woodfuel was marginal and ill recorded by national statistics. A distinctive indication of this is that although there is precise data on electricity from biomass, data on wood used for energy purposes, including heat, is not recorded by the Forestry Commission. Some very recent attempts have only produced crude estimates of volumes traded based on incomplete surveys and specialists’ estimates (Forestry Commission, 2009b; 2010) and Rawson (2010) for a segment of the market in the South West.

The data collected had five specific objectives:

- Improve and update the contextual framework of the study (general opportunities and constraints of woodfuel market development)
- Construct a panoramic view of the experience of building the woodfuel market based on individual stakeholders’ experiences

\footnote{The research project was approved by the School’s Ethics Committee and was granted field work permission from 11-2008 to 08-2009. As such the principle of informed and voluntary cooperation to the project as informants was applied throughout the project.}
Table 5.3: Originality of data (N=20)

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is this the first time you are interviewed about your woodfuel activities?</td>
<td>16</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
</tr>
</tbody>
</table>

- Identify how stakeholders see themselves as being active links in a supply chain with particular interest in the level of interconnection experienced by the actors around woodfuel

- Identify the dimensions of exchange that drive woodfuel development from a neo-institutional perspective to test their main hypotheses

- Identify the strategies, plans or ideas developed by the stakeholders to control for the barriers to exchange where relevant

Despite its logistical demands, a bespoke database is advantageous to case study analysis. This strategy allows for a richer understanding of the value and pitfalls of the evidence provided (Alston, 2008). An additional justification for this came from the evidence itself as only a fraction of interviewed businesses had been contacted before to share their experience in developing wood energy.

Table 5.3 shows that almost none of all interviewed businesses had ever contributed to research on wood energy. At the time of interviews, those that had been contacted previously had only provided snippets for the media or information to business statistics as rural enterprises but none on wood as energy (firewood, woodchips or wood pellets).

5.4.1 Written sources

The basic documents available providing evidence on the structures governing transactions are woodfuel procurement contracts or other formal agreements. Authorisation to access such contracts were requested when meeting stakeholders, following a strict signed protocol of confidentiality. A simple checklist retaining the defining characteristics of such documents was used to identify the main contractual specificities of

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10 Please note that the first 10 participants were not asked if they were contacted previously to share their experience with woodfuel as a business. However given the way the interviews developed it is most likely that they had not, making the proportion of those having never contributed to research a conservative estimate.
long-term agreements. The checklist was used as a reference for the analysis of formal contracts examined in Chapter 8.

Although such written sources provide direct verifiable evidence, the fledgling nature of woodfuel use makes such documents currently very scarce, reflecting the uptake of formal contracts as a governing mechanism. It goes without saying that as a traditionally marginal product, informality has tended to render it invisible, document wise, particularly when trading firewood. As such, the project had access to four templates and the oral description of a fifth one that governed fuel contracts regarding woodchips and pellets.

5.4.2 Oral sources

Data collection was strongly theoretically driven. However, special care was given to provide space for open answers, not only in terms of data collection but also theoretically speaking. Although this meant longer interviews, this kind of information provided support to develop internal validity by providing options for rival or complementary explanations to the main hypotheses.

The main body of evidence on the case study was derived from a series of interviews described in the following Sub-section 5.4.3.

5.4.3 Instruments

As introduced earlier, the main instrument of data collection was an in-depth semi-structured interview. The objective of this strategy was to be very rigorous in recording systematic aspects of transaction characteristics to ensure comparability between participants whilst allowing enough flexibility for participants to express their views. A systematic record was needed to ensure that the majority of aspects surrounding transaction cost were accounted for, and were subsequently pre-coded. Other aspects, such as comments and sometimes aired complaints were coded ex post using the CAQDAS NVivo.

As many relevant actors as possible were contacted. Given the costs involved; such procedure stopped when a trend was established without substantial difference identified, assuming diminishing returns on the number of interviews conducted each major actor. However, given the small universe of actors directly related to the woodfuel sector it was expected that the proportion of contacts reached the overwhelming majority. Table 5.4 provides the numbers and groups of actors identified.
Table 5.4: Organisations contacted

<table>
<thead>
<tr>
<th>Types</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Businesses interviewed</td>
<td>30</td>
</tr>
<tr>
<td>Businesses which declined</td>
<td>7</td>
</tr>
<tr>
<td>Businesses that accepted but did not commit</td>
<td>4</td>
</tr>
<tr>
<td>Businesses that could not be contacted by telephone*</td>
<td>23</td>
</tr>
<tr>
<td>Supporting organisations</td>
<td>11</td>
</tr>
<tr>
<td>User, boiler owner</td>
<td>1</td>
</tr>
<tr>
<td>Total formally interviewed</td>
<td>42</td>
</tr>
<tr>
<td>Formal face to face</td>
<td>17</td>
</tr>
<tr>
<td>Formal telephone</td>
<td>25</td>
</tr>
<tr>
<td>Informal contacts with businesses, including site visits.</td>
<td>6</td>
</tr>
<tr>
<td>Total interviewed (formally and informally)</td>
<td>48</td>
</tr>
</tbody>
</table>

*Includes leads that were not relevant or were not active at time of contact

For the interviews, 64 businesses were contacted\(^{11}\). Of these, thirty businesses formally participated in interviews, lasting between one and two hours. The estimated population of companies and organisations operating in the region was mainly gathered from professional directories, but not only, as invaluable suggestions were provided by the participants, widening the potential contacts through the snowball sampling technique. This represents the participation of almost half of all businesses contacted but more than two thirds of the population of businesses confirmed to be engaged with woodfuel supply. Six additional businesses contacted informally provided valuable information about the sector as well.

Additionally, 11 representatives from supportive organisations (public and private) were also contacted. Only one declined but organised the contact with another, more relevant organisation. Finally, in the spirit of triangulation achieved by Palay (1984), a recently installed boiler user was also interviewed as the individual shared a case commented on by other actors in the supply chain.

Of all formal 42 interviews, 17 were conducted face to face, the remaining were conducted through the telephone.

**Interviews with businesses**

Interviews with business participants focused on identifying the transaction costs related to woodfuel transactions, along with the contextual issues of market development. This

\(^{11}\)Note that a recent estimate of the number of businesses supplying woodchips and wood pellets to for medium to large boilers was 60 (Rawson, 2010).
instrument was deployed through two methods according to the importance of the assumed role of the actor as a market builder. Face to face interviews and telephone interviews were chosen using the same questionnaire. The questionnaire used for these interviews is attached in Annex D. However, this distinction did not have major input consequences as both instruments demonstrated a very similar richness of insights given the time granted to the researcher by generous participants. The contact time for these interviews spanned from November 2008 to July 2009.

In-depth personal interviews were conducted with market builders (i.e. brokers, fuel suppliers, users). In addition, access to formal woodfuel sale contracts between parties was requested to account for their format, clauses and degree of incompleteness.\footnote{This is understood as an indicator of an agreement’s flexibility towards future uncertainties and possible needs for ex-post re-negotiation.}

The choice of using both telephone and face to face interviews as complementary methods derived from two constraints. First, the fact that, unlike other rural actors such as farmers, this population of business managers\footnote{Please note that some may also be farmers.} was not routinely contributing to social research. Requesting participation through written questionnaires was assumed to result in a lower response rate. A possible solution to the first barrier, that of personal face to face interviews was not logistically practical for all potential participants given their number and their scattered geographical distribution. The majority of interviews were tape/digitally recorded with the consent of the participants and subsequently transcribed. When consent was not granted, detailed notes were taken alongside registered answers to close-ended questions to feed the data base. Only nine were not tape/digitally recorded but more due to location or technical reasons as only one participant declined to be recorded.

To support the development of the interviews, a questionnaire with both open- and close-ended questions was formulated with the following five sections:

- General characteristics and history of businesses and participants, assuming that, in general, woodfuel is only a share of their activities.
- Type of activities developed around woodfuel, outsourcing, physical and human asset specificity, and relationship with competitors and degree of integration along the supply chain.
- Sources of material, information and measurement issues, and proxies for spatial specificity.
- Type of contracts upstream and downstream, preferences and experiences, and bargaining costs issues.
• Government support and grants and perspectives on support for bioenergy development both on supply and demand-side initiatives

Interviews with supporting organisations

The contact with supporting organisations was carried through in-person and telephone interviews. The exchanges focused on the current strategy of woodfuel promotion, achievements, failures and the visions for the future. This also included concrete answers to barriers linked to transaction costs, when identified as such. These interviews mainly took place after the business interviews between May and September 2009 and were substantially less structural with mainly of open-ended questions.

The questionnaire used for these interviews is attached in Annex E. This was used as the main template and was adapted according to each organisation, expanded or simplified as required.

5.5 Stakeholders and informants

5.5.1 Contact data base

A data base of contacts was compiled, collating the stakeholders along the supply chain. This data gathered the main contacts of the stakeholders identified, including a contact person, and their assumed role along the supply chain.

The purpose-built list of informants was sourced from i) exiting business directories, namely from the South West of England Energy Agency (SW Regen) and ConFor (2008), ii) personal contacts of the author and iii) complementary contacts born out from the so-called “snowball” effect where contacts lead to additional contacts.

Following the objectives of the study, the contact list covered the specific geographical area encompassing the South West Region of England, in the United Kingdom. Although this was the core focus for primary data collection, informants from public national entities and support organisations were also included.

The informants were classified according to their assumed role in the supply chain, including support programmes and national public institutions. This distinction aimed at identifying which data collection method would be the most appropriate according to the degree of in-depth information required. The closer to the core of interest, the more privileged the in-depth interview compared with the telephone contacts. Both sources were interviewed with the same questionnaire allowing for direct comparison.
Although, it was expected that the overall richness of the telephone information could be more limited, several telephone interviews lasted more than two hours and none less than an hour. The richness of both strategies ended up being comparable although these could not have been interchangeable given their respective logistical requirements.

5.5.2 Categories of stakeholders

The main stakeholders of interest for the interviews were classified according to their role in the supply chain. The following five groups were identified:

**Land Owner**: Represents an owner, public or private, of forested land already supplying material to the energy market or with the potential and interest to do so.

**Arboriculturist / Supplier or Provider**: This category represents small to medium businesses that generate material as a sub-product of their core activity or that could do so when working on contracts in parks and gardens. They are expected to be involved in log production and sale.

**Broker / Aggregator / Processor**: These actors are central to the analysis as they are transaction costs economisers by definition. They are constituted of entrepreneurs that focus on aggregating enough material to provide security of supply or combine their extracting activity with conditioning and storage. Producers of processed material such as pellets are included in this category, as it is known that they combine their own production with externally supplied products to ensure security of supply to their customers.

**Forest Contractors**: This category is separated from the arboriculturist as it handles the main stock of fresh material potentially directed to the energy market within high material standards, particularly for chips.

**Supporting Organisations**: These institutions can be private or public. Please note that local authorities can also be important “Suppliers” and “Users” of woodfuel.

As we focus on transactions, the privileged transactions are the ones gravitating around “Brokers” either upstream toward the provider (Land Owner or Contractor) or downstream (User). The importance of brokers, who not only in Van Vactor’s (2004) terms, take stock in woodfuel but also engage in asset-specific transactions, are at the core of the data collection process, favouring in-person interviews.

Although the categorisation may appear to be clear cut with stable roles along the supply chain, informants of organisations often represented structures operating at different levels simultaneously. For example a “Land Owner” that is also a “User” of woodfuel can also provide a “Broker” with material, a “Land Owner” can also be “Broker”, or
in turn, a “Local authority” can be a provider in an area, and a “User” in another
area. Finally, an agent can also play all roles from “Land Owner” to “User”, already
providing hints about the diversity of governance structures coordinating the supply
chain. When several roles were played simultaneously, the initial identification simply
reports the role of most interest to the research (i.e. broker), even if it is a minor part
of the activities of the organisations.

5.6 The process and experience of field work

5.6.1 The process

The data gathering process followed a protocol to invite and interview participants in
confidence. The protocol was based on the principle of voluntary cooperation from
invited stakeholders and was applied throughout the project, following ESRC\textsuperscript{15}
guidelines, along with the ESOMAR\textsuperscript{16} International Code on Market and Social Research,
which is recognised as a reference for best practice for telephone interviews.

The disclosure of commercial information (i.e. partners, costs, prices, supply sources,
etc.) to other stakeholders may damage their competitiveness and jeopardize their
growth in a fledgling and new market. Although the purpose of the research is to
contribute to higher levels of coordination within the woodfuel supply chain, primary
information was handled with care to guarantee the anonymity of the sources, limiting
their identification to the role(s) they may have or plan to have in such a chain (i.e.
contractor, landowner, broker, local or national public servant, etc.). As mentioned
earlier and following Palay (1984), this did not prevent triangulation around particular
transactions among different actors and verify the content of shared experiences. This
enhanced the understanding of the woodfuel market.

The protocol consisted of six main steps:

- Invitation letter presenting the project of thesis along with sponsors and detailing
  the purpose of the interviews (The template can be found in Annex A).

- Telephone call and if an interview was granted, a schedule for an interview at a
  later date.

\textsuperscript{15}The Economic and Social Research Council.
\textsuperscript{16}The European Society for Opinion and Marketing Research.
• At the interview, a protocol of recalling the purpose, conditions and rights of the participants including refusing to be tape/digitally recorded.

• A Consent Form was also submitted before face-to-face interviews (The template can be found in Annex B).

• Thank you note through email.

• Formal thank you note and a 10 page summary of main trends found.

The interviews, as a data gathering instrument, proved an effective way to reach the actors of interest. However, they were logistically demanding, particularly when contacting businesses, as agreed meetings or telephone interviews had to be rescheduled, sometimes several times.

5.6.2 The experience

The telephone interviews were as rich in content as the face-to-face ones but they did not provide the larger context. Meeting the participants did require traveling throughout mostly rural areas of the South West and not only offered site visits but also the larger picture of individual contexts.

A very effective tool to enhance the participation level was to offer very flexible times with the possibility of reconvening when necessary. This meant conducting telephone interviews throughout evenings, very early meetings or during lunch breaks at working sites through mobile devices. The possibility of reconvening was very useful in developing interviews through a comprehensive questionnaire with often very enthusiastic and passionate participants. The flexibility offered by interviews, contrary to postal or email surveys was that the researcher was able to adapt to the flow of questions and redirect focus if questions were not relevant to those that had to make the most of the contact time available.

The protocol followed was also successful, as participants that were contacted by telephone, following an invitation letter requesting them to grant interviews, were generally open to share their experience. Although not part of the questionnaire, several participants spontaneously acknowledged the request and the interview to have been very professional, having appreciated the invitation letter preceding the first telephone contact in particular.

A counter-factual of the interview strategy was actually experienced by an official postal and email survey conducted by the Forestry Commission to gather volume of woodfuel
traded by the sector in the region and in the UK as a whole. The type of information was inevitably more limited given the more targeted objectives and the quality of the data collected was poorer. The exercise did not provide enough data to construct an accurate picture of the sector’s importance and had to rely on additional sources, mainly secondary and expert judgment to publish an estimate (Forestry Commission, 2009b).

5.7 Summary

A case study as a methodological approach was justified by a small-N sample but also by the need to develop a context to the nascent woodfuel sector in the region. The major shortcoming of this approach is an inherent risk of ex-post rationalization and not being able to generalise as with other approaches. However, the interpretation of evidence is an “analytical narrative” in the sense that it uses a theoretical framework in a narrative using various sources of data. In this case, the background is provided by an extended version of Transaction Cost Economics (TCE). The exercise is supported by the identification of dependent and independent variables linked to the governance choice and transaction characteristics derived from the literature.

In depth semi-structured interviews were devised as the instrument to gather the main source of evidence. Two different questionnaires were developed with one targeting businesses and a second, shorter but more flexible, was aimed at supporting organisations. Given the logistical requirements associated with interviewing very scattered participants, the administration of interviews followed two strategies depending on the (assumed) influence in market building of business participants with the brokers at the centre of focus. Those closer to this position were asked about their experience face-to-face while those with a more reactive role were initially interviewed by telephone. The representatives of supporting organisations were contacted when convenient.

The strategy of interviews as data gathering instrument revealed itself to be logistically demanding, particularly when contacting businesses and agreeing (and sometimes rescheduling) meetings. However, it proved to be the most effective way to reach involved businesses and supporting organisation with 42 formal interviews completed with some further informal ones.

One of the main aspects to highlight from the overall experience was the general openness and generosity of participants in sharing their experience and time.
Part III

Evidence
Chapter 6

Woodfuel supply market characteristics

6.1 Introduction

The characteristics of the woodfuel supply chain could also be encapsulated in the *who does what* question. Knowing which organisations are involved in the woodfuel sector plays a twin role. The first is to provide background information on the sources of the main body of evidence gathered to understand woodfuel in the South West of England. The second, and more dynamic one, is that the characteristics of businesses are expected to play a role in shaping market development, as identified from more mature experiences in continental Europe. The thesis shares this view and highlights that who is involved also shapes response to governance challenges of a new sector. To do so, it is imperative to record the type and degree of integration of activities developed.

Analysis by Peltola (2005) illustrates the influence of who is involved in the sector. He insists on the importance of the prevailing structure of the forestry industry and how the roles are distributed among actors in shaping a woodfuel sector. Comparing the trajectory of the industry in Finland with other well developed bioenergy markets, Peltola establishes that Finland has an industry that is dominated by large integrated forest companies that control the management of forested land and favours clear-cutting, in opposition to continuous cover management. Finland developed bioenergy a decade later than Sweden where the forest industry is less dominant. In Austria, the forest industry has a minor role and clear-cutting is restricted, enabling a major role for small businesses. Such small businesses are generally farm related as bioenergy development was led by Chambers of Agriculture, only followed later by forest owners associations
and other actors (Rohracher, 2002). The origins of the emergence of a bioenergy market differ according to context. It is very instructive to note that although Finnish wood energy policy "is also based on the idea that industrial forest fuel production provides the best means for sustainable energy production" (Peltola, 2005: p. 205), small under-managed forest owners developed dynamic heating businesses as a response to the marginalisation of their woodlands from the harvesting plans of the forest companies. Their woodlands were considered too young to be clear-felled, although they represented a large source of material through thinnings (Åkerman et al, 2010). As such, small bioenergy developments were able to "offer practical solutions to pressing policy problems that industrial forestry has not been able to provide" (i.e. the problem of under-managed woodlands) (Åkerman et al, 2010: p. 187). This was achieved despite not offering competitive prices compared to the larger businesses. According to Peltola (2005), the small businesses and cooperatives from a case study of eastern Finland developed two main strategies to "survive" (Peltola, 2005: p. 202). The first was the integration of small scale initiatives into the concept of local and rural development to justify higher prices and thereby securing stable markets for these bioheat initiatives. The second route, although not exclusive from the first, was the sometimes reluctant investment in energy conversion facilities (i.e. equipment and networks) to become heat providers. This meant great efforts by a regional supporting public body to "encourage forest owners to make investments outside the scope of their traditional economic activities" (Peltola, 2005: p. 203).

Governance is also expected to be influenced by the degree to which businesses are reliant on woodfuel. Woodfuel in general and the specific type of woodfuel in particular (logs, woodchips or pellets), has implications for the chosen mode of governance. The experience from the forest product processing is clear: more stable exchange platforms, if not vertical integration, are preferred to spot market when the activity is central to the business (Jantunen et al., 2009). Although the formal match between governance and the characteristics of the transaction (and of the transactors) is developed in Chapter 8, the first categorisation of the actors and their activities presents the backdrop of governance. As such, this chapter presents who populates the supply chain in a first section and then, in a second part, explores activities and their degree of integration along the chain.

6.2 Who populates the woodfuel supply chain?

The first aspect to highlight in this section is the great variety of businesses and organisations involved in formal woodfuel supply in the region. Previous national snapshots
of the biomass actors’ base assert that it was “characterised by a multitude of players in the feedstock supply, conversion technology and energy-use stages of fuel chain that reflect the diversity of biomass energy options” (ICEPT and E4Tech, 2003: p. 62). This image of great heterogeneity is magnified when looking at a specific woodfuel feedstock supply chain. Although the national overview mentioned above suggests heterogeneity linked to the type of feedstock, the following picture provided by businesses and organisations in the South West shows that even at the level of each type of feedstock, there is great diversity in the type of suppliers. More diversity was suspected among informal activities but this was not directly addressed by this study, and is a potential area for further research.\footnote{Some hints about an ongoing professionalisation as part of informal activity were provided but cannot be said to be conclusive, not only because of the lack of specific data but also because any trend could have been modified by two cold consecutive winters (2008-09 and 2009-10) coupled with the recession affecting the traditional forestry, attracting newcomers into the firewood market (i.e. logs) both formally and informally.}

Businesses differed in their core activity, size (expressed in number of employees) and age, ranging from organisations that had operated for less than a year to those that had existed for centuries. Not all have entered the woodfuel market for the same reasons and are not expected to operate in it in the same way. The background of these organisations in the supply chain was crucial as they were expected to influence its structure providing:

- institutional experience and a certain tradition in doing transactions on timber products;
- (low) degree of dependence on outcomes of woodfuel transactions and long-term commercial relationships.

This description starts by presenting the individuals contacted for interviews on their woodfuel business experience, their type of business, size and years in operation. Possible implications of business characteristics on the woodfuel market are briefly outlined. Finally, the motivations for individuals and business engagement into the woodfuel market are identified and classified to present trends that are expected to influence the development of wood energy in the region.

### 6.2.1 Individuals contacted

The study focused on organisations. However, the experiences gathered as primary data for the analysis were shared by individuals with a top managerial role when available.
Therefore, basic demographic details are presented to introduce the decision makers of this sector.

Given the objectives of the study and the data shown in Table 6.1, most of the interviewees were individual owners or partners. The remaining group was generally composed of salaried general managers. However, there was a gender imbalance as only one female respondent with partner status and managerial role was interviewed.

The age distribution of respondents is shown in Table 6.2.

Table 6.2: Age class of respondents, (N=26)

<table>
<thead>
<tr>
<th>Age class</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-35 years</td>
<td>3</td>
</tr>
<tr>
<td>36-45 years</td>
<td>8</td>
</tr>
<tr>
<td>46-55 years</td>
<td>9</td>
</tr>
<tr>
<td>56-65 years</td>
<td>4</td>
</tr>
<tr>
<td>66-76 years</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
</tr>
</tbody>
</table>

Please note that almost all of the recorded participants pursued education after school. Table 6.3 provides a record of their formal education, with more than half of the people contacted having a degree or higher qualification.

Table 6.3: Formal education of interviewees, (N=26)

<table>
<thead>
<tr>
<th>Level</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>No education after school</td>
<td>4</td>
</tr>
<tr>
<td>A-level / Vocational A-level or equivalent</td>
<td>3</td>
</tr>
<tr>
<td>BTEC, other qualification below degree level</td>
<td>4</td>
</tr>
<tr>
<td>Degree level, including foundation degrees, PGCE</td>
<td>13</td>
</tr>
<tr>
<td>Postgraduate degree, MA/MSc, PhD</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
</tr>
</tbody>
</table>

Finally, it is relevant to highlight that in the last 2-3 years, almost all participants attended at least one seminar or a specific course dedicated to biomass energy (e.g.
Although several criticisms about the quality and the ultimate impact of the promotion initiatives were gathered from the interviews, a sense of improvement was shared by respondents with several experiences. This last aspect is developed in Chapter 7.

6.2.2 Type of businesses

The categories chosen were based on the definitions provided by the interviewees about their businesses. The data gathering process interviewed the following businesses, by alphabetical order:

CHIMNEY SERVICING: Maintenance service providers to solid fuel energy conversion devices. They are in frequent contact with users and may retail woodfuel products.

ESTATE: Traditional and long-standing land-use entity which is a diversified business that mainly manage farming, forestry, recreational/hospitality services and real estate activities. Its main characteristic is that it owns forested land and that its decision making process over a large variety of activities and land extension is centralised.

FARM: Mainly an agricultural unit that can diversify into forestry based products and recreational as well as hospitality services at a smaller scale than the estates. They can be on lease from an estate or have freehold status.

COMMERCIAL FOREST: Forested land owning business solely producing timber to be sold on the market to contractors, timber merchants or sawmills. Its management activities of plantations generate all grades of wood quality.

RECYCLING COMPANY: A waste management company that may or may not be specialised in biomass waste but handles large quantities of waste wood. This material has to be graded according to the waste disposal and incineration regulation as waste wood is often contaminated with toxic additives or have accumulated silicates.

SAWMILL: Primary forest product processor of imported, nationally and locally sourced timber. Its activity generates large amounts of wood by-product (i.e. off cuts and sawdust) that can be transformed, among others into garden inputs, horse and other animal bedding and woodfuel.

TIMBER MERCHANT: Trader and intermediary that provide semi-processed timber and wood material to sawmills and other forest product processors. Can be involved in harvesting and deals with imported, nationally and locally sourced material.

TREE SURGEON / LANDSCAPING COMPANY: This service provider is linked to wood harvesting through the management of parks, woodlands, and forested areas (e.g. along
railway lines and motorways). Their core activity generates large amounts of biomass by-products that have to be either disposed off as waste or transformed into garden inputs such as mulch.

**Woodfuel processor / broker:** Business that is (almost) exclusively operating as an intermediary and processor of wood energy material to be sold into the energy market. Its activities generally include the production and/or trading in logs, woodchips, pellets and other compressed products such as “ecologs” or briquettes. Material can be imported, nationally and locally sourced.

In terms of their relative representation, the kind of businesses included in the sample\(^2\) are presented in Table 6.4.

The majority of businesses have their roots in rural enterprises but not all. Such differences tend to reflect the origin and type of the raw material; whether locally sourced or imported, green or waste material. The rural based businesses are related to the forestry sector both at the production and processing stages. Although most of the group is generally related to forestry management and wood processing, only a minority actually owns woodland. Other backgrounds would be represented by farmers and waste management companies.

One woodfuel broker listed in Table 6.4 was the property of a landfill company holding. Although the affinity of the developing woodfuel sector to an established forestry sector may seem intuitive, important nuances exist. One of the factors is the variety of ownership structures of forestry and how forest management is organised. Another identified difference is whether bioenergy develops from the core of mainstream forestry or from its margins (e.g. small actors, neglected or expensive woodlands to harvest).

\(^2\)Please note that less structured exchanges were also conducted with five other businesses, mainly by visiting their facilities or attending sector meetings. When relevant, the experience of these actors is shared and referenced for information.
In the South West of England woodfuel is generally portrayed as a "by-product" of processes related to a core activity; so it is a side-line undertaking but for a minority of businesses. In only one case, was it the single activity of a specialised "firewood merchant" (No5 Woodfulex broker). In another case, a specialised company is a subsidiary of a parent organisation and benefited from its support, therefore being less reliant on its own (early) performance. All others, even the larger suppliers engaged in other activities not directly related to woodfuel supply or energy conversion devices. A detailed account of woodfuel-related activities and their implication for the structure of the sector is presented in Section 6.3.1.

### 6.2.3 Age of business and time in woodfuel trading

Keeping in mind the potential role of capabilities, the age of a particular business is important as it may be associated with experience. As such simple mean of the age of contacted business was twenty-three years old. In this first estimate, traditional estates older than 100 years old were excluded as they could be seen as outliers. However, they are important players in this specific market. Taking them into account raised the average age of the organisations that contributed to the study to 90 years old. The details and distribution are presented in Table 6.5 providing an adequate context to interpret the means of age as they are produced from a small sample.

When looking specifically at woodfuel activities, businesses had been operating during the last ten years on average but most had been active for six years or less. Woodfuel had not being an integral part of their activity and one that has recently been developed, even in the case of logs. Although it could be expected that estates differ as they historically played an important role in supplying wood as energy. However, they had gradually abandoned it as a major operation with the advent of coal. Some kept a supply of logs but it was only recently that interest in woodfuel has surged again as
new organisations entered the market.

6.2.4 Size of businesses

To illustrate the size of the type of enterprises contacted, a simple mean was produced stating that businesses employed between 16 and 17 people, ranging from sole-traders to larger companies employing up to 90 people. Please refer to Table 6.7 for a detailed account of the distribution size of enterprises according to their number of employees. In addition, and following the assumptions that the businesses are diversified, it was important to identify what share of the workforce were mobilised in woodfuel production and trade by the sample of organisations contacted. However, it was difficult to establish with accuracy the actual labour mobilised for woodfuel operations. When conducting forestry activities, labour carries multiple tasks and disentangling such efforts from the ones exclusively dedicated to woodfuel is not always possible or not routinely recorded separately. As such not all businesses were able to provide estimates.

By way of illustration, woodfuel mobilised the equivalent of almost three full time employees (2.8 on average) based on the educated estimates of participants. Table 6.6 details the employment distribution found on a small sample.

<table>
<thead>
<tr>
<th>Number of full-time equivalent</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>3</td>
</tr>
<tr>
<td>1-2.9</td>
<td>5</td>
</tr>
<tr>
<td>3-5</td>
<td>4</td>
</tr>
<tr>
<td>&gt;5</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
</tr>
</tbody>
</table>

6.2.5 Implications of the type of businesses

The group of businesses formally supplying woodfuel was wide ranging but the relatively small size of players, projects an image of a sector vulnerable to shocks that could jeopardise the energy security of users. The great majority had only been formally engaged in the woodfuel sector for a short period of time. However, when looking at their longevity as businesses, they may be small but were resilient.

A more important weakness in terms of the stability of the supply chain is the relative dependence such players had on the woodfuel dimension of their businesses. As businesses were seldom woodfuel based, we would expect this aspect to negatively influence
its dynamism as a sector and to lower the incentives for players to engage in ensuring its long term stability.

6.2.6 Origin of the woodfuel venture and motivations

The objective of this description is to identify the motives that have driven the participants to engage into woodfuel commercially. Recurrent themes will be used as representative of the motives that favoured entrance into the woodfuel market.

This material was mainly gathered from the answers participants provided when prompted to share why they had commercially engaged in woodfuel, but not exclusively as motivations sometimes also surfaced at other moments during the interviews. The motives exposed only partially represent the drivers of businesses and could be seen as subjective (re)presentations. Information on the history of businesses shared at other moments during the interviews provided examples of previous and failed ventures in supplying biomass for energy such as *salix spp.* (willow family), short rotation coppice, poplar plantation, unprocessed timber residues or energy crops. As such experiences are expected to have had some influence over their engagement they are also included in this section. Despite its limitations, the presentation of this data also provides some clues about perceptions of the woodfuel market.

The motivations explicitly mentioned by participants can be grouped into three recurrent main themes interacting with the emerging business opportunity connected to woodfuel, namely:

- Need
- Personal drive
- Resource-based

Table 6.7 on the next page, represents a systematic coding of answers relative to the motivations for entering the woodfuel market. Identified trends in Table 6.7 seem to be closely related to the core activities of the organisations concerned.

Two large groups emerged from the importance given to motivations with a clear distinction between those driven by “need”, mainly to manage their own waste, and others

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3 Please note that the answers of participants are quoted in small case and questions by the interviewer in capital letters.
Table 6.7: Motivations for woodfuel

<table>
<thead>
<tr>
<th>Organisation type</th>
<th>Size</th>
<th>Need</th>
<th>Resource</th>
<th>Opportunity</th>
<th>Past</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of employees</td>
<td>Personal drive</td>
<td>Waste</td>
<td>Security of supply</td>
<td>Intangible/ knowledge</td>
<td>Tangible/ financial</td>
</tr>
<tr>
<td>Chimney servicing</td>
<td>1</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.5</td>
<td></td>
<td></td>
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<tr>
<td>Estate</td>
<td>32</td>
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<td></td>
<td>+</td>
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<td></td>
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<td></td>
<td>60</td>
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<tr>
<td></td>
<td>n/d</td>
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</tr>
<tr>
<td>Farm</td>
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<td>20</td>
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</tr>
<tr>
<td>Recycling company</td>
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<td></td>
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<td>3</td>
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<tr>
<td>Sawmill</td>
<td>8.5</td>
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<td></td>
<td>12</td>
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<td>15</td>
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<tr>
<td>Timber merchant</td>
<td>12</td>
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<td></td>
<td>36</td>
<td></td>
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<tr>
<td>Tree surgeons / Landscaping companies</td>
<td>4</td>
<td></td>
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<td></td>
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<td>17</td>
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<tr>
<td></td>
<td>n/d</td>
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<tr>
<td>Woodfuel processors / brokers</td>
<td>1.5</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>3</td>
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<td>n/d</td>
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</tr>
</tbody>
</table>

*“+” Hints that this could be the case
*“$” Has the capacity to produce woodchips for energy

*“negative* Environment is seen as negative because of a lack of effective government support, therefore no development has been undertaken despite having readily accessible raw material

*“$” Implied from comments from salaried manager
by “capacity”: knowledge and resources to do so. This was also mirrored in their more frequently mentioned “opportunity for diversification” or “investment” by what could be called, the resource-led organisations. Although all motivation can eventually be found to a certain degree in all cases, this distribution is expected to influence the way different businesses engage in woodfuel transactions. Sawmills and tree surgeons had entered the market by necessity to manage their waste. Estates, recycling companies and some woodfuel brokers had been driven by their resources and capacity.

Before expanding on the motivations, it is important to illustrate how participants present opportunity.

Opportunity is generally perceived as:

“there is a niche market and a demand” Nº3 (Recycling company).

This is presented as the “Opportunity: Environment/Demand” in Table 6.7 on the preceding page. In this sense, the indirect influence of grants to stimulate boiler installations is also acknowledged on several occasions.

Additionally, opportunity resulted from an active search for diversification in the portfolio of investments, including the benefits resulting from embracing Corporate Social Responsibility.

Woodfuel was seen as an opportunity to diversify and could take the following shape:

"I have been in forestry for 25 years and there has been little money in forestry management because of the combined effect of the change in the fiscal policy and tax relief -that used to incentive plantation- and depressed timber prices. In parallel, wood-burners have been picking up and setting up this firewood business was a right move. Now, it represents 70% of my income with 30% of forestry services remaining" Nº19 (Woodfuel broker)

Need A first group is classified as motivated by "need" and arose here from two different factors. The main one is linked to waste management requirements derived from a core activity such as sawmilling, tree surgery but not exclusively. The need to ensure energy supply for wood powered boilers also played a role in developing woodfuel in the region, but this was either mentioned by actors who were users or those who were in partnership with users.

The following saw-miller’s account is illustrative of this main motivation:

"We are in a very small yard, we have no room. We were being swamped with our own waste materials. So we were giving the sawdust away as fast as
we could make it, and we were making a lot of sawdust. The slab wood was mounting until we could give it away and it was time consuming because we would deliver it, as well. It became a drain in the business." (Sawmill) N°32

Such space pressure resulting from a core activity prompted most of the concerned parties to dispose of it as fast as possible. Again this was clear with all participants directly involved in harvesting and processing timber:

"Before, we used to pay somebody to take it away and produce shavings for the bedding market but even (such prices) were very low, so I looked for alternatives" N°17 (Timber merchant)

In the cases where the waste as a cumbersome by-product had historically been solved, changes in established waste clearance channels had revived the interest in looking for alternatives:

"The mill produces 80 tons a week [of wood residues]. Formerly a large part was sold to a chipboard factory but now, it is only buying recycled wood". N°6 (Sawmill)

Finally, "need" can be linked directly to the use of woodfuel and expresses the requirement for energy security, as exposed by a member of a cooperative of users/suppliers. It was expected that some of this effect is present, but with much moderated influence, on other users also involved in supplying, such as the estates. Although a causal relationship was more difficult to establish for the estates, as it was not explicitly formulated, such possibility is indicated in Table 6.7 on page 152 because some of them were also commercial users of wood energy for space heating purposes.

**Personal drive or interest** Personal drive could be defined as the business owner or senior manager’s pet project. This is derived from personal usage of wood energy and convictions on specific topics (e.g. climate change).

Participants shared stories that led to more commercial engagement with woodfuel providing insights into both motivations and opportunity, such as the following experience:

"I realised, ten or eleven years ago that woodfuel could be a huge boost for British forestry. [...] I put a log burning central heating system in my house about 27 years ago and I was considered to be a lunatic: A thatched cottage with a log burner! [...] I always have been convinced that woodfuel was the way. [...] Then I started to get interested in the concept, fascinated by the machines and how they developed from my own wood burner. [...] [After a coincidental meeting at a European fair], we are (also) now the official UK agent for [a boiler brand]". N°20 (Sawmill)
In the same vein, the following illustrates the interaction between motivations and opportunity in promoting the development of woodfuel as a commercial activity:

"It is a personal thing really. It followed a large contract [...] Then I was building a house and decided to put a biomass boiler into it. It followed from there, really. Commercially, it was that particular contract and we had a huge volume. At least 1400-1500 tonnes were sent to the CHP station of Slough. It is a lot of material to move or dispose of [...]. So that particular contract opened our eyes, I suppose. Rather than looking at woodchip as a means of getting rid of it, whatever the cost, we are looking at it in a different way". No22 (Tree surgeon)

**Resource-based** In addition, resource-based motivations for the development of the activity also emerged from the interviews but tend to be more associated with the larger organisations (e.g. estates), including the ones not coming from the forestry sector (e.g. recycling companies). However, such a trend was not as marked as the trend linked to the core activity. The capacity to engage in woodfuel was formulated as a motivation. These motivations can be presented in the following classification developed by the Competence or Resource-Based View of the firm (RBV). Using this model in interpreting the answers to the motivation driven by "capacity" was closer to how participants intuitively shared their experience on why they were developing a woodfuel arm to their businesses. An overview of the central tenets of this approach are presented in Chapter 3.

A thorough review of the RBV literature specific to the Finnish woodworking industry was developed by Lähtinen (2007) and, as an adapted base for reading the participants comments, was used as a reference here.

As developed in the theoretical chapter, Chapter 3, RBV understands that firms' resources can be tangible or intangible and their combination will define their competitiveness in a business environment. The tangible resources are related to geographical location, raw material access, availability of trained workforce, characteristics of productive plant and machinery and financial capital. With respect to the intangibles, firms are seen as "repositories of productive knowledge" (Foss, 1996: p. 8). These include human capabilities and know-how, organisational capital and routines, technological assets and designs and "relational capital" based on reputation and certifications.

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4As developed in Chapter 3, this framework of what is a firm is an alternative to the Transaction Costs but shares several assumptions with it.

5Although it is a competing framework to explain the make or buy decision, this family of theories of the firm are complementary in many respects. Following Bohlin here, we are not centring on the theoretical debate and contradiction but rather using the "complementary factors between theoretic stances" (2001: p. 7).
Spontaneous mention of resources as a motive tended to resonate more in terms of intangibles such as:

"What became quickly apparent is that we had the logistical skills to handle high volume and low weight product in terms of woodchips. On forestry I was losing money on our lowest grade forest products [...]. So anything that we could do or use it for would make a difference." N°15 (Estate)

This versatility in adapting skills in new activities followed Teece as "externally, these competencies may be perceived as a firm’s skill in a particular product area. However, a competence is the ability of a firm to solve organisational technical problems, and thus it is not limited to a specific set of products" (2008: p. 58).

Such know-how as the corner-stone of starting the activity had also been expressed more precisely as:

"There was a market gap with boiler suppliers with no one who knew anything about the fuel. The boiler suppliers thought they knew about but (we) quickly found out that they didn’t. They didn’t know how to store it, deliver it nor how to make it. [We] realised that was an opening for [us] and [we] had the experience of what the boilers needed, graded chip and that sort of thing." N°25 (Woodfuel broker)

The tangible resource-based motivation is mainly related to access to raw material:

"[We] produce large quantities of woody residues and woodfuel is one of the natural niches. [We have] always sold some waste for heat, particularly for open fires" N°1 (Sawmill)

However, this access to raw materials was shared by almost all participants but tended to be more frequently presented as a liability linked to the motivation of "need" derived from waste management imperatives, rather than as an asset. Evidently however, once engaged in the biomass market, this liability evolves into an asset.

Financial resource as an asset does not spontaneously emerge as a motivation to engage except for a few of the businesses. These options arise from self-financing, venture capital⁶, subsidies and grants from public programmes. Paradoxically it is worth mentioning that the majority of businesses contacted had specifically benefited from some government support to develop their woodfuel activities. This excludes those that only

⁶Note that this, although at a smaller scale, could be possibly associated with the recent development of private equity in in the forest, paper and packaging industries, identified by an analysis of non-traditional investors by PricewaterhouseCoopers (PWC, 2007).
benefited from grants to purchase energy conversion devices such as a boilers, and focuses on capital support to develop productive capacity. A higher proportion of the participants was expected to have benefited from public grants in general and not exclusively for woodfuel, if linked to agriculture, but such data is not reflected here. The most likely explanation of this apparent paradox of not having a spontaneous stronger influence of financial asset as a motivation is the fact that many would have engaged in woodfuel with or without support. Public support seems to have had the effect of allowing larger and potentially more profitable levels of investment in infrastructure and machinery for the producers.7

For non-forestry actors, resource was clearly the main motivation and a rich combination of both tangible and intangibles was mentioned. The assets range from financial capital to know-how that is generally alien to forestry-based businesses:

"We were very prominent in the landfill gas business in the 1980s, which was seen as a renewable. [...] That led to some experience in [electricity] generation. [With that and] the moral and social responsibility that the company has, [it] decided to look at more renewable technologies from landfill gas, green hydrogen from landfills as most hydrogen is produced from fossil fuels. They looked at woodpellet in 2005. They purchase a stake in [an existing bioenergy company]." N°33 (Woodfuel broker)

Finally, a historical relationship with the resource itself, along with previous (failed) commercial experiments and sunken investments can be identified as a factor influencing engagement, if not directly as a motivation per se. For the estates, biomass production for energy was not new, particularly through traditional logs but several had recently engaged in failed feedstock production for bioenergy, following governmental initiatives in the 1980s and 1990s. The products based on willow or poplar were:

"never (used) for biomass energy" N°15 (Estate)

or

"that failed: it wasn’t used as biofuel" N°13 (Estate)

Some of the woodfuel brokers also experimented with various products before identifying a suitable one, as the original ones:

"[did not] give enough added value" N°32 (Woodfuel broker)

7The details of this aspect are presented with Section 8.3.
6.2.7 Who populates the supply chain: Summary

The first aspect to highlight is the great variety of organisations involved in formal woodfuel supply in the region. The majority had their roots in rural enterprises but not all. The differences reflect the origin and type of the raw material; whether locally sourced or imported, green or waste material. The rural based businesses were related to forestry but only a minority actually owned woodland. Woodfuel was generally portrayed as a "by-product" of processes related to a core activity; so it was generally a side-line undertaking with only a few specialist operators. Woodfuel had an influence on employment, however when conducting forestry activities, labour carried multiple tasks and disentangling such efforts from the ones exclusively dedicated to woodfuel was not always possible or not routinely recorded separately. The motivations for engaging in woodfuel explicitly mentioned by participants were grouped into three recurrent main themes interacting with the emerging opportunities for woodfuel, namely: i) personal drive and interest, ii) need to manage waste, and iii) resource-based in know-how and capital to invest in new ventures. These motivations and their various combinations partially explain why these businesses had engaged with woodfuel but other factors were not controlled for here. A more complex issue was the consistency of their interaction with opportunity which was not possible to establish here, given the available evidence. What was not clearly identifiable was the extent to which they created the opportunity for woodfuel as the overwhelming majority saw woodfuel as a side-line. This may translate into lower interest in developing long-term relationships along the supply chain.

6.3 Characteristics of the woodfuel market

6.3.1 Range of woodfuel-related activities

The flow from upstream to downstream of woodfuel supply can be divided into several steps or activities. Here, we divide it into activities that can be easily associated with Williamson's "technologically separable interface" and therefore be susceptible as objects of a transaction where "one stage of activity terminates and another begins" (1985: p. 1).

Following the rich literature on forest energy logistics (Anderson et al., 2002; Asikainen et al., 2002) a simplified list of activities was presented to participants to record whether they undertook them (by "yes" or "no"). The answers of participants were then aggregated to produce an image of what part of the supply chain is generally controlled by
suppliers, regardless of size and volume produced. We approach the chain of activities from its core: the storage of woodfuel. This should be seen as our reference when analysing its connection with the upstream part of the chain involving land ownership and harvesting activities, and in turn with the downstream section looking at retailing, haulage and other service-related activities. Figure 6.1 provides the visual support to this representation.

6.3.2 Degree of integration of activities along the supply chain

Looking at the activities carried by the businesses contacted in Figure 6.1, activities and processes potentially undertaken by woodfuel suppliers were more frequent than others. This is presented as percentages to allow a visual examination of the two groups but does claim to have statistical significance given the small sample.

The first aspect to highlight, starting upstream of the chain, was that less than a third of businesses formally offered woodfuel from their own forest land. However, businesses tend to be close to the source of their material as about two thirds were also involved in harvesting, both purposely or generating material as a by-product of a management service.

All processed and/or sold some woodfuel product. Log processing was the most common activity, with more than half the businesses contacted involved. However, woodchip production capacity was almost as common but this should be interpreted as “capacity” to do so, rather than a systematic commercial undertaking. This data represented businesses involved in harvesting that tended to possess some chipping capacity. Actual production and sales of woodchip for the energy market was only recorded for a third of organisations contacted. Pellets were far less common as a produced and sold commodity in terms of the number of actors involved. Only a marginal proportion of the sample contacted was active in pellets. Some important overlap in offering different types of fuel was recorded from the sample, however. These details are recorded in Table 6.8 and disaggregated by combined products such as offering both logs and woodchips.

The parallel production of logs and woodchips was the most common combined production and provides additional rationale to avoid marginalising log processors from study of the woodfuel market.

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8 Please note that one of the businesses contacted is offering alternative biomass feedstock to wood (i.e. straw, miscanthus) and was not included in this details of products.

9 This represents the total of business offering logs. Please note that this also includes businesses offering logs in combination to other fuels, such as woodchips. The result is therefore the addition of the businesses producing logs only and the other businesses that may do so in addition to another fuel.
Figure 6.1: Activities around woodfuel, Percent of businesses, (N=28)
Further downstream, almost two thirds ensured haulage of their products to their customers; the rest relied on either the buyer’s capacity or more generally on haulage contractors. Fuel suppliers rarely provided bioenergy consulting, installation of boilers and stoves and their respective servicing. However, a majority asserted that they provide informal information to their current and potential customers, although some complained that this was very time consuming, reflecting weaknesses in the level of information held by users and potential users of woodfuel.

In parallel to the nature of the product, the outlet channel was also recorded as sales to end-users, wholesale to brokers and own consumption, which was partially captured by the concept of own commercial use. The breakdown of channels and their combination is presented in Table 6.9 where direct retail to end-users was the most common one. The

<table>
<thead>
<tr>
<th>Outlet</th>
<th>Frequency</th>
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</thead>
<tbody>
<tr>
<td>Retail to end-users</td>
<td>14</td>
</tr>
<tr>
<td>Wholesale to broker</td>
<td>6</td>
</tr>
<tr>
<td>Sells to both end-users and brokers</td>
<td>6</td>
</tr>
<tr>
<td>Own consumption only*</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

* These are currently not commercially operational but are to become so

This is probably the result of the sample being biased towards businesses that are generally advertising their material to potential end-users. Despite this bias, it is worth noting that about a fifth of all interviewees were actually exclusively selling to woodfuel brokers. To identify possible differences between the two groups, Figure 6.2 presents the proportions of the different outlets: selling exclusively to woodfuel brokers or to end-users. Again, as in Figure 6.1, this is presented as percentages to allow a visual examination of the two groups but does claim to have statistical significance given the

\[10\] This reflects the total of suppliers retailing only and those doing both retailing and wholesale.
small sample. From the visual inspection of the activities of each groups two possible trends may differentiate one from another: one associated with the upstream and the second with downstream part of the supply chain.

The first possibility\textsuperscript{11} is that the majority, those dealing with end-users, may be less likely to own forested land and even less likely to be involved in harvesting. This suggests limited levels of vertical integration between primary extraction and processing into woodfuel, implying the reliance on other channels for the management of the upstream part of the supply chain (i.e. spot markets, contracting and other hybrids). Although coordination is needed from a physical perspective, in a stricter sense of an external transaction this is not necessarily the case. Several businesses that neither owned land nor harvested could both produce and then process material into woodfuel without engaging in exchange, as it is the case for sawmills and other actors gathering material as a by-product\textsuperscript{12}. This opens the issue of the economic dimension of the transaction as woodfuel does not always emerge directly from the forest but can do so further downstream, resulting from an industrial process as by-product or waste.

Woodfuel can be seen as the result of a process that creates joint-products. Let’s take the example of a sawmill that in one hand it produces timber for construction purposes and, in the other hand, basic woodfuel material (slab wood and off cuts) as a joint-product. Even if it still has to be processed the cost of Bringing the raw woodfuel to a sawmill yard or other processing facility to process it into logs, woodchips or pellets is close to zero and almost inseparable from that of bringing the material in for the main product (i.e. timber for construction). As such the transport costs could be assumed to be undistinguishable between timber for construction and woodfuel and be fully borne by the main activity: timber for construction. The effect of the joint-products on the transport costs of woodfuel can be captured with the concept of the “economic distance” to be differentiated from a simple geographical measurement of distance that would account for the origin of the wood but would over estimate the importance of transport costs, as they can safely be assumed to be close to zero in the case of joint-products. Please refer to Section 6.3.5 for its definition and an example for the South West, based on the data gathered for this project. As long as these woodfuel processing businesses do not buy in material specifically designated to be processed as woodfuel, there is no relevant external transaction upstream. Such an example of a by-product (that could be associated with the same properties of joint-products) from a service related activity is special as it could be seen as partially reproducing the effects of land-ownership. However, it does not offer its advantages in terms of controlling the supply of material as it remains dependent upon other core processing activities.

\textsuperscript{11}Any meaningful non-parametric test is prevented by one group being less than ten cases strong.

\textsuperscript{12}Please refer to the Section 6.3.5.
Figure 6.2: Activities around woodfuel by outlet, Percent (N=28)
The second is related to the possible trend that land-owning businesses and those involved in harvesting are more likely to use woodfuel as a source of energy for commercial purposes, either for office space heating or industrial process such as drying.

6.3.3 Volumes

The measurement of woodfuel volumes traded in the region is a difficult exercise that has been attempted recently with not much success. Specialist estimates have been used as a reference instead. The only recently compiled figures for the UK were presented “as broadbrush estimates rather than accurate figures” (Forestry Commission, 2009) and were only published as an aggregated figure\(^\text{13}\).

In the framework of this project, the results of the exercise are limited to the sample contacted and only provide some indication of volumes actually traded in the region. Given the great variety of units used, once the data gathered, it had to be standardised into a single metric. Participants provided estimates of their volume traded in a year of operation. As several measures of weight and volumes are used by businesses in their daily trade, the following data has been standardised to the Oven Dry Tonnes (odt) metric used by the Forestry Commission. This standard measure assumes 0% moisture content (MC). However, the conversion coefficients between weight, volumes and moisture content vary and there is no officially recognised conversion standard. The standardisation used here combined the measures used by FAO (2004), Forestry Commission (2009) and Hudson (1993). The material is rarely oven dried, but only seasoned and generally sold with moisture content compatible with the use of the material with woodchips at less than 35% MC. The “seasoned” logs are assumed to be at 25% MC. Finally, pellets are assumed to have a 10% average for moisture content. The conversion rates used here for the standardisation of volume traded are as indicated in Table 6.10.

\(^{13}\)Please note that attempts were made by the author to access the regional results of a survey aimed at feeding this estimate. However the data was not shared. The poor quality of the data and its confidential nature was heralded for not disclosing the information by the Forestry Commission contacts.
Table 6.12: Estimated volumes traded by businesses in the South West (2009-2010)

<table>
<thead>
<tr>
<th>Woodchips</th>
<th>Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimates</td>
<td>16000*</td>
</tr>
</tbody>
</table>

* Originally estimated as 2100 and 24000 tonnes respectively. These were converted into odt, following the rule used in Table 1.10.

Source: Adapted from Rowson (2010) for the IEE FOREST project.

Table 6.10: Conversion table: Coefficients for standardising weight and volumes into Oven Dry Tonnes equivalent (odt).

<table>
<thead>
<tr>
<th>Logs and roundwood</th>
<th>Woodchips</th>
<th>Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green tonne</td>
<td>0.47</td>
<td>0.44</td>
</tr>
<tr>
<td>Green CUM (m³)</td>
<td>0.20</td>
<td>0.11</td>
</tr>
<tr>
<td>Seasoned* tonne</td>
<td>0.75</td>
<td>0.70</td>
</tr>
<tr>
<td>Seasoned* CUM (m³)</td>
<td>0.32</td>
<td>0.18</td>
</tr>
<tr>
<td>Tonne of pellets</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Seasoning is assumed to have reduced moisture content to 25% for logs and to 30% for woodchips.


Table 6.11 presents two different results for each main fuel. The first line, “Results” consists of material actually traded in the South West for which double accounting was controlled for when possible (i.e. if the sale was to an end-user or a broker). This result also excluded aggregated data provided by businesses for sales that have not occurred in the region.

Table 6.11: Volumes traded by businesses contacted in the South West (2008-2009), odt equivalent.

<table>
<thead>
<tr>
<th>Logs</th>
<th>Woodchips</th>
<th>Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>4766.25</td>
<td>2795.75</td>
</tr>
</tbody>
</table>

To provide perspective on this sample, it is useful to also include an estimate for the region as a whole on the material traded. Note that this estimate is not the result of records but an extrapolation from known installed capacity developed to compare the state of development of the South West with other European regions fostering their wood energy (Rowson, 2010).\(^\text{14}\)

\(^{14}\)The aggregated data of this reference was also presented in Chapter 2.
6.3.4 Prices of woodfuel

The interviews also aimed at collecting information of the selling prices set by businesses at the time. Although this information could be expected to be public, not all participants were willing to share this information, some because of confidentiality concerns but others asserting that prices would be very different according to each transaction.


<table>
<thead>
<tr>
<th>Prices</th>
<th>Logs</th>
<th>Woodchips</th>
<th>Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>93</td>
<td>45</td>
<td>170-195</td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>66</td>
<td>215-250</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>131</td>
<td>122</td>
<td></td>
<td></td>
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<tr>
<td>187</td>
<td>157</td>
<td></td>
<td></td>
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<tr>
<td>187</td>
<td>163</td>
<td></td>
<td></td>
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<tr>
<td>200</td>
<td></td>
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<td></td>
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<tr>
<td>218</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>234</td>
<td></td>
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</tbody>
</table>

However, as highlighted in section 6.3.3 about volumes traded, prices were not provided according to a common standard. They could be expressed in ill-defined “loads”, green or dry, volumes or weights. All prices have been converted to a common denominator (odt) to circumvent this problem. This was performed following the conversion rates chosen and presented in Table 6.10. The results of the conversions are presented in Table 6.13. However, the conversions are based on assumptions and his may affect the accuracy of the converted price, possibly widening the distribution of the prices.

That said, the data available is consistent with the known fact that woodfuel sold as logs tends to be more valuable\(^\text{15}\) than if sold as woodchip.

This could be linked to the fact that the log market offers retailing price opportunities (i.e. households) and that woodchips will tend to be sold in larger bulks. Also, logs will tend to be made of hardwoods generally more valuable than softwood.

For comparative purposes, Table 6.14 presents a more recent estimate of prices (Feb. 2012) for domestic and small commercial users contrasted with calculated averages

\(^{15}\)This is also the case in continental Europe, as developed upon during informal interview with a representative of the Forêt Privee Française, the French Woodland Private Owners Association. They recommend woodland owner members possessing hardwood to develop their activity with logs as it is in general more profitable.
Table 6.14: Average prices in GBP comparing odt and seasoned tonne (30% MC) of material

<table>
<thead>
<tr>
<th>Unit</th>
<th>Woodchips</th>
<th>Logs</th>
<th>Pellets</th>
<th>Source</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasoned tonne</td>
<td>100</td>
<td>45</td>
<td>200</td>
<td>Biomass Energy Centre</td>
<td>2012</td>
</tr>
<tr>
<td>Seasoned tonne</td>
<td>120</td>
<td></td>
<td></td>
<td>Author</td>
<td>2009</td>
</tr>
<tr>
<td>odt</td>
<td></td>
<td></td>
<td></td>
<td>Biomass Energy Centre</td>
<td>2012</td>
</tr>
<tr>
<td>odt</td>
<td>105</td>
<td>160</td>
<td>170-250</td>
<td>Author</td>
<td>2009</td>
</tr>
</tbody>
</table>

Source: Author from interviews (2009) and Bioenergy Energy Centre (2012).

from Table 6.13estimates in odt and seasoned tonne (30% MC). The estimate from the Bioenergy Energy Centre is rare data. Data on prices is even less available than for volumes traded.

### 6.3.5 Distances from source to combustion

Although traded internationally at large scales, a major characteristic of woodfuel at the smaller scale is its geographical limitation associated with inland transport costs. During the interviews, information regarding distances to and from the processing / storage facilities was gathered from estimates provided by the participants. In the South West, sourcing was within 60 miles\(^{16}\). For more than half of the businesses it was within a 30 mile radius and for the overwhelming majority it was under 60 miles to the processing or storage facilities. This data refers to the biological source of the material and was biased in the sense that it does not account for the volumes traded with these ranges. The frequency of average haulage distances from source to processing or storage yard of interviewed businesses is presented in Table 6.15.

Table 6.15: Mean hauling distances from source to processing/ storage yard (valid N=23).

<table>
<thead>
<tr>
<th>Distance range in miles</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>8</td>
</tr>
<tr>
<td>10-29</td>
<td>6</td>
</tr>
<tr>
<td>30-59</td>
<td>4</td>
</tr>
<tr>
<td>60-150</td>
<td>2</td>
</tr>
<tr>
<td>beyond 150</td>
<td>3</td>
</tr>
<tr>
<td>No data</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

\(^{16}\)This excludes businesses that act as pellet brokers that only imported their material from outside the region and, more importantly, from abroad. The average distance including imported pellets jumps to 110 miles from source to yard. This group is only marginally represented among businesses.
Table 6.16: Mean “economic distance” from source to processing/storage yard, accounting for joint-products (valid N=23).

<table>
<thead>
<tr>
<th>Distance range in miles</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>11.0</td>
</tr>
<tr>
<td>10-29</td>
<td>6.0</td>
</tr>
<tr>
<td>30-59</td>
<td>4.0</td>
</tr>
<tr>
<td>60-150</td>
<td>0.0</td>
</tr>
<tr>
<td>beyond 150</td>
<td>2.0</td>
</tr>
<tr>
<td>No data</td>
<td>7.0</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>

To make such estimates more representative, weighted averages were calculated, meaning that the influence of one particular business is proportional to its volume traded in dry tonne equivalent as estimated in Section 6.3.3. In addition, given the by-product nature of woodfuel which can be treated as a joint-product, the actual “economic distance” from source to processing facility can be substantially smaller. The main example of these are sawmills, where off-cuts, slab wood and some round wood were generated on site, actually making the distance to source close to zero. All transport costs are assumed to be borne by the main timber product when woodfuel is a joint-product.

The revised distances accounting for actual transport distances associated with woodfuel material are presented in 6.16. The difference between Table 6.15 and Table 6.16 is that the latter replaces the original distance from source to processing facility of the main material of the joint-production resulting in a main timber product and woodfuel to zero when woodfuel is not purposely transported.

Accounting with the volume coefficient alone the average distance between source and yard is about 100 miles, pointing to the large proportion of material ultimately used as fuel that originate well beyond the simple average distance. However, what we call the “economic distance” drops to 20 miles as some businesses use wood originating as residues from other activities, as in joint-products for which it is not possible to separate the respective contribution to transport costs and which safely be fully attributed to the non-woodful core activity. When looking at some of the processed woodfuel products separately, the weighted averages were in the range of 6.5 miles for logs and 16.5 miles for woodchips. Pellets tends to be imported from outside the region, if not the country.

Only as indicative information, maximum distances to source were also collected averaging 200 miles for logs and woodchips. Participants engaged in woodchips and logs unanimously identified such maximum distances as indicators of sub-performance. However this was not necessarily the case for pellet suppliers as some profitably import part or their entire volume from continental Europe. In turn, weighted average sales
were within a 50 mile radius when excluding recorded exports to mainland Europe. As expected, log sales tend to be very localised and were developed within an average 15 mile radius. Conversely, woodchip sales reach 45 miles on average with pellets going well beyond that as they are shipped by courier services to any point from the region, for example to the Scottish border. For reference, please note that estimates for forestry material are within a maximum of approx. 60 mile (100 km) radius around processing or user location (Asikainen et al., 2002) and an average approx. 35 miles (55 km) for Scandinavia (Anderson et al., 2002).

6.3.6 Customers

The information of the customers of the business contacted is sketchy and the percentages presented here have the only purpose to suggest proportions and allow for a visual suppor to the data. As mentioned in Section 6.3.2, not all businesses sell their produce to end-users, with some trading exclusively with woodfuel brokers. Those that deal with end-users have a customer base that can be divided into five main categories and it is illustrated in Figure 6.3. End users have been classified as domestic users, rural (i.e. farms, estates) and urban commercial users (i.e. services and industry), public organisations (i.e. schools) and CHP or power plants. Figure 6.3 is dominated by domestic users, mainly reflecting the great proportion of businesses offering logs more widely at this end of the market.
Figure 6.3: End-user customers of woodfuel, Weighted percent (N=19)

However, when looking at the businesses actually offering woodchip for energy (N=8), excluding those that only have stated the potential to do so, the picture was more evenly shared between the different categories of users. From the little evidence gathered, participants trading chips and pellets had a smaller proportion of transactions involving domestic users with commercial or institutional users being the main users.

6.4 Summary

The first aspect to highlight is the great variety of organisations involved in formal woodfuel supply in the region. The majority had their roots in rural enterprises but not all. The differences reflect the origin and type of the raw material; whether locally sourced or imported, green or waste material. The rural based businesses were related
to forestry but only about two thirds actually owned woodland. Woodfuel was generally portrayed as "by-product" of processes related to a core activity; so it was generally a side-line undertaking with only a few specialist operators. Woodfuel had an influence on employment, however when conducting forestry activities, labour carried multiple tasks and disentangling such efforts from the ones exclusively dedicated to woodfuel was not always possible or not routinely recorded separately. The motivations for engaging in woodfuel explicitly mentioned by participants were grouped into three recurrent main themes interacting with the emerging opportunities for woodfuel, namely: i) personal drive and interest, ii) need to manage waste, and iii) resource-based in know-how and capital to invest in new ventures. These motivations and their various combinations partially explain why these businesses had engaged with woodfuel but other factors were not controlled for here. A more complex issue was the consistency of their interaction with opportunity which was not possible to establish here, given the available evidence. What was not clearly identifiable was the extent to which they created the opportunity for woodfuel as the overwhelming majority saw woodfuel as a side-line. This may translate into lower interest in developing long-term relationships along the supply chain.

Although only one third owned woodland, businesses tended to be close to the source of their material and about two thirds were also involved in harvesting, both purposely or generating material as a by-product of a management service. Log processing was the most common activity. However, woodchip production capacity was almost as common if understood as accounting for businesses involved in harvesting but also possessing some chipping capacity. Actual production and sales of woodchip for the energy market was only recorded for a third of the organisations contacted. Only a marginal proportion of the sample contacted was actively selling pellets. However, some important overlap in offering different types of fuel is recorded from the sample. As expected, log sales tended to be localised and were developed within an average 15 mile radius. Conversely, woodchip sales reached 45 miles on average with pellets going well beyond that as they could be shipped by courier services almost anywhere in the country.

Some information about the customer base was also gathered and was divided into domestic users, rural (i.e. farms, estates) and urban commercial users (i.e. services and industry), public organisations (i.e. schools) and CHP or power plants. The data showed that log use is dominated by domestic users. In turn, actual woodchips suppliers were selling their produce evenly between the different categories of users.

\[17\] This is a weighted mean. Although the sample is small, it is illustrative to present it as a reference of the order of magnitude of distances.
Chapter 7

The difficulties and issues raised by participants

7.1 Introduction

Critical factors to the development of the woodfuel supply chain were identified from the literature (see Chapter 2) and were evaluated by participants in the interviews.

The material collected had two dimensions. The first was a ranking exercise and the second gathered the rationale for such a ranking. The initial part aimed at identifying, following respondents’ experience, the importance of a series of barriers in developing their woodfuel business opportunities. These were ranked by the participants on a Likert scale with the options ranging from “not relevant”, “minor”, “important” and “very important” to identify general issues. Not applicable (N/A) was coded when the question was not considered by participant to be in the realm of their experience and when irrelevant to their activity. The results for interviewed businesses are presented in Figure 7.1. The questions were repeated by insisting on the current situation to identify improvement or a sense of status quo, assuming that past experience could have been different. In addition to the businesses, participants from supporting institutions and organisations have also been requested to do the same exercise on barriers, looking this time at the market as a whole and their comments were included in this Chapter.

The second part of the information gathering process consisted of requesting further comments and details about the rationale behind the ranking. Finally responses to questions involving aspects, such as barriers and other critical factors highlighted by
Figure 7.1: Importance given by businesses to barriers to the development of their woodfuel activity (N=26)
the participants, were identified and coded and are to be discussed in this section.

7.2 Material availability

7.2.1 Physical dimension

At the most basic level, physical availability of woody material is a deterministic factor, in the spirit of Schmidt (1992 in Wörgetter et al., 2002). The potential of bioenergy depends on area, productivity and population density. Although the UK only has about 0.05 ha of woodland per inhabitant, it can be argued that forest extension is not defining per se, as shown by the success of Denmark with a not so different 0.1 ha per inhabitant, well below the EU27 average of 0.36 ha, or Austria with 0.5 ha per inhabitant (McKay 2006; MCPFE, FAO et al. 2007; Eurostat 2009).

When directly asked, wood scarcity as such does not seem to be the most important challenge faced by the participants as more than 50% ranked it as “not relevant”. Such participants implied a good supply and future prospects confidently saying:

“There are vast amounts of wood available” N°23 (Commercial forest)

Actually, they complained about excessive material availability:

“All our woodchip, at the moment, goes to Slough power station. Well not all of it because they never want all of it. So we are looking into other markets at the moment. England seems to be glutted with woodchips at the moment”. N°14 (Tree surgeon).

This largely echoed the drivers of a large portion of suppliers needing to process by-product wood material\(^2\). However, the share dependant on a by-product is susceptible to the variations in the volume of activity from the traditional forestry sector, itself linked to the business cycle. Although there are hints of counter-cyclical behaviour of woodfuel activity\(^3\), physical availability of wood by-products will follow the rest of the economy. A reminder of this link was provided by the following recent development:

\(^1\) Question Q14a in the Appendix D.  
\(^2\) Developed in Section 6.2.6  
\(^3\) As shown by the resilience and even development of labour implications of woodfuel within traditional forestry actors currently suffering from the recession triggered by the sub-prime bubble bust since 2007-08. See also Subsection 6.2.4.
“If you take last year [2008], for instance, there was a large bedding shortage for wood savings, so they were taking a lot of pulpwood out of the market. That coupled with the economic downturn, meant that Forestry Commission weren’t cutting the trees to get the saw logs, because the sawmills [went] all quiet. So, we didn’t have any pulpwood and the prices started shooting up for the pulpwood which then made the cost of the raw material for the woodchips incredibly expensive.” N°3 (Recycling company).

Material availability was also corroborated by public agencies and private supporting organisations. However, physical availability was not a guarantee per se for the development of the sector.

“It is not difficult to access logs. If you wanted it, you could find it. But a log is different from a woodchip, as we discussed and I think there is a problem with the process. [However], I cannot be sure about that because every boiler that is installed seems to be running or would be running if the technology was right: they are not [stopped] because of a lack of supply!” N°29 (Private supporting organisation).

However, when physical wood scarcity was seen as relevant by the business interviewees, it seemed to be a central issue with a quarter of respondents ranking it as “very important”. The comments on material availability in the South West provided a stark contrast between Cornwall and the other counties of the Region, as depicted by Table 7.1. Almost all businesses operating in Cornwall expressed current or foreseen difficulties related to procurement, irrespective of the nature of their business. Even tensions between alternative energy uses of wood had been reported, such as the competition between firewood merchants and woodchip suppliers over softwood, which is generally of less interest to the firewood merchants that traditionally focus on hardwood.
Table 7.1: Importance given to perceived wood scarcity, by county of activity (N=26)

<table>
<thead>
<tr>
<th>Importance</th>
<th>Devon</th>
<th>Cornwall</th>
<th>Dorset</th>
<th>Gloucestershire</th>
<th>Somerset</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Minor</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Important</td>
<td>0</td>
<td>1*</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Very important</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>26</td>
</tr>
</tbody>
</table>

*Although based in another county, this business also operates in Cornwall. Follow up comments on scarcity were directed to issues faced in Cornwall, so here it is classified as based in "Cornwall".

Table 7.2: Woodland area by county

<table>
<thead>
<tr>
<th>County</th>
<th>Woodland area (Ha)</th>
<th>Woodland cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avon (former)</td>
<td>8 364</td>
<td>6.3</td>
</tr>
<tr>
<td>Cornwall</td>
<td>26 869</td>
<td>7.5</td>
</tr>
<tr>
<td>Devon</td>
<td>66 661</td>
<td>9.9</td>
</tr>
<tr>
<td>Dorset</td>
<td>28 758</td>
<td>10.8</td>
</tr>
<tr>
<td>Gloucestershire</td>
<td>29 752</td>
<td>11.2</td>
</tr>
<tr>
<td>Somerset</td>
<td>24 290</td>
<td>7.0</td>
</tr>
<tr>
<td>Wiltshire</td>
<td>27 326</td>
<td>7.9</td>
</tr>
<tr>
<td>Total</td>
<td>212 022</td>
<td>8.9</td>
</tr>
</tbody>
</table>


Comparing perceived scarcity on Table 7.1 with the recorded woodland cover in Table 7.2, does not provide a direct explanation of the highly spread perception of scarcity in Cornwall, particularly when contrasted with the sample from Somerset, which has similar woodland cover.

*Please note that the Forestry Commission is currently updating the Forest Inventory methodology given questions about the precision of its estimates. The data provided here is the official one and for the purpose of a simple comparison it is assumed to be reliable (Forest Research and RDI, 2009).
Table 7.3: Proportion of broadleafed and conifer woodland by county

<table>
<thead>
<tr>
<th>County</th>
<th>Conifer (Ha)</th>
<th>Broadleafed (Ha)</th>
<th>Mixed (Ha)</th>
<th>Broadleaf / Conifer and Mixed ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avon (former)</td>
<td>866</td>
<td>5569</td>
<td>1820</td>
<td>2.07</td>
</tr>
<tr>
<td>Cornwall</td>
<td>5096</td>
<td>17758</td>
<td>2739</td>
<td>2.27</td>
</tr>
<tr>
<td>Devon</td>
<td>16792</td>
<td>39417</td>
<td>8788</td>
<td>1.54</td>
</tr>
<tr>
<td>Dorset</td>
<td>8620</td>
<td>3829</td>
<td>4308</td>
<td>0.30</td>
</tr>
<tr>
<td>Gloucestershire</td>
<td>6526</td>
<td>14825</td>
<td>4813</td>
<td>1.31</td>
</tr>
<tr>
<td>Somerset</td>
<td>6715</td>
<td>13623</td>
<td>3068</td>
<td>1.39</td>
</tr>
<tr>
<td>Wiltshire</td>
<td>3729</td>
<td>15171</td>
<td>4669</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Source: Adapted from Forestry Commission (2002).

However, when looking more closely at the details of each county’s woodland cover, they diverge in terms of composition. Conifer plantations can be safely assumed to be commercially active forests with viable access to them. This could also be assumed for the “Mixed” category. However, this is not necessarily the case for the broadleafed areas. Taking into account these differences partly explains why the perception of scarcity is higher in Cornwall. Table 7.3 offers a ratio between conifer plantations (mixed) and broadleafed ones. Broadleaves are generally more extended throughout the region but its ratio is substantially higher in Cornwall as compared with other counties. If broadleaves woodland is generally less accessible, the initial crude comparison of woodland cover between counties requires a closer look at its composition to be meaningful in terms of perceived scarcity. This fact relates back to the concept of potential and availability of wood developed in Chapter 2, following Smeets and Faaij (2007). In this case, the percent of woodland cover is encapsulated by the concept of “theoretical potential”, whereas the proportion of broadleafed and conifer woodland brings us closer to the “economic potential”, as both types of cover are linked to different constraints and costs. Here we use the assumed accessibility to the forest as the main constraint, which is more likely to be present for broadleafed than conifer forests.
Table 7.5: Off the gas grid households and fuel poverty by county for 2006.

<table>
<thead>
<tr>
<th>County</th>
<th>Households not using gas, proxy for off the gas grid households (%)</th>
<th>Households in fuel poverty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avon (former)</td>
<td>12.84</td>
<td>8.36</td>
</tr>
<tr>
<td>Cornwall</td>
<td>48.26</td>
<td>17.65</td>
</tr>
<tr>
<td>Devon</td>
<td>23.62</td>
<td>14.48</td>
</tr>
<tr>
<td>Dorset</td>
<td>15.12</td>
<td>11.87</td>
</tr>
<tr>
<td>Gloucestershire</td>
<td>19.95</td>
<td>9.61</td>
</tr>
<tr>
<td>Somerset</td>
<td>32.78</td>
<td>12.25</td>
</tr>
<tr>
<td>Wiltshire</td>
<td>25.08</td>
<td>7.98</td>
</tr>
</tbody>
</table>

Source: Adapted and calculated from DECC (2009) and DECC (2010).

To construct a better picture of the issue of scarcity, an understanding of the potential domestic use of bioenergy for heat is useful. Table 7.5 offers a picture of areas that are currently more dependent on alternatives to gas from the grid for heating purposes. Some counties of the region stand out as relatively isolated from the gas grid\(^5\) such as Cornwall and Somerset. For information, fuel poverty among counties’ households is also indicated and its prevalence is strongly influenced by not having access to the gas grid.

Before returning to the general trend, it is very informative to detail the comments made about the supply chain in Cornwall. The comments offer an extreme example and condensed experience, shedding light on the tensions that can develop within this sector. As one respondent reminded us:

“Cornwall is a small and bounded area. It is easier to assess [its potential and limits] as you can’t get lost in other counties.” No32 (Sawmill)

However, despite such physical limitations, it had a comparable number of actors mobilising woodfuel to other regional counties (i.e. Devon, Somerset). Please note that Dorset and Gloucestershire are probably under-represented in the sample of all suppliers operating in the South West.

\(^5\)Please note that no officially published statistics about off the gas grid households are available. This is an approximation calculated from the data about households using gas (mainly connected to the grid) and those using alternative fuels. The data presented here about households not using gas can be used as a proxy for off the gas grid households in each county and area described (i.e. former Avon county). The unit of Avon has been recalculated to make it comparable to the forestry statistics presented in Tables 7.2 and 7.3.
“To be honest, really it depends on the size of the market. [...] Cornwall is not a very wooded area. So if suddenly it all kicks off and everybody wants woodchip, and you know, having enough wood is essential, I question whether Cornwall itself has enough forestry to supply a very large market.”

Nº13 (Estate)

The origin of the limited resource is linked by respondents to weak planting programmes:

“It is not wood, the issue: it is trees! There are not enough trees available. That is a major problem. We have material that we can take now, but if the focus on wood fuels that is the search light that is on right now and if people want to carry business as wastefully as usual, all available biomass will be sucked up. The cost will be skewed very quickly...without the plantings that should be have been planted 10 years ago.” Nº32 (Sawmill)

And

“[...] there hasn’t been any big planting in Cornwall for years, especially for hardwood...it is a barrier”. Nº11 (Tree surgeon)

Although softwood tends to be associated with woodchips⁶, the finite resource of hardwood in the county has had implications for woodfuel development through price hikes and market substitution:

“In Cornwall, you can probably say there is not enough wood available. Just this winter, that has had a big effect of the price that we would pay for chip wood. In Cornwall, chipboard would pay similar prices to what we are prepared to pay. It has more to do with the firewood merchants that are selling much more softwood than before because no more hardwood was available. Their processing costs are smaller so they are prepared to pay between £5 and £10 more the m³ than what we could”. Nº25 (Woodfuel broker)

This is corroborated by other experiences:

“A lot of the tree surgeons, about three to four years ago had a lot of cord wood, which are the big chunk, too big for their chipper. The idea was to get them all chipped up around the country to get woodchips but now, with

⁶This has not always be the case, as the Country Land and Business Association (CLA) originally aimed at supporting the development of woodchip from hardwood sourced from under-managed woodland (Interview Nº36, Private supporting organisation).
the firewood market, all our tree surgeons pretty much chopped all that and made between £100 and £120 per tonne on firewood. So the external market forces are incredibly tough.” N°3 (Recycling company).

As a result, it is also claimed that log prices in Cornwall, mainly composed of hardwood, were twice as high as they were in the eastern part of the region, such as Dorset. It is important to note here that such a phenomenon hints at economic scarcity generated by vigorous demand. This can be been linked to the proportionally large off-gas grid share of the Cornish population. As indicated in Table 7.5, almost 50% of the Cornish households were not connected to the gas grid, compared to only 32% in Somerset, 23% in Devon or only 12% in the former county of Avon. However the quantity problem (i.e. physical scarcity) is not completely translated into price rises (i.e. economic scarcity) as there could be some resistance to do so, as suggested by this comment:

“[…] in terms of the raw material, there is plenty of timber that comes into the market. It is actually a question of what the suppliers are prepared to pay for that timber. There is timber out there that is coming to the market if they are prepared to pay for it. If they pay enough, private owners, local authorities open their gates and give them anything they want. So there is plenty of raw material. N°29 (Private supporting organisation).

Nonetheless, the apparent historical lower interest in forestry in this county can also be seen as offering positive opportunities for woodfuel as:

“So, basically, the quality of timber I don’t think is brilliant. Not throughout the South West, but certainly in parts of Cornwall. It all goes to firewood, fundamentally or joinery, if you have the quality. The pulpwood market is totally or pretty well gone. So having another outlet for reasonably bad quality timber in the form of woodfuel could or should potentially be extremely positive.” N°13 (Estate)

### 7.2.2 Economic dimensions of scarcity

To conclude on the specific example of Cornwall, demand throughout the region was not limited to the material for energy but was in tension with alternative uses and users of this material, mainly board manufacturers, landscape users, animal husbandry activities and also more active bioenergy markets in mainland Europe. A genuine concern was that a dynamic energy market could encroach on the hunting grounds of more traditional forest product processors.
“In the future it is expected that energy uses of woodfuel may be competing with pulp and board industries.” N°1 (Sawmill)

“We basically supply wood residues to vary different markets. Anything from the panel board manufacturers, the CHP stations both in the UK and abroad.” N°3 (Recycling company).

“The majority of woodchips are sold for cattle and horses but an increasing volume is destined to the energy market. Logs are not exploited yet but could be so soon.” N°6 (Sawmill).

To conclude:

“There is material around but it is market substitution. I would be taking material that is being produced and going to the chipboard factory. I can get it here because I can pay more for it. But that is finite, it is fine for a couple of 1000s tons, but if I wanted to put a capacity of 20,000 tons, that would be fundamentally different.” N°15 (Estate)

Non-energy users tend to have the upper hand in terms of their willingness to pay and tend to be price makers. Buyers of wood for energy seems rather in a position of price takers, instead:

“I have a better sales figure for woodchips going off to garden nurseries to be used for decorative woodchip or [...] mulch than I do for actually woodchip for burning.” N°11 (Tree surgeon)

“The power station will never give us as much as a landscaping company would give us. We can get a very good [prices] and different prices from different landscaping companies and we don’t have a fixed price, as of yet.” N°14 (Tree surgeon)

“There are a number of large users of low quality timber who take in vast quantities. So in a way their price forms the base from which woodfuel would be judged ” N°40 (Private supporting organisation)

“When buying fuel, there are two or three people that you can go to. It should not be too much of a difficulty. With respect to getting the fuel from the forest, you may get in trouble because other uses may be competing for the same material (i.e. animal bedding)” N°34 (Private supporting organisation)
However, most comments indicated that this is not a stable state. It evolves season- 
ally, according to availability and demand but also following the economic scarcity of 
alternative products in a continuous dialogue such as the following detailed experience 
explains:

“We produce timber waste and five years ago, the value of our by-products 
was very low. I was looking at areas to increase the value of our by-products. 
Before, we used to pay somebody to take it away and produced shavings 
for the bedding market. But even the prices for bedding were very low, 
so I looked at alternatives. [But is it still the case?] Now, shavings are 
more profitable than pellets. They were not five years ago but this winter, 
I could sell bedding for £300 a tonne. For pellets, it was only between £160 
and £260 a tonne. [...] Well, it is all about what products are available in 
the marketplace. Last winter there has been no straw, there has very few 
shavings around because a lot of sawmills have closed down and because all 
the European sawmills are producing pellets instead of shavings, so there is 
scarcity. (But) it always changes. It changes year on year.” N°17 (Timber 
merchant)

Changes can also occur for a single user. For example, some board manufacturers are 
more inclined than before to use recycled wood:

“Formerly a large part was sold to a chipboard factory (MFI Group) but 
now it is only buying recycled wood instead of green one”. N°6 (Sawmill)

This latest example introduces us to the existence and implications of competition 
between different sources to feed the energy market.

7.2.3 Alternative sources

For some, recycled wood simply did not have any influence:

“That has not been a problem either because it is never a regular source 
so (people) have to come back to a regular supplier if they wish to keep a 
wood burner going, so that is no problem.” N°12 (Tree surgeon)

However, even from this perspective the issue is complex with contradictory effects. It 
is clearly captured by the comments, and to a certain extent by the ranking exercise 
with some “not relevant” and those that give it some importance seen as a hindering
factor. Recycled material can compete very strongly with forest residues and even sawmill residues, however it was also qualified by those affected as an unreliable source because of its lack of quality consistency and issues of contamination:

“They have the ability to sell it at very little money because it is a waste product for them.” N°25 (Woodfuel broker).

“But now, viewing the recycled as a cheap waste is very false. It is all down on the moisture content.” N°3 (Recycling company).

The perspective offered by these actors is that cheap material will compromise quality. On the other hand, it may provide an affordable start, more propitious to users’ wood-fuel infrastructure development.

“That is good. It is not hindering. The more people that burn wood, the better. If anybody says so, they are selfish and blinkered because we should be encouraging people to burn anything as long as it is economical to do so”. N°23 (Tree surgeon)

A comparable perspective is shared through this, although more prudent, comment:

“It would almost be an advantage to us. [...] for the woodfuel industry, the more wood there is, the more cheap wood there is floating around, the more people are going to buy our boilers! Having said that, the quality of landfill-type chip, is a major problem. Even for the wonderful ETA boilers, they struggle with poor quality chip. Pieces of aluminium getting in [...], silicates from demolition timber that generates clinker etc.” N°20 (Sawmill)

These comments were more in line with a pattern that can be observed in more mature markets. This is the case in continental Europe, and in Germany in particular, where cheap recycled material is getting behind users’ growing need, pushing prices up and offering more opportunities for the more expensive virgin wood to feed the energy market (Pleninger et al., 2009).

7.2.4 Local sources and beyond:

Some production takes place in the South West and some sourcing is done in the UK and abroad. This is the case for pellets. From the few traders of this processed fuel, imported pellets seemed to be the most reliable and affordable way to supply
them, with implications for the development of the supply chain. However, some of the businesses are more aware of the recent economic conjuncture and its effect on the currency market with important consequences for the purchasing power of Sterling. Between July 2007 and December 2008, Sterling lost about 30% of its purchasing power against an annually updated basket of international currencies weighted according to the importance of the trading partners (Bank of England, 2010). However, when compared to the UK timber statistics (Forestry Commission, 2009), the Sterling Exchange Rate Index (ERI) macro weighting may be biased towards the relationship with the USA (15% coefficient) when it only accounts for a fraction of the timber imported compared to the large Swedish forestry product contribution but in turn only represents about 2% of overall trade. The purchasing capacity for forestry products from traditional sources probably reduced more than the general exchange rate as it is more heavily dependent on trade with the Eurozone and other EU commercial partners than with the general basket of trade. Lower importing capacity is a reality that has to be accounted for, making local providers potentially more attractive.

Despite a general image of plenty shared by participants when asked about wood scarcity, physical characteristics of the material still translated into barriers, beyond locally bound quantity limitations, such as in case of parts of Cornwall. Additional comments gathered throughout the interviews addressed a more complex problem: quality and consistency of such quality.

“Indeed [there is not enough wood available], with respect to the useful one to us”. No17 (Timber merchant)

“It depends what sort of wood. There are so many different types of wood-fuel out there. Wood is just not wood. You have the virgin wood; you have the dry version of virgin wood. It depends what the boiler demands you. Then you have the clean and the dirty recycled wood. If there is enough material out there just depends on the boiler, to be perfectly honest! No3 (Recycling company).

### 7.2.5 Supply of material and some governance issues

The Forestry Commission manages about 18% of the forested land in the country but produces 40% of the total timber volume in England. The 82% of the rest of the forested land, which is privately owned only produces 60% of the timber\(^7\) (Forestry

\(^7\)Note that this is clearly documented for conifer related woodland but less so for hardwood, which only accounts for about 5% of the volumes registered.
Commission, 2009: p.9 and 26). Such ratios point to the issue of "under-management" of privately-owned woodland, already identified by all actors, but also that the main source of forest material (as opposed to waste wood) is managed under the Forest Enterprise programme of harvesting and established channels. This can be seen as a stabilising factor to the forestry sector as a whole, and was understood as such:

"We already play a stabilizing influence in many respects by offering the long-term contracts both at the sale of timber standing and, in a limited number of cases, for the sale of timber delivered into market." N⁰43 (Public estate manager).

Moreover, some direct contribution to the woodfuel market had been made according to the official source:

"We have made available through standing sales rather more significant volumes of the material which have been offered for sale as woodfuel and they have been bought. But they have been bought by the normal collection of standing sales merchants and I am pretty confident that not much of it has actually found its way into the woodfuel market." N⁰43 (Public estate manager).

However, the result of this is not only a constraint on supply controlled by certain established commercial partners (i.e. large timber and forestry contractors) that have long-term harvesting contracts with the public estates. This leaves little elbow room for the public estates to mobilise additional resources. More precisely, it is not able to allocate more material to the energy market through specific sales or contracts. This availability also echoed future worries about the competing users of second-rate wood material:

"We have a fairly high annual volume of timber production: about 90,000 m³. A significant proportion of that is committed on long-term contracts. […] The volumes that we put directly into the market, into the end-users, we are working into longer-term contracts, so we don’t have spare volumes that we can simply make available for woodfuel. The point is that we do offer that stabilizing influence and in theory we could offer it for the woodfuel market but the fact of the matter is: all or the vast majority of our production is already committed so we have no spare capacity. […] there isn’t an extra volume to produce, if you like for a new market or what will have to take place in due course is market displacement". N⁰43 (Public estate manager)
When suggested, the hypothetical support of the Forestry Commission as providing woodfuel from its own stock as an option to underwrite any private long-term contracts between contractors and energy users is not seen as a simple option and one that should be embraced lightly:

"I think we should be very careful about what we mean by “market stabilisation”. We would not be prepared to underwrite supplies at any price, for instance. We would be prepared to underpin, perhaps, in terms of volumes of supplies and offer some type of stabilisation but not at any price, no!"

N043 (Public estate manager).

The majority of material readily available is influenced by a specific governance system of the supply chain with its established contracts and networks when spot markets are offered. As stated it does provide some stability to the forestry sector but at the same time it may prevent the development of opportunities suited to woodfuel development. A saw miller sees it as a missed opportunity:

"They have got a plantation here that nobody wants to work. They are on steep ground and are on first thinning which we would love because we produce round fencing stakes but you ring the Forestry Commission and try and buy anything from them: they tie themselves so much in red tape. They have contracts and they have preferred contractors and it is impossible to buy anything from the Forestry Commission. [...] We can buy from contractors of the Forestry Commission but on the other hand, their preferred contractors don’t want to work with a block [...] I have my eye on" N020 (Sawmill).

7.2.6 Summary and conclusions

Physical availability is currently not the primary concern of suppliers, although scarcity has been influencing the sector in Cornwall. Such tensions translated into competition between woodchip suppliers and those aiming at the firewood and logs market. More important comments centre on economic scarcity and competition. First, there is competition among different users of the material with “traditional” or non-energy users and the newer energy suppliers. A second dimension of competition exists between sources of the material such as forest residues and recycled wood. This receives a mixed reception among suppliers as either a threat or support to the development of the sector. Please note that the current flow of virgin wood is dominated by what is produced by
the public forest estate. Availability extends well beyond a matter of quantities and physical access. Variability of the supply in general and the existence of alternative users created competition and therefore potential instability in supply. In turn, these characteristics of the physical supply influenced the degree of flexibility of suppliers in answering the needs of their customers, with implications in the way relationships were managed. Chapter 8 explores how such physical characteristics translate into economic dimensions and governance challenges. Quantity restrictions may ultimately influence future development but quality issues were a daily challenge with implications stretching deep into the supply chain. This tension around quality persisted even if imports were available. Quality is linked to information with implication for all actors along the chain. As such the following section is dedicated to information and information-related costs.

7.3 Information:

Information is unambiguously central to the development of a market for an innovative energy source with respect to the established ones. As such, its absence or weakness has been widely recognised as a barrier to the development of markets. The interview questions on information focused on four aspects as presented in Figure 7.1. These explicit questions identified information-related costs associated with exchange along the supply chain as reminded in Table 7.3. Please note that both measurement and search cost are central to transaction cost analysis and the problem of learning costs is generally associated with the resource-based view of the firm.

Several other crucial aspects of information-related costs also surfaced during the exchanges, with special mention of the dynamics between user, woodfuel supplier and energy conversion device installers.

Table 7.6: Information-related costs

<table>
<thead>
<tr>
<th>Question / Type of cost</th>
<th>Search</th>
<th>Measurement</th>
<th>Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users and potential users’ lack of information</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Lack of quality standards of woodfuel</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Businesses’ difficulties in finding stable commercial partners</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Businesses’ lack of experience in the trade</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

*As defined by Freeman and Soete (1997) and developed in Section 2.6 in Chapter 2.

*Please refer to Chapter 2.
7.3.1 Quality standards.

Quality standards have unanimously been recognised as core to the development of new markets by reducing measurement costs, and as such are meant to reduce transactions costs. This is even more so for solid biofuels as they have a wider range of types compared to other renewable energy sources (Mitchell, 1992; Thrän et al., 2005). This research identifies how standards are influencing the development of the existing businesses by mainly focusing on fuel standards, more than on energy conversion devices standards or installation certification. However, all have appeared as key in the current development of the sector.

The fuel standards aim at providing a reference for three main dimensions, which are i) the mechanical properties of the material and its handling behaviour; ii) its properties at combustion and gasification; and iii) its chemical properties related to ash and emissions. Various biomass energy standards have been developed in different European countries such as Austria, Finland, Italy, Germany or Sweden, among others. Although all may establish references for all three main dimensions they may not put emphasis on the same indicators, and therefore may not be as comprehensive or directly comparable. This has consequences for trade across countries (Thrän et al., 2005). However, trade should be understood as a larger opportunity than just the fuel trade as the importation of boilers designed on specific national standards will be associated with them and not directly transferable to local standards either locally developed or adopted. To circumvent this problem, efforts at European level are aiming to produce a uniformly recognised reference through the European Committee for Standardisation (CEN) that will eventually overrule existing national standards (Thrän et al., 2005).

Effects and implementation of product quality standards.

The influence of product standards was captured at different times during the interviews. First, a broad “How important is the lack of quality standards in developing your woodfuel business opportunities” was asked and was ranked by importance as represented in Figure 7.1. The ranking exercise should be seen only as a general appreciation of its importance. Then, more detailed and contextualised comments were gathered on this issue when discussing the difficulties in implementing such standards, their historical development and their effect on transactions. Although the ranking of how standards were influencing the development of the sector focused on product quality, many comments included important reflections on service quality in procure-

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10 For the technical details and different standards recognised in the UK, please refer to the Forestry Commission’s Biomass Research Centre website on: www.biomassenergycentre.org.uk.
ment, sale, adaptation and installation of energy conversion devices (i.e. boilers). It was expected from early comments that businesses involved in the traditional production of firewood (i.e. logs) could give specific standards less importance, compared to businesses focusing on the more scrutinised woodchip and pellet markets. However, this was not supported by the data, as reported by the cross tabulation according to product, presented in Table 7.7. About two thirds of respondents to the question (excluding N/A responses) in each group answered “important” or “very important” to the question, although there were some “not relevant” answers by businesses only trading logs. From a visual inspection\textsuperscript{11} of Table 7.7, it is not possible to identify a difference in trends between businesses exclusively selling logs and those engaged with woodchips and pellets. This may be due to the small size of the sample but may also be a consequence of the openness of the question and implies that it was not possible to assert specific relationships between the importance given to the concept in the ranking exercise and the nature and/or activity developed by the respondent business. It emerged from the follow up comments that the results were better interpreted as how important are quality standards for this trade in general (hence “Quality standards” in Figure 7.1) rather than a specific question of how the lack of such standards was affecting their activity. This prevented any meaningful interpretation on correlation with specific characteristics, such as activities or location.

Table 7.7: Importance given to lack of quality standards as a barrier, by product (N=25)

<table>
<thead>
<tr>
<th>Importance</th>
<th>Logs (exclusively)</th>
<th>Active in woodchips and pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Minor</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Important</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Very Important</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

Despite the limitation of the quantitative data gathered to answer this question, the accompanying comments provided valuable insights into transaction costs.

Product standards with reference to producers, mainly revolve around the moisture content of the product, although the ones concerning pellets also focus on other dimensions.

Woodfuel standards while not fully aligned with European practice are now generally understood as a reference for specifications. The data suggests that it is no longer the

\textsuperscript{11}Given the size of the each group sample, testing to identify any statistically significant difference between the two samples is not reliable.
problem it had been previously, with almost 40% of business respondents who classified the issue as minor or not relevant anymore:

“I think it is reasonably clear now with most boilers. Perhaps it used to be a problem. [...] we are not using European standards; we are still using the old norm G30, G50. Moisture content is pretty standard. People and we understand it.” No25 (Woodfuel broker).

This is clearly echoed by both public and private supporting organisations:

“Most people seem to be aware that there are standards. Moisture content and chip size are pretty important. Most people that we talk to, although they may not be aware of the details of standards, they are certainly aware that the quality and consistency are pretty crucial. They wouldn’t know that they should insist on a European standard for quality but they would know that size and moisture content are very important.” No28 (Public estate manager).

And

“Standards need to address the size and moisture content issues; those are two critical things. If those could be addressed that would be a really big step in the right direction. Generally, they are beginning to be addressed. There is still bad fuel being delivered but those are beginning to be understood.” No36 (Private supporting organisation).

However, their implementation also depends on the customers’ awareness and ability to identify the most important characteristics and their variations within a standard, highlighting the necessary link to an informed public. A recurrent comment concerning all three main types of fuel (i.e. logs, woodchips and pellets) was that although there was a consciousness that reference standards exist, decision making processes in procurement do not necessarily focus on quality:

“People buy on price and on the cheapest price until they have problems with this cheap product, or they cannot have it delivered”. No17 (Timber merchant)

Again:
“When we talk about the advantages of pallet waste being recycled wood instead of virgin wood, our material is a lot more expensive than their recycled material. There are people trying to put compost [...] as well. So quality is major issue. [...] another company gets the contracts, but then that company always falls out of bed because the customer realises what is happening”. N03 (Recycling company).

Several of those comments imply that businesses see people using this heating option only because it is cheaper than fossil fuels, so they will systematically go for the cheaper option available, regardless of its actual properties, opening the door for poor products until the performance or the investment in boilers is damaged, thus:

“[...] giving the industry a bad name” N017 (Timber merchant).

Again:

“Lack of quality standards is not an issue to start with but after installation, people with bad experiences provide bad reputation”. N06 (Sawmill).

Before looking at specific issues for each type of fuel available, an indicator of weakness in the implementation of standards is the way the material is sold and recorded. All the data collected throughout the interviews about volumes needed to be adjusted to a common denominator (i.e. dry tonnes equivalent) to make meaningful comparisons\textsuperscript{12}. This was not spontaneously identified by interviewees and emerged from the data set. Material can be either sold green, “seasoned” or with an estimated moisture content by weight (i.e. tonne) or volume (i.e. m\textsuperscript{3}). However, some businesses sold material as “loads” with varying and approximate capacities and moisture contents. This assessment is valid for logs and woodchips but pellet suppliers traded more standardised product by weight. This lack of consistency can be related to the place of the specific business along the supply chain, with a trend of having green material being sold closer to source than drier, which was handled by intermediaries. However, all were posing as wood energy suppliers but were not projecting an image of selling standardised products.

**Quality standards of the specific fuels**

With respect to logs, the existence of standards tends to be based on custom more than on a set of external guidelines. The basic standard is “Wet” and “Dry”, or seasoned. However, an informed public is crucial to make any reference to quality meaningful:

\textsuperscript{12}As detailed in Section 6.3.3 and Table 6.10.
“People have got common sense [...] But some have absolutely no idea of what a log is, how it burns and what you should be looking for”. N°12 (Tree surgeon).

It is noticeable that although the log sector is mature given its historical existence, it only displayed a weak reputation for quality. The experiences gathered did confirm previous reports such as Dagnall’s (2004) highlighting *ad hoc* arrangements for supply and complaints about the quality of wood purchased:

“Until very recently the usual standard of firewood in the UK is very poor: It is a guy with a pick up, getting trees for nothing, logging them up at the back of his pick up. The quality is awful, the reliability is pretty poor. N°15 (Estate).

In the same vein:

“We had so many negative comments from other people that have said, you know, I have tried logs before and they are wet, they take ages to burn and they are so expensive and that’s because they are buying from an ill reputable source”. N°12 (Tree surgeon).

It is worth noting that there is a precedent in the establishment of log standards in Exmoor National Park, involving a voluntary certification scheme. However, it would seem to have failed in delivering price premium to certified logs:

“There are several people over the years who have tried to make a standard, to give them an edge. I mean, Exmoor National Park is doing “Exmoor WoodCert” where you have a certified timber but it does not give anybody more money: there is no premium”. N°20 (Sawmill).

Please note that this initiative aimed at promoting the use of material from woodlands under the stewardship of the Exmoor WoodCert Chain of Custody and focused on the sourcing rather than on the quality of the product. As it is the case for timber certification in general such as the Forest Stewardship Council (FSC) certificate, prices have not systematically provided a premium for producers (Purbawiyatna and Simula, 2008; Varley and Wilding, 2008).

The conclusion that there was no need for certification schemes for logs also came from the same participant as:
“You just get a bill for £150 per year from Exmoor National Park, it is waste of time. The market sorts itself out. If somebody supplies wet or poor quality logs, they will not get any more orders. End of the story, really. Supply and demand is a wonderful thing, and quality of supply!”

NO 20 (Sawmill).

An alternative to certifying a specific source, certification of the product more in line with its equivalent for pellets is potentially necessary to raise standards. There is a pioneering example just outside the borders of the region\textsuperscript{13} that is producing kiln dried logs and is the first to have obtained a HETAS\textsuperscript{14} certification as a log supplier. Standards for logs can therefore be introduced if they offer a substantial difference with respect to the “average” log sold to the ambiguous “seasoned” standard. Since August 2010, any supplier of the major fuels (i.e. logs, wood chip, pellets and briquettes) can apply for HETAS\textsuperscript{15}.

However, the development of standards, although fostering woodfuel market development has been perceived as potentially precluding the participation of a section of actors (i.e. small woodland owners) as these have tended to be marginalised. The largest actors may be favoured over the smaller ones when pursuing woodfuel as a product but this is not the always the case:

“The other thing on standards has to do with environmental standards like the FSC which will be a constraint, basically. Those are already becoming an issue for woodland management generally but if you are trying to get owners of smaller woodlands currently being unmanaged under this supply chain, they will never engage if they are going to be under an avalanche of bureaucracy on standards of woodland management. [...] It is already being demanded by government. If you want to supply a government boiler, they will be saying that you need to be certified. The government procurement policy requires that the timber is coming from a legal and sustainable source. It applies for everything that has wood in it, from pencil to chairs etc. The easiest way for them is if it comes with certification. It is not currently mandatory for local authorities, but most of them will adopt that standard. Some of the local authorities may resist it as they are more pragmatic if they have been putting boilers into schools to have local woodlands managed.

\textsuperscript{12}Certainly Wood Ltd. This company was contacted and after a guided tour, the managers were informally interviewed.

\textsuperscript{14}A voluntary scheme, the Heating Equipment Testing and Approval Scheme (HETAS), is under the auspice of DECC and DEFRA and aims at “the official testing and approval of domestic solid fuels, solid fuel burning appliances and associated equipment and services” (HETAS).

\textsuperscript{15}http://www.hetas.co.uk/public/Solid_Biomass_Assurance_Scheme.html
Some will just go with it. If it becomes mandatory for everything, it will just kill it. It is a very complicated supply chain. If it is a hub that supplies a school, that timber will come from a whole range of places. In theory, to fill these things, all your haulers will have to have chain of custody. […] that could have a massive effect on it probably a bigger effect than the quality standards.” No36 (Private supporting organisation).

The assertion that new demands may preclude the participation of smaller players is however reliant on the current individual management practice. It could be seen to be offering a new incentive to explore more efficient forest management practices such as woodland group management schemes16. The future role of local authorities as drivers of the woodfuel sector has been identified. At present, the adoption of the recommendations from the Central Point of Expertise on Timber Procurement (CPET) is only compulsory for national bodies. However, they are being voluntarily adopted by local authorities as demonstrated by the recent initiative of Devon County Council (DCC) which stipulates them in its draft17 woodchip umbrella procurement contract. Additional incentives are also expected to come from a growing trend regarding standards and voluntary schemes. A recent record from timber trade trends (ITTO, 2009) sheds light on how to see the future of standards and certification for woodfuel. The public sector has revised its procurement policies with special emphasis on certified timber by requiring “all timber and timber products should come from independently verifiable legal and sustainable sources not excluding woodfuel unless it comes from short-rotation coppice” (2009: p. 1)18. This evolution associated with the fact that the public sector has grown in relative importance in construction, compared to the private sector due to the recession, has made timber merchants increase their percentage of certified wood. A similar trend could be developing with respect to woodfuel as the public sector has also grown in importance as one of the major users and potential user of biomass boilers, due to the recession.

16 In this scheme, a group of woodland owners close to each other cooperate by hiring a forester to manage their woodland as a single management unit, providing opportunities for economies of scale and integrated management of the area. These schemes have the potential to provide the much awaited incentive to thin undermanaged forests, thus providing more material to the bioenergy market in the short term and quality saw timber in the long term. Such schemes are supported by the Devon County Council with the Forestry Commission in the “Ward Forester” project (http://wardforester.co.uk).

17 Regen SW and the DCC have developed and amended a draft umbrella procurement contract through three workshops with potential suppliers and other local authorities representatives (January 2010- June 2010). The document is analysed in more detail in Chapter 8, along with other existing template contracts used in the region.

18 “Short-rotation coppice: means a specific management regime whereby the poles of trees are cut every one to two years and which is aimed at producing biomass for energy. It is exempt from the UK government timber procurement policy requirements and falls under agricultural regulation and supervision rather than forestry. The exemption only refers to short-rotation coppice, and not “conventional” coppice which is forest management and therefore subject to the timber policy” (CPET, 2010).
“Our first customers that we were supplying, beginning 5 years ago, were tree huggers. These were the enthusiastic ones; they had all the moral grounds for coming in. Then, you look at the government bodies with a second group of people who came in. After that, 18 months to 24 months ago, before the recession when the price of oil was high, you saw the commercial people coming in who purely did it on money; that is all what they were looking at. And now we are doing full circle again, and we are seeing only government bodies coming back in. Those who have got grants, they are the new customers now. [Is it because the price of oil was waned?] Yes. It is not commercially viable for anymore to burn woodpellets: they are too expensive. In fact we have lost a couple of customers who have gone back to oil. But they know they will be coming back to us when the price of oil goes up. [They have both installations?] Yes.” N°17 (Timber merchant)

This view on the recent evolution of potential users was also shared by supporting organisations.

Pellets have detailed characteristics under the current standards ranging from mechanical properties to combustion behaviour to chemical composition. These are what we could called composite standards in the sense that they are multidimensional but also have ranges of acceptance for all dimensions. The following experience provides a critique on how they are set up and the difficulties in sending the right message to users:

“Within any standard, there is good and bad. And although what we see out there is within a standard. In fact I see the EU standards as a terrible document because you can make pellets to a pretty good standard (UK equivalent) but you don’t say what your ash content is. Unless you say a “01”, 1% ash, it can be any percentages of ash. And people ask, do you make on standard, well, you do. But standards encompass everything. N°17 (Timber merchant).

Then, when commenting on the UK document about woodfuel standards:

“Here you can see the diameter and moisture content and it says “up to 20%”. It is still within the standard. [But that would break down, isn’t it?] Exactly! So it is just not the standard. It is to what part of the standard you are relating to. People don’t say to us they want a 0.7, M10, Sulfur etc. They don’t go through these things they would just say do you manufacturing and delivering to a standard. […] you are actually looking at
people buying a product to a standard; all they see is the name and number of that standard: they don’t break it down.” No17 (Timber merchant).

Even at the level of procurement of wood fuel brokers, standards may still have some way to go in implementation as far as pellet UK producers are concerned:

“We want a 100% quality. This time last year [June 2008], we had 1200/tonnes of UK-sourced pellets in stock. We had to write it off because it was very poor quality, and that lead us to source from Europe. [...] The work with the Scandinavian and the French leads you to believe that to produce quality pellet, you have to be doing it at a certain scale. [But] a lot of the UK producers at this moment are very small scale, so they cannot give quality the full attention that it deserves. They think that producing a pellet is the result of taking some wood, grinding it, hammer-milling. But it is the quality of the pellet: its integrity, its ash content and all those things. In the UK they just focus on producing pellets. They see that they can get rid of waste, sawdust that is seen as waste in certain processes. They see that producing pellets is the answer, not realising that, in order to sell those pellets, they have to be of quality and that the equipment people have invested in to use those pellets in boilers [will not work on poor quality pellets].” No33 (Woodfuel broker)

Scale does offer lower pellet production costs through economies of scale. Small-scale production is still viable but production costs are heavily dependent on whether the raw material is dry or wet as both capital and running costs of the drying system are high. In Austria where pellet production is also undertaken at a small-scale, the drying costs can make up to almost 30% of the whole production cost of pellets (Thek and Obernberger, 2004). However, it is questionable that production volume and quality are related per se as suggested by the pellet trader quoted above (Woodfuel broker, No33). This could point to a possible lack of interest in smaller producers and towards incipient production pellet ventures.

**Users’ knowledge: Quality, origins and implications**

Although the focus of the project is not to analyse demand per se, elements of the perception of how demand is shaped has been identified as relevant by suppliers.

When looking at Figure 7.1 most scores confirmed the view that weak knowledge by the public on woodfuel was hindering the development of the woodfuel market. Users and

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10Please refer to Chapter 2 for more details on production issues of woodfuel.
potential users’ knowledge of woodfuel was generally seen as weak, although improving. This image was shared by suppliers of all three types of fuel. Compared to more established markets, the demand was still looking for bearings:

“In the timber market, customers know what they want. They know the product. You actually put the product, take the money and the deal is done. In the pellet market, the majority of people don’t know what they want. They want to talk to you, they want information”. Nº17 (Timber merchant)

“This winter, a lot of people put wood burners in their houses but [...], to be polite, I would say that there is a lack of practical information and understanding”. Nº16 (Sawmill)

For some, the objective of mainstreaming the use of wood energy should focus on releasing market forces although the drive to thoroughly inform the public could be overplayed:

“I think the sector is overburdened with this issue that people need to know about woodfuel. How many people know anything about gas, oil or coal, other that it comes from the ground and it is shipped a long way? Who knows exactly what coal is or exactly how oil is extracted from the ground? Not many people! People just want it delivered and for it to work. It was an issue at the start, when the people investing wanted to know (because) they were very keen on using renewable resources but we should be moving away from that. [...] If you are selling this as a cost-effective opportunity, your audience is huge and they should not need to know about it. They should only need to know about woodfuel that they want”. Nº29 (Private supporting organisation)

More generally, change has been acknowledged by both some of the suppliers and supporting organisations. The actual picture was more nuanced and more importantly, the comments were spread around two common themes: simple lack of knowledge and misguidance.

The simpler information weakness was the plain lack of knowledge on something new:

“They are lost. They don’t know the difference between softwood and hardwood. They think that all hardwood is good and all softwood is bad. […] They are not helped. Nobody helps them”. Nº23 (Commercial forest)
“People have got common sense but some have absolutely no idea what a log is, how it burns and what they should be looking for”. N°12 (Tree surgeon)

According to the participants, the more complex origin of this barrier was rooted in distorted information or not accounting for its central tenets as an energy source, which led to misplaced expectations on woodfuel.

One general expectation was linked to the overall price advantage of wood as an energy source, excluding capital costs:

“Well, the bulk market is quite well established. But the biggest challenges are for the smaller domestic and industrial boilers, where people have very high expectations for a fuel they can purchase relatively cheaply”. N°3 (Recycling company)

“Part of the problem at the moment is that initially this was marketed as a cheap fuel and it raised people’s expectations that it was going to be a lot cheaper than it is. It should be marketed as an alternative fuel, not necessarily a cheap fuel”. N°36 (Private supporting organisation)

The second dimension derives from the way energy conversion devices are promoted by licensed sellers and installers. Given the importance of this aspect in the development of the market, it is fully treated as a separate section. Please refer to “Installers and other cowboys of the Wild West” within Section 7.3.2, for further details.

Summary

A majority of the respondent businesses think that users and potential users’ knowledge of woodfuel was weak and hinders the woodfuel market. Although there were some signs of improvement, the lack of knowledge was seen as simple ignorance but also as the result of bad information, that then translated into expectations about woodfuel as an unrealistically cheaper source of energy.

7.3.2 Know-how.

Experience of suppliers  Given the recent development of the sector, the current know-how of businesses was identified as a possible barrier to its further growth. More than half of the participants said that they were still learning about this trade, although it was not seen as a major hindrance. As Figure 7.1 shows that a third considered it an important or very important barrier. Several actors, both businesses and supporting
organisations used the same expression about woodfuel describing it as “not rocket science”.

“The woodfuel business is very simple, it is not rocket science.” N°03 (Recycling company)

“It is not complicated as it is made out to be but the understanding of it is relevant. It has not to be underestimated by all means but it is not impossible. I am pretty confident now that we have it all sorted. So it is a minor one, it is fine tuning.” N°27 (Farmer)

“How difficult is it to chip wood? It can’t require that much knowledge!” N°29 (Private supporting organisation)

“I think there is a lack of knowledge but I think it is beginning to be addressed. Woodfuel supply is not that (difficult).” N°36 (Private supporting organisation)

Although the technical aspects of processing and production as such seem to be well mastered, other dimensions of the trade remained to be defined. Learning is acknowledged to still be necessary. Of the issues raised, we can highlight management challenges. An example shared by an experienced manager was how to handle customer’s expectations about the price and properties of the different fuels, particularly for woodchips, which was directly linked with the lack of understanding of the public about woodfuel.

“[As businesses,] I don’t think we learn about woodfuel, it is more the customers we still learning about! Because woodfuel doesn’t vary, it doesn’t change. If we are given the specifications, then we know. It is more about learning the customer’s expectations.” N°03 (Recycling company)

As a more general issue it goes beyond controlling a specific process, such as woodchip production. The challenge has more to do with acquiring management skills adapted to handle and successfully develop a biomass for energy business. Not all businesses had the same abilities and the structure of the sector at the time had two to three leaders way ahead over all other players:

“[A sector leader] has become very experienced and I think that there is a big gap between what he can do and what many aspirants want to do. I think there is a lot of knowledge and experience out there but seems still difficult for people to get good quality advice.” N°28 (Public estate manager)
“The real challenge is having the right business model and entrepreneurs coming into the sector. I think that this is an issue if you are trying to set up a cooperative of landowners who are not businessmen or entrepreneurs. That is not an issue if you find the right people to do it. For instance, we have someone applying for funding who has an agriculture engineering background, used to run big machinery on farms. To me he is a very good bet, because he has a lot of knowledge of running a business like that. Although it is not woodchip, it is very similar.” N°29 (Private supporting organisation)

Only a few of the businesses interviewed formulated management requirements as the main know-how barrier. Such barriers are sometimes implicit in their comments on their learning efforts, although it was generally about production processes:

“Arrogantly we didn’t think we needed to learn: because a log is a log. [...] So we got educated but after making a few mistakes, of course, along the way.” N°12 (Tree surgeon)

“What is the most demanding aspect of learning: is the logistics of delivery. The actual vehicle size, actual access, etc. We are still developing those models and that is learned on the mistakes of others. You can see some people that have built themselves into corners.” N°15 (Estate)

“[From other participants’ comments, I understand that making pellets is somewhat of an art]. Yes, it is an art and it is difficult, you know. You have to have the right equipment, the right process and it has to work in your situation.” N°32 (Sawmill)

“Woodfuel is different from other timber products and requires time to learn how to properly market and successfully present its products.” N°8 (Timber merchant)

A clear concern was the right involvement of staff in woodfuel activities; a skill that seems only superficially taught by vocational training:

“The most demanding part of learning is making sure that the woodfuel aspect of the business is serious and able to provide quality products” N°4 (Tree surgeon)

“That is just over time, through trial, success and error. [Was it difficult to learn] It is not really taught. [...] [For example,] we have just taken a guy that is at college and he is part time here. He is getting on with his tickets
on machinery etc. but actually, he will start work […] but woodfuel is not really shown. [So basically we learn by doing]. Whether this is the right way or not, I don’t know. Probably it isn’t. But it is one of those things! N°22 (Tree surgeon)

“One of the major issues for me is not cost but it is education for staff. You must remember that we are working in a very busy environment and you are dealing with lots of staff who are putting a lot of waste in a back of a vehicle when such waste has to be 100% clean. It can’t be stones in there. If you put 25 tonnes in an artic to go to Slough to be burn and is rejected because it is full of crap and we waste money. So there is a huge issue on education”. N°13 (Estate)

The acquisition of know-how in the sector is an uneven process with a few leaders, although the understanding of woodfuel was downplayed as “not rocket science”. What transpired from the evidence was that know-how is achievable in terms of processing material but the more general managerial skills to handle it and distribute biomass energy were still being acquired. Furthermore, learning in this field was closely linked to experience through “learning by doing”.

**Installers and other cowboys of the Wild West**.

Suppliers blame installers and providers of boilers for misleading the users and potential users of woodfuel based boilers. The indictment was based on the belief that salesmen’s drive to make a deal when promoting energy conversion devices make them irresponsibly downplay the actual requirements and general maintenance demands of woodfuel energy conversion devices. Almost a third of suppliers attributed the existence of some degree of misguided public when this criticism of the actual level of professionalism was also extended to related services, such as consulting and design of installations. That group (a quarter of all interviewed suppliers) mobilised the overwhelming majority of woodfuel in the region according the quantities registered through this sample. Please note that this criticism was also shared by the supporting organisations contacted.

“I would say that over 50% of the people who bought pellet stove have been sold them incorrectly, in that they believed it is going to work like an oil burner. But it doesn’t. […] They feel let down by the supplier of their boiler, of the device. Not because there are bad devices but because they don’t live up to their expectations. I believe that the people that are selling

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[20]Title inspired from one of the off the record comments collected.
the boilers are overselling them. They are making too many promises”. N°17 (Timber merchant)

“From my own personal experience, and for someone that knows the basic material, which is wood in its all different sorts of forms, I think that I was disappointed about what the guys had said about the boiler, the moisture content [on which it would run], how it would function. [...] You know, when people are selling you something, well they want to sell it at the end of the day, don’t they?” N°22 (Tree surgeon)

In addition to the basic information problem, two main critiques emerged from the comments on the development of projects from both suppliers and supporting organisations. One was an alleged mismatch between available fuel and the technology promoted. The second was the lack of professionalism in the actual sale and installation of the devices, including the design of the heating systems in situ.

At a basic level, there did not seem to be a systematic effort to match available biomass resource with the promoted energy conversion device. This was mainly the case for woodchips. This observation on the possible mismatch raises a fundamental question about the direction of how the market was driven by either demanding a tightening in the specifications of fuel quality or the deployment of more tolerant\footnote{More tolerant in terms of types of fuel and resilient in terms of grades of a given fuel.} energy conversion devices and systems.

The issue of heterogeneous material has structural implications as it requires management strategies. One option is to put the pressure upstream of the supply chain by requiring highly homogeneous produce, with evident cost implications for suppliers. The second, is to favour more resilient, flexible and robust boilers able to cope with more heterogeneous material, this time with capital cost implications to users. The different strategies have implications on how the supply chain is structured both in allocation (i.e. what logistics) and governance (i.e. who and how activities are negotiated) terms. Larger boilers can be more flexible but also require larger loads that can only be justified by grouping the heat demand through heat networks or district heating. This option has critical financial but also transactional implications as it makes heat production an outsourced service. Although both strategies are not exclusive to one another, the current focus on the tightening of specifications, results in the crowding out of parts of the woody biomass available and reducing the attractiveness of fostering heat networks which justify larger and more resilient boilers.
This is particularly true when the larger share of available material for woodfuel is generated by arboricultural risings which are heterogeneous by definition:

“The city originally said that once we had done a job for the City council we could take our chips to X and tip them. I thought that it would be interesting but the boiler could not cope [with the heterogeneous material]. So now it is a bit of a folly: they have the boiler but they need a certain type of chip. So it is no good, as they originally developed the boiler to utilise all these risings but actually they can’t. So you end up having to use a certain type of woodchip, to produce it and then you still have got all the risings! It does not make sense”. N°22 (Tree surgeon)

“There is a misfit between the boilers installed and the material actually available in the region”. N°8 (Timber merchant)

“They only have themselves, these people who are putting this equipment. They have so little knowledge and experience that they put in machinery that has very, very small tolerances. Because they are being convinced by the suppliers of the equipment that such and such is good bit of kit and 99 times out of a 100 they are wrong. It is all about conveyors and how do you convey the wood to the burning section. And very few people understand about conveying woodchips. The suppliers of equipment insist unnecessarily about having a very tight spec. They are too heavily specified. Turning the problem on its head, it just depends on what equipment you are encouraged to use. And if intelligent people don’t buy (tolerant enough) equipment, that is suicide. It is the end of the road”. N°23 (Commercial forest)

Similar concerns about the mismatch were aired at a regional discussion on long-term contracts experiences. In Finland, the sector had engineered out the quality problem by developing robust devices, more adapted to deal with variability and the heterogeneity of the fuel. It was pointed out during the discussion that this was a different approach from the currently followed quality refinements of the Austrian energy conversion systems.

More generally the sense was that:

“We can use biomass in the large plants but it won’t come from the woodland. At the moment we haven’t worked out what are the long-term sustainable supply chains with question like: What resource should be going

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22 According to the 2003 resources assessment, between 30-40% of the material available for wood energy was arboricultural risings (McKay et al., 2003).

into what end-user? It is all fairly mixed up at the moment”. N°36 (Private supporting organisation)

Finally, the mismatch can also be linked to the inadequate promotional discourse where less tight specifications were relevant to large users but not medium or small ones:

“A lot of people were opportunists and saw the potential of Europe and of the boilers, but they didn’t understand the fuel. So a lot of the people that had licenses to sell the boilers were just saying “You can go to any tree surgeon and he will give you the woodchips for free”. That wasn’t the case because their woodchip was too moist, too wet and had too much fine content and too much over sized (material). The domestic and industrial markets need a very selective, a much specialised fuel, whereas the big power stations can be a bit more flexible on it”. N°3 (Recycling company)

The second, although more often mentioned problem was the lack of experience and sometimes lack of professionalism that seems to have been displayed by boiler sellers and installers.

Lack of experience is often compared with that of their counterparts in continental Europe:

“They now have the infrastructure in Europe. They have the knowledge and the experience whereas a lot of our people don’t have the knowledge and experience. We have consultants in the UK who have been working in the industry for one or two years and think they know woodfuel. It is very opportunistic at the moment. [...] this is why woodfuel took a while to get going because none of our engineers or architects understood boilers. They planned in such a huge financial risk factor that they made all these installations incredibly expensive. Finally, now people are understanding the wood, the boilers and the infrastructure. Now the cost are coming down and down, making it more affordable”. N°3 (Recycling company)

“It is new technology in Britain although it is not so in Europe, where it is mature. The plumbers know how to do it. But here, you have new people coming in that see it as an opportunity. They don’t have the experience, so they advice customers incorrectly.” N°32 (Sawmill)

Problems tended to surface at the interface between planning, infrastructure and delivery logistics requirements. These were not limited to woodchip but extended to all installed systems, as shown by the following examples:
“The Council is already looking to be supplied by somebody else because we cannot deliver by blowing lorry and they have all their silos advised by “the specialists” to have blown deliveries and are not top accessible! It is stupid, you know. They can’t even put one bag in! They have to blow it in. This sort of advice by people who ”know” about pellets or delivery that just have read a lot, you know. It doesn’t make sense. There is a huge mismatch. We tackle it every day with poorly designed plants, poorly advised customers etc”, N°32 (Sawmill)

“We have experienced continuous technical problems with boiler installers. […] First, the delay in deciding installing them, and then the delay in installing them […] but even once installed, they still don’t run properly, they break down with a plethora of technical difficulties. It has to do with the engineer’s experience in installing. It has to do with the heating engineers specifying the correct boiler, the experience of the installing engineers to get the installation right in the first place. […] I don’t really understand why European boiler suppliers aren’t sending more of their engineers over here to show English ones to do it properly. It does a huge disservice to the industry”. N°25 (Woodfuel broker)

“There are quite a few boiler installations going in where the fuel has to have to be piped in and they haven’t really thought how the fuel has to be delivered. It is fine for delivering pellets but not very good for delivering chip. It is really those simple and silly things. So there is a need for better knowledge and better understanding but it is not that complicated. It is being addressed but there are still boiler installations going on where they haven’t thought these things through.” N°36 (Private supporting organisation)

Mismatch between expectations and the actual requirements of woodfuel boilers translate into higher costs for users.

“The [chosen] size of fuel stores is also an issue. If we bring our big articulated lorries, the fuel is cheap. But if you have to deliver on smaller vehicles, the fuel is very expensive.” N°3 (Recycling company)

Not only running costs were affected by experiences of overpriced and oversized boilers with the result of heat generation being reverted to previous fossil-fuel installation because the boiler was burning more resource than what it was supposed to. Negotiation costs also emerged when such problems were transferred as frictions with their fuel suppliers. Once installers leave, the only remaining direct contact of a user with the sector is through suppliers and their product:
“If there is a problem with a boiler, the first thing anybody blames is the fuel, every time!” N°17 (Timber merchant)

“The boiler installation suppliers whose business it is, in my view, to do customer service and to make sure their customer is 110% happy when it goes live, knowing exactly what they are doing and holding their hand. Getting it up and running and not leave site until it is working. [What they did was to set up] the boiler, gave them hardly any training and buggered off! They had their problem and the guy who the customer has confidence in, i.e the guy that have put their money to by buying this very expensive piece of kit says “its your woodchip”, because it is the easiest thing to say. [...] Subsequently their fuel usage was far greater than what they had thought. And again they were questioning the chip: moisture content, is it too dry, how old is it etc. These are good questions to ask but the problem [is] a technical one”. N°15 (Estate)

The comments shared about the quality of service and advice provided by the infrastructure leg of the bioenergy chain was weak and, at times, misleading. Two conclusions emerge from such comments. The first is the confirmation that many recent boiler installation projects have been experimentations for the supply chain, pointing to the lack of maturity of the sector. The second that is related but that should be clearly highlighted is the apparent lack of coordination between the fuel supply leg of the bioenergy chain and its device sale and installation. Of course, this bleak picture of the reality only reflects views gathered from suppliers24. Given the scope of this research, installers and providers of energy conversion devices were only contacted if involved in supplying fuel. However, this has also been identified by supporting organisations also as weakness, and as such it is necessary to highlight it as a likely major issue in the development of the market.

7.3.3 Conclusion on information issues:

Product quality standards remain a weakness, although improvements were clearly identified by participants. This situation has consequences on information and how the supply chain is perceived. In terms of the perception gathered during the interviews, both from businesses and supporting organisations, the issue of standards was developing beyond the quality of the product itself towards service instead. There needs to be

24External evidence gathered later through the Intelligent Energy Europe (IEE) FOREST project, pointed at a blame game between installers of boilers and fuel suppliers around the issue of quality (Garzon Delvaux et al., 2010). More details on this ongoing (until 2012) project can be accessed at www.forestprogramme.com.
more focus on service reliability as standards do not stop with the product but are also linked to processes (i.e. FSC) and service, particularly in relation to energy conversion devices. The relationship with the customer is more demanding both at fuel and boiler installation/maintenance but lacks any explicit standards besides simple market forces around reputation. Installer’s practices have been widely criticised. For some, however the problems attributed to standards have to do with the limitation in ensuring the compatibility between boilers and the locally available resource. Such comments suggest that overly tight-specified boilers are promoted, despite the great variability of resources among locations, creating tensions and disappointments with respect to the actual savings in operating costs associated with adopting woodfuel. A fundamental and recurring weakness of the wood energy sector expressed by fuel suppliers was the lack of experience of the designers and installers with both conceptual and technical flaws in the development of the infrastructure. This issue has costly consequences in running woodchip and pellet appliances. The friction tended to appear at the interface between the location of the storage of the fuel, its road access and the requirements of the device. A possible explanation could be that they were not vertically coordinated, as only a few fuel providers are involved in fuel delivery infrastructure design and/or boiler installation. Also, no coordination on projects was identified from the participants’ experience.

7.4 Institutional factors

To provide additional context to the study and identify other important critical factors, institutional aspects were explored with the participants. The first consisted in identifying the awareness of participants about several recent initiatives and strategies aimed at supporting the development of biomass energy nationally and within the Region. The second which is directly related to awareness looked at the importance given to grant support in the form of soft loans from the public sector and charities. The third and final point identifies the degree of access to credit that the engaged businesses have.

7.4.1 Awareness about support available

Some of the initiatives were generally aimed at bioenergy in general (i.e. Energy Aid Payments, Microgeneration Certification Scheme) but the majority were directly relevant to businesses involved in this research. This was confirmed by the results but initiatives, such as the Woodfuel Strategy or the regionally focused BioHeat programme, were not unanimously known. The support programme that was more widely known
was attached to the England Rural Development Programme (ERDP). These results are presented in Figure 7.2 and shows if the person is aware of such initiatives. The result does not capture whether the respondents had a detailed understanding or had benefited from the scheme.

7.4.2 Capital grants and more

Some importance was given to capital grants and support in the form of soft loans. This was also reflected in the fact that more than 62% of the participants benefited from this kind of support to develop woodfuel as an activity (presented in Chapter 6). However, it was either seen as very important or a minor factor. Despite a few exceptions, businesses tended to see the grants as an opportunity to expand the scope of identified projects but they did not seem to be the triggering factor to invest in woodfuel supply.

“There is money but the producers are not pulling it down”. N°27 (Farmer)

“We would have done it without [the grant]”. N°15 (Estate)

 “[A lack of grant] can be a barrier. However, I think there is enough people looking at going into it who are entrepreneurial enough to invest in it if there is a return. It has relevance but it is not going to kill the industry”. N°29 (Private supporting organisation)

Two main characteristics to the support provided so far were criticised; i) the lack of regularity and nature of grants with extended uncertainty periods between each cycle; and ii) specialised personnel on the ground coordinating different woodfuel support activities suffered from recurrent turn over, generally following the pattern of financial support. Both characteristics were seen as having created boom and bust cycles in the sector.

More than the actual availability of grants, what seemed to be a more pressing issue was their rigidity and sluggishness. An example of this, is that flexible option of leasing with a buy option, which has a lot of appeal for entrepreneurs, is generally not accepted by grant systems, reducing the elbow room of small businesses when investing.

An additional aspect to highlight is that respondents from the sector did not see themselves as historical beneficiaries of subsidies and grants. Comparisons with agriculture were made contrasting it with forestry-related activities. Moreover several participants highlighted with a sense of pride their independence from public funds.
Figure 7.2: Awareness of participants to initiatives and support grants? (N=20)
7.4.3 Access to credit

Accessing credit and the financial market was not unanimously identified as a decisive barrier. A weak emphasis on a lack of access to credit may be a reason why the importance given to these barriers would probably not have changed if evaluated before the deterioration of the economic environment since 2008, as suggested by the results in Figure 7.1.

However, the picture of credit that emerged from the comments and experiences shared was rather more complex. In many cases where it mattered, there was an interaction between a grant and access to credit. For example, successful applicants for grants which would have covered a percentage of their project, did not always get the remaining share from the banks. This aspect can also be compared to agriculture. As identified from the sample, only a third of the businesses owned land; an asset generally used by farmers as collateral. So the majority of businesses that operate in this sector were not in an advantageous position when requesting a loan. In the experiences shared, banks did not signal clear support for this kind of project. An alternative could be the production of significant contracts related to the loan requested for investment. However these were not necessarily wide spread, as developed in Chapter 8.

7.5 Summary

This chapter aimed at drawing a perspective of the most critical factors identified by participants in the interviews, both businesses and supporting organisations’ personnel. The exploration followed three main dimensions. The first accounted for the potential difficulties around the different dimensions of material availability, be it physical or socio-economic. The second part focused on information related issues and factors. Finally a brief account of the institutional context was also developed.

Under physical terms, material availability was not seen as a barrier. As such, this confirms anecdotal accounts (Forest Research and RDI, 2009) and more structured assessments for the potential for the region (Hammond et al., 2008). More important comments centre on economic scarcity and competition. First, there is competition among different users of the material with “traditional” or non-energy users and the newer energy suppliers. A second dimension of competition exists between sources of the material such as forest residues and recycled wood. Availability extends well beyond a matter of quantities and physical access. Variability of the supply in general and the existence of alternative users create competition and therefore potential instability in supply which had to be dealt with by the actors. In turn, these characteristics of the
physical supply influenced the degree of flexibility of suppliers in answering the needs of their customers, with implications in the way relationships were managed. Quantity restrictions may ultimately influence future development but quality issues were a daily challenge with implications stretching deep into the supply chain. This tension around quality persisted even if imports were available. Quality was linked to information with implications for all actors along the chain.

Although improvements were clearly formulated by participants, product quality standards remain a weakness with consequences on information and how the supply chain is perceived. In terms of the perception gathered during the interviews, both from businesses and supporting organisations, the issue of standards was developing beyond the quality of the product itself and became more related to service than to product. Installers' practices have been widely criticised. For some, however the problems attributed to standards have to do with the limitation in ensuring the compatibility between boilers and the locally available resource. Such comments suggest that overly specified boilers are promoted, despite the great variability of resources among locations, creating tensions and disappointments with respect to the actual savings in operating costs associated with a conversion to woodfuel. A fundamental and recurring weakness of the wood energy sector expressed by fuel suppliers is the lack of experience of the designers and installers with both conceptual and technical flaws in the development of the infrastructure. This issue has costly consequences in running woodchip and pellet appliances. The friction tends to appear at the interface between the location of the storage of the fuel, its road access and the requirements of the device. A possible explanation could be that they are not organisationally integrated, where only a few fuel providers are involved in boiler installation.

Finally, the institutional context focused on access to grant funding and credit from the private sector alongside the degree of awareness that the business had about different existing initiatives to support bioenergy. Of the several options mentioned, the support programme more widely known was attached to the England Rural Development Programme (ERDP). However, the directly relevant Woodfuel Strategy or the regionally focused BioHeat programme was not unanimously known. In the case of the Woodfuel Strategy, this may be due to the fact that, at the time, it still had the launch of its Implementation Plan pending. Some importance is given to grants for investment in supporting the development of the supply chain. However, the actors engaged from the forestry sector seem to have a lower reliance on subsidies, in contrast with the agricultural sector. Several participants highlighted their independence from public funding, even if about 60% of all businesses benefited from a grant for woodfuel development. In

\[25\text{Only launched four years after the Strategy, in June 2011 (Forestry Commission, 2011b).}\]
turn, accessing credit and the financial market was not unanimously identified as a decisive barrier. However, the accompanying comments and experiences shared presented a more complex picture about credit. This aspect also calls for a comparison to agriculture. Collateral is more difficult to provide by many in the business as only a third own land. When submitting projects, the production of significant contracts related to the loan requested for investment was practised but such contracts are currently hard to come by, which is developed in Chapter 8.
Chapter 8

Crafting order

8.1 Introduction

Distinct governance structures can be observed for woodfuel with clear differences between logs, woodchips and pellets. Each type of product can be associated with transactions with different characteristics. At first, following the argument of the component product, asset speciality is expected to influence the relationships in the sense that “buyers and sellers are locked into a technology, but not to each other” (Van Vactor 2004: p. 30). When only asset speciality is present, through the component effect, the market remains competitive after the transaction as no Fundamental Transformation\(^1\) occurs, unlike when there is asset specificity. Asset speciality links a distinct technology or investment to an activity; whereas asset specificity would link such investment to a given relationship. Dedicated assets and spatial specificity are expected to play a role in requiring the transaction around woodfuel to be consciously coordinated to some degree, beyond the spontaneous market mechanism (Williamson, 1991), hence the title of this Chapter as “crafting order”. This effect is also expected to be reinforced by woodfuel transactions being prone to dependence on technology, as energy commodities (Van Vactor, 2004).

To present and better understand the main relationships at play along the supply chain, the chapter unfolds with a discussion of the governance mechanisms ruling transactions in the sector.

The second part of the chapter focuses on the classical determinants identified by TCE

\(^1\) As developed in Chapter 3, it refers to the transformation of a situation where there is competition between a large number of bidders at the outset into a small numbers supply relation during contract implementation because of asset specificity. Asset specificity generates “bilateral dependencies present the parties with contractual hazards for which, as discussed above, governance supports are introduced to effect hazard mitigation in cost effective degree” (Williamson, 2007).
as influencing governance choice, followed by a discussion of their explanatory power in this specific context.

8.2 Governance structures

Using the theoretical framework developed in Chapter 3, we see that beyond spot market transactions (i.e. transactional contracts) which is the simplest form of exchange, governing the trade of logs, we found fully integrated structures that harvest, process, store and use for energy purposes the wood for energy. In between, we also find a series of options around relational contracts, mainly dealing with woodchips.

8.2.1 Spot market

Logs are overwhelmingly exchanged in arm’s length relationships representing the archetypal spot market transaction. The promise of repeated business is seen as the guardian against opportunistic behaviour. Competition is seen by all involved as the structuring factor of how transactions are undertaken. As such these exchanges do not seem to suffer from transactional failures.

8.2.2 Fully integrated

TCE sees the integration of activities under a hierarchical authority as the result of transaction costs economising when the transactions studied are under the influence of a significant degree of asset specificity, uncertainty and frequency. In the case of woodfuel supply, the typical integrated organisation can be a landed estate, which also pre-dates the development of modern wood energy. This type of organisation combines different assets in space, woodland and, in some cases, investment capacity. However its integration as an organisation is independent from woodfuel development, as identified in subsection 6.2.6 on page 151 in Chapter 6. Under this scenario, the woodfuel activity developed is the result of combining certain skills and resources and is not the outcome of pursuing a transaction costs economising strategy.

However, other examples of fully (or mostly) integrated organisations recorded in recent information gathered on the development of initiatives close to the “heat entrepreneurship” model in Scandinavia (Alankangas, 2003; Kokkonen, 2005; Okkonen and Suhonen, 2010) or Austria (Rakos, 2005) are responding, to a certain extent, to transaction cost considerations.
8.2.3 Contracting or not contracting (i.e. relational contracts)

Contracts can be seen as very comprehensive and include all agreements, however here we follow Macneil in restricting the concept to “legally binding promises” (1974, p. 693 in Ménard, 2004). Such promises have the additional characteristic of also being relational contracts, in contrast to transactional contracts which are only based on repeated business. The difference lies in that transactional contracts only govern the transfer of a good whereas the relational ones frame long-term relationships (Brousseau, 2008). As the focus of the analysis entails how the relationships are governed, the definition is also set to include contracts that last at least one year, excluding shorter ones as these are considered to be only transactional agreements. Contracts of one year or more are considered as long-term. The first important aspect of the evidence is to show the prevalence of contracting as mechanism to govern woodfuel transactions.

Only a very small proportion of surveyed businesses were selling material under formal long-term contracts to supply a given quantity and quality of material where the price would be indexed each year (Table 8.1).

<table>
<thead>
<tr>
<th>Type of contracts</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>Procurement</td>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>

Table 8.1: Businesses with long-term contracts (N=28)

Although a few procurement contracts were mentioned by participants, they barely qualify as relational contracts and tend to be more transactional because they were only based on repeated business rather than on a long-term. So the actual proportion of procurement contracts was close to zero. Only one procurement relationship between a woodland owner and a woodfuel broker was found to be ruled by a long-term agreement. Given this state of affairs upstream of the supply chain, most of the discussion on contracts focused on sale contracts involving woodfuel suppliers to end-users.

8.2.4 Current experiences of long-term contracting: sales contracts

Comparing the few contract templates actually in use, which were collected during field work, offers an insight into woodfuel transactions governed by contracts.

A common pattern emerged from looking at a sample of four documents and a fifth contract (under the form of a description by a supplier). The contracts gather between
them a large proportion of the wood for energy traded under formal governance in the region. Such a pattern is matched by the features expected in fuel procurement contracts as outlined by Saussier (2000) and RegenSW (2008c). The other clear picture was that none relate to energy provision through energy service contracts or Contract Energy Management (CEM)\(^2\). They only do so to procure fuel, confirming the current restricted structure of the wood heat sector.

All sampled contracts had a take-or-pay structure. This specifies that buyers are required to take in scheduled deliveries, incurring penalties otherwise. In terms of Saussier (2000), these contracts appear to be fairly complete in the sense that they cover the main aspects of fuel deliveries as presented in Table 3.5 in Chapter 3. However there are discrepancies in how complete they are and the reasons given for variation by the parties using them. Only woodchips and pellets are the fuels discussed here as no firewood as logs were found to be traded under long-term contracts. Both relevant fuels showed distinct behaviours when traded under contract, although not being fully uniform in each category. Please note that penalties are discussed in relation to the other main clauses of the contracts. Although this was a very small sample of contract templates, their discussion offers the opportunity to better understand their function as governance mechanisms of the woodfuel market.

Although all contracts had a take-or-pay structure not all were developed by the seller. What transpired from the examples identified is that when the buyer drafts a contract, in addition to the take-or-pay, there seemed to be a take-or-leave spirit to it as well, something absent from the ones developed by sellers.

Being under contract is an indicator that they could simply be responding to the “component effect” as both sellers and buyers are locked-in a particular technology\(^3\). This dimension could be responding to manage risk, in line with the role given to contracts by Cheung (1969). However, their distinct behaviour when traded are more likely to point towards an asset specific explanation as pellet transactions are less likely to be embedded in relation-specific characteristic than woodchips. A summary of the characteristics of each contract is presented in Table 8.2.

Quantities Quantities are a central piece of a procurement contract. They are generally specified in almost all contracts as a commitment of the supplier to deliver and of

\(^2\)Terminology generally used in the UK for energy contracting, although the terms used do vary (Sorell, 2005).

\(^3\)Please note that certain woodchip boilers can take pellets as feedstock, although it is a more expensive fuel and having to switch inputs may represent an unforeseen and additional cost, consistent with categorisation of such installation as asset special and quickly becoming asset specific when site specificity and dedication of assets is involved.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Contract 1a</th>
<th>Contract 2a</th>
<th>Contract 2b</th>
<th>Contract 3</th>
<th>Contract 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed by:</td>
<td>Buyer</td>
<td>Seller</td>
<td>Seller</td>
<td>Buyer</td>
<td></td>
</tr>
<tr>
<td>Type of fuel</td>
<td>Woodchips/Pellets</td>
<td>Woodchips</td>
<td>Woodchips</td>
<td>Woodchips</td>
<td></td>
</tr>
<tr>
<td>Type of contract</td>
<td>Heat based</td>
<td>By the weight/volume</td>
<td>By the weight/volume</td>
<td>By the weight/volume</td>
<td></td>
</tr>
<tr>
<td>Duration (years)</td>
<td>3</td>
<td>(Up to 15)</td>
<td>(Up to 15)</td>
<td>(Up to 15)</td>
<td></td>
</tr>
<tr>
<td>Renewal renegotiation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantities agreed</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Take or pay</td>
<td>Yes</td>
<td>Yes</td>
<td>Implicit but there is room for renegotiation</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Minimum quantities</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fuel standards</td>
<td>Yes. Very precise</td>
<td>Yes. Basic description is provided</td>
<td>Yes. Precise.</td>
<td>Yes. Very precise</td>
<td></td>
</tr>
<tr>
<td>Location / Origin of Source</td>
<td>Yes. Has to follow CPET standards. Waste wood is not excluded.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No (“domestic and foreign origin”)</td>
</tr>
<tr>
<td>Penalties in case of seller default, including potential end of contract</td>
<td>Yes.</td>
<td>No</td>
<td>No</td>
<td>Yes on issues of quality. Quantity is not.</td>
<td>Yes</td>
</tr>
<tr>
<td>Penalties in case of default of buyer</td>
<td>Take or pay volume clause</td>
<td>Implicit take or pay volume but there is room for renegotiation</td>
<td>Implicit take or pay volume but there is room for renegotiation</td>
<td>Yes</td>
<td>?</td>
</tr>
<tr>
<td>Price indexation mechanism (Redetermination)</td>
<td>Yes</td>
<td>Yes. More complex index for longer agreement.</td>
<td>Yes</td>
<td>Not specified</td>
<td>Yes. Based on available index</td>
</tr>
<tr>
<td>Provisions for negotiations</td>
<td>Yes</td>
<td>Implicit</td>
<td>Implicit</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
the user to receive in full pre-agreed volumes in a take-or-pay type of agreement. However, it is not always expected that loads are to be paid for in their totality if delivery is not taken. Volumes are stated and include foreseen and accepted variations (i.e. ± 10%, annually or other frequency). Beyond such volumes, delivery price is generally adjusted to the current spot market price. If less quantities are purchased than agreed, an agreed fee is imposed such as 20% extra on the contract price in addition to increased delivery charges.

Quantities can be expressed in volume, weight but also in heat. Heat-based contracts are expected to tackle specific incentive issues so to encourage high quality fuel to be delivered. However, measurement (transaction) costs do not disappear from the relationship and this requires specific monitoring mechanisms of heat output and actual performance of boilers.

**Quality: Standard of fuel, processes and rules of origin** When the contracts are only based on standards such as moisture content, weight and dimensions, including some clauses about contamination, simple sampling procedures are set up to monitor and prevent possible conveyor or combustion problems. However, when heat-based contracts are agreed upon, poor heat performance can also be attributed to the energy conversion device (i.e. boiler), whatever the fuel characteristics. Although standards are also monitored through sampling, heat production is required to be monitored and the measurement instruments to be regularly and independently calibrated (i.e. unbiased) with both parties having the right to conduct additional efficiency checks at any time.

Quality is not limited to product quality and performance. Processes and rules of origin can be specified, leaving less room for renegotiation. In the case of public procurement, legally sourced material answering the demands of the Central Point of Expertise on Timber procurement (CPET) are becoming more widely spread. Although compulsory for national entities, such requirements currently remain optional for local authorities.

This group of measurement costs can also be expected to be lowered by attaching a Quality Assurance Scheme by the supplier to the contract, in addition to the specification of the fuel. Contract 1a in Table 8.2 was a large contract drawn being negotiated by a public buyer that was attempting to make its supply contract as complete as possible with the development of multiple scenarios and steps to follow in each case. This spirit towards completeness was less present in the other contracts reviewed.

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4For details, please refer to Chapter 7.

5Here we distinguish this contract as "large" compared to the other examples. This is done because it refers to the supply of larger volumes to supply several installation and not only a single one.
**Price and price indexation mechanism** An agreed price is at the centre of the contract. It is paramount and it is a dimension which is complete even in very light-touch documents. As such this is expected and, in certain countries, if a document that aims at governing a trade relationship does not have a price, it is not considered a legally bonding contract, as it is the case in France (Saussier, 2000). However, it is the evolution of this price through time that is more contentious and may imply negotiation costs to agree upon an updating mechanism. Such costs are expected to be lower within a contract than having to renegotiate each transaction in the future if carried out at arm’s length through spot markets.

As woodchip procurement arrangements are more likely to be governed by more complex contracts than other fuels, the discussion on price adjustment is almost exclusively based on the experience with this particular fuel.

Uncertainty surrounding the contractual mechanism agreed upon to govern the long-term relationship is pervasive. As no nationally recognised index exists that could be readily applicable to wood energy transactions, every contract has to engage in relatively costly negotiations. Moreover, this aspect seems to be the most contentious of all as it is the heart of the agreement. Following Crocker and Masten’s (1991) categorisation, the mechanism used in the relevant woodfuel contracts is redetermination of prices rather than renegotiation. This choice seems to indicate that transparency of the update mechanism is preferred to greater flexibility, implying concern for opportunistic behaviour from the parties.

Price change is expected through rising cost (or value) for this fuel. However, given its belongs to two distinct traditional sectors, one foot in forestry and the other in energy, uncertainty has two dimensions. The first uncertainty depended on which rose faster: timber or energy prices. In turn, the second source of uncertainty depended on how they interacted. Moreover, given the expectations of users to use biomass as a protection from fossil-fuel price fluctuations, users might be more inclined to push the settlement away from energy indexes given the idea of wood being the cheap energy alternative, as lamented by various actors and observers interviewed:

“Part of the problem at the moment is that initially this was marketed as a cheap fuel and it raised people’s expectations that it was going to be a

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6Following the suggestion of Lafontaine and Slade (2012, forthcoming) it is useful to use the distinction introduced by Crocker and Masten (1991), two main types of adjustments are used. One is redetermination, which is a formulaic either through a fixed rate, with reference to external raw material indexes or prices of the competition. The other option groups price renegotiation clauses that are more flexible and stipulate a process to update prices through arbitration or offers and acceptances. The advantage of redetermination is that it is transparent and automatic whereas renegotiation offers the opportunity to use updated information but is more vulnerable to opportunistic behaviour.
lot cheaper than it is. It should be marketed as an alternative fuel, not necessarily a cheap fuel”. N°36 (Private supporting organisation)

More complex mechanisms are expected to develop to reflect what we could call the dual identity of woodfuel, particularly in the larger and longer-term deals. A clear indication of this was that although using the same contract templates, a supplier clearly explained that:

“We use the Retail Price Index (RPI). But for the long contracts we have also attached an energy index. We are expecting an increase in woodfuel prices because of the feed-in tariff system that is about to be introduced” N°25 (Woodfuel supplier)

For example, serious efforts have been made to develop an umbrella contract by a public authority (Contract 1a, in Table 8.2) through several meetings with potential suppliers and other interested parties discussing the features of the contract and particularly technical proposals on which price update mechanism to adopt. Although participants fundamentally agreed over all other features, the price update mechanism had not been agreed upon, after almost a year?.

Documented experiences in other energy sectors such as natural-gas and petroleum coke (Crocker and Masten, 1991; Goldberg and Ericson, 1987) have linked the length of contracts to choosing between redetermination or renegotiation of prices. In inter-firm contracts of more mature industries, the introduction of a price renegotiation clause is more frequent the lengthier the contract becomes. In our case, the only documented change in strategy because of a lengthier contract for woodfuel was to choose a more sophisticated formula for redetermination. As such, renegotiation had not been used, thus being consistent with the fact that even so called long-term contracts were not going beyond three to four years?. If longer relationships are to develop, we could expect the introduction of these clauses in the future.

The middle ground option consists of agreeing upon a formulaic and automatic redetermination until prices reach a certain lower and upper limit, after which some sort of renegotiation would be required. This could offer some protection to suppliers if prices were to decrease and provide some protection for users against potentially rocketing energy prices if wood energy prices are too closely indexed to fossil-fuel prices. Although possibly considered, renegotiation over prices seems overridden by preoccupations for manifestations of ex-post opportunism. On a more speculative level, negotiations over a

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?This was still the case at the end of 2010.

?Only one contract was identified to go beyond this time scale.
mutually acceptable price index mechanism is probably more difficult than it should be if redetermination is limited to a band outside which a renegotiation clause is allowed to take effect.

The very clear message from available contracts, associated comments and comments from discussions, was that the transaction implications of reliable price statistics and relevant price index were not provided for. Being a public good, this is an existing and very concrete transaction cost that requires market building intervention from the government. As Bohlin (2001) unambiguously asserts that although public intervention had been uncertain and contradictory at times in Sweden, the early development of reliable price statistics was crucial to reduce this kind of transaction costs with ex-ante implications. The implications of reliable statistics are not limited to reduce ex-ante transactions costs but are also expected to have ex-post effects. Ex-post effects are also expected from the nonexistence of reliable statistics on both the quantities traded and those available. An example of this is the pellet market “turbulence” that unfolded in 2001-2002 which pointed at the need for quality information about the market and volumes available. According to the researchers, some sort of complacent attitude about abundance caught a whole sector off guard in one of the more established wood energy markets by not detecting growth of the domestic user sector. Faced with the aforementioned cold snap in the winter, only drastic decision making avoided a crisis threatening the take off of this type of woodfuel. These measures included partial breach of contract and forced renegotiations with large users and collaboration between suppliers (Helby et al., 2004).

In turn, suppliers of pellets are not dependent on a price update mechanism but solve uncertainty by negotiating (or simply offering) a fixed price upfront for an agreed period so that uncertainties are embedded in prices. Price is fixed ex-ante but whether there is a formal contract or not, it is noticeable that quantities are incomplete and left to the user’s discretion. The alleged rationale for this is that it is seen as a necessary adaptation mechanism so that buyers can collect information about their actual requirement before including them more formally (and perhaps in a more binding way) into the agreements. One of the three pellet suppliers contacted lost a major contract because of not being able to supply the volumes expected due to technical difficulties but was continuing to supply this customer using spot markets as with all other buyers. Others simply have rejected the option of contracts and rely on an adapted version of spot market transaction with annually revised prices for set quantities. Although this choice hints at the need for some stability, the option is still closer to spot markets than structured governance through contracts.
Provision for negotiations between the parties and terms of payments  Negotiation is understood as a means to “settle differences” that arise when facing a problem in the transaction. It is generally presented as a series of steps with increasing formality as a resolution is not reached internally. After a certain level, all contracts envisage arbitration with a third party. Some offer to use the Centre for Effective Dispute Resolution (CEDR) model procedure, following a seemingly growing trend among contracting parties in the UK (Carroll and Jackson, 2010).

Some of the examined documents did the same although more directly by requiring a third party to be knowledgeable of the trade:

“The Arbitrator and umpire shall be resident and directly engaged in the timber or plywood trade in the United Kingdom” Contract 3, Table 8.2.

This practice has been identified as a protective governance feature, such as an arbitrator or umpire is expected to “have the capacity to evaluate disputes in a more knowledgeable way than the courts may arise in this way” (Williamson, 1983: p. 527). This has clear advantages compared to litigation as the arbitrator not only is expected to be knowledgeable but has the opportunity to be educated about the transaction throughout the process. As such, “the end result will usually be a clarification that will enable everyone to proceed more intelligently with the case” (Fuller, 1963 : p. 12 in Williamson, 1983). In the UK such practice is only starting to develop but has already demonstrated clear advantages (Carroll and Jackson 2010)⁹. In other cases, clauses about negotiation suggest more explicitly incompleteness of the agreement as potential issues may not be developed through scenarios. Such clauses are rather an invitation to establish a living working relationship so to allow unforeseen or costly to formulate problems to be resolved. As such some suppliers offered a clear window for communication:

“The supplier is keen to develop a regular dialogue with the client and staff to encourage an exchange and feedback to overcome/resolve any potential issues that may occur. This can be by phone, email or site visit and the supplier considers this particularly pertinent during the initial period of fuel delivery” Contract 2a. Table 8.2.

The stance of encouraging exchange is interesting in the sense that it acknowledges that both parties can learn about how to improve the trade of woodfuel. Real case examples were shared by seasoned suppliers such as:

⁹“The CEDR reports that the value of cases mediated each year is now approximately £5.1bn and that in 2010 the commercial mediation profession will save business around £1.4bn in wasted management time, damaged relationships, lost productivity and legal fees - 89 per cent of cases settling on the day of mediation or shortly after” (Carrol and Jackson, 2010).
“Well, the customers always provide the contracts. […] There is a lot of bargaining in that. You can add and remove clauses. We do a lot of work on the contracts so they suit. If there would be no movement on the contracts, we would not sign them, because they are very heavy on the customer. […] But we help the customers as well. A lot of the customers are very clueless about wood. For instance, one contract said that there had to be no heavy metals in the wood, such as lead, cadmium etc. They did not understand that these heavy metals naturally occur in wood and they had no idea. So they would test our wood and see that all our wood is out of specification. So we also try to educate them on the wood.” Nº3 (Recycling company)

Please note that the terms of payment were very similar, if not identical for all cases where formal contracts were used. They all tended to repeat a set of simple boilerplate clauses. Arrears are penalised in similar ways through premiums added to London Clearing Banks base minimum lending rate.

Hypothetical contracting

Given the changing behaviour of the sector and in addition to the evidence on what we can call revealed governance mechanism preferences, hypothetical data was also gathered on whether participants would consider developing long-term contracts. Assuming an increasing trend towards longer-term relationships along the supply chain, hypothetical questions about the interest in long-term contracts were asked to participants, along with the conditions that such contracts should possess. The participants that were currently not involved in any formal contract were nevertheless interested in developing this mechanism. More than three quarters of them expressed so in principle, although only a fraction would be interested to purchase material this way, see Table 8.3. Participants interested in such contracts expressed an average length of four years but a median of three years only (as shown in Figure 8.1).

Interest in long-term supply contracts was seen as realistic under the following first graph in Figure 8.2 and second graph in Figure 8.3 most important conditions. The figures present the results as percentages to allow for a visual inspection of the results. The possibility of renegotiating the terms of the agreements dominated the picture as the most important first characteristic, followed by the need of trust. What is striking in this result is that formal guarantees attached to financial penalties were never considered the paramount characteristic of a long-term contract (Figure 8.2). It is only relegated to a second level and only concerned a marginal proportion of the participants (Figure 8.3).
Table 8.3: Would you be interested in formal ongoing long-term contracts? (N=26)

<table>
<thead>
<tr>
<th>Type of contracts</th>
<th>Yes</th>
<th>No</th>
<th>N/A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>26</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Procurement</td>
<td>7</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

*Not Applicable because business is a primary producer and was wrongly assumed not to be purchasing any material. Businesses having fully integrated wood energy system or managed forests or wood resources were (wrongly) assumed by the researcher not to be engaged in any procurement transaction. In order to save time throughout the interviews, actors identified having access to the resource where not asked about their potential interest in developing long-term contracts. As such, the results are probably under-representing the interest in this type of arrangement. However, three producers engaged in both internal and external procurement, mainly to increase their production volume of processed woodfuel to be sold this was limited to the upstream segment of the chain. This fact only detected late in the process, indicates that the potential interest in procurement deals for raw material is likely to have been underestimated in this exploration.

Figure 8.1: Ideal length for a supplying contract to user (N=13)
Figure 8.2: Foremost feature required from a long term agreement (N=17)

Figure 8.3: Second most important feature required from a long term agreement (N=17)
Table 8.4: Flexibility versus Stability trade-offs (N=19)

<table>
<thead>
<tr>
<th>Trade-off</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possibly higher than current but unstable price and quantity</td>
<td>52.6</td>
</tr>
<tr>
<td>Lower than current, but guaranteed price and quantity over agreed period of time</td>
<td>47.4</td>
</tr>
</tbody>
</table>

Although the formulation in the questionnaire could be seen as guided by the traditional hypothesis of risk management explaining the adoption of contracts, it can also be linked to the characteristics of the transaction, as dictated by the chosen theoretical framework. However, the hypothetical question was very open and probably only lightly considered by participants. To control for this possible bias, a second wave of questions were asked on whether they would be prepared to forego part of their flexibility in constantly adjusting prices in order to ensure the stability of a given relationship. The actual question was less nuanced to ensure that the answer would clearly distinguish two profiles that would be contrasted to the earlier question of the willingness to engage in long-term contracting and was formulated as a trade-off, as presented in Table 8.4.

Although the underpinnings of the exercise are not fully compatible with the general theoretical framework focusing on economising transaction costs, the formulation of certain issues through the more traditional aspect of risk versus stability identified the potential of those buyers more seriously interested in long-term contracts. The first effect is that less than half of the participants would choose the constraints of long-term contracts, in stark contrast to the nearly three quarters in the open question. The profile of those that would accept to lower income but for greater stability provided some clues to envisage the future of long-term contracting and nuance compared to the hypothetical first question.

8.2.5 Other hybrid options

Selling

Although the long-term contract is the most common governance option alternative to spot market, other possibilities which do not exclude contracting have been registered for the region, of which it is illustrative to highlight the woodfuel cooperative. This family of organisational choice is common in other European settings for the structuring
of woodfuel supply chains. However, only one case was reported during the field work for the South West\textsuperscript{10}. It was set up thanks to several grant schemes and the leadership of its current manager. The cooperative was about to receive its registration number as an organisation to: provide woodfuel product and services; support members to develop their supply chain (users and producers); and supports the establishment of new boilers. This initiative was bringing together suppliers and users information\textsuperscript{11} and to act as a guarantee of concerted spaces and quantities to ensure security of supply among members. At the time of the research, it was not possible to assess the initiative due to its very recent development.

**Procurement**

If the main focus of the research is on supply transactions from the point of view of woodfuel suppliers, it is important to present other connected strategies that support procurement and reveal relevant ways of how transactions may be organised. For this, two procurement systems are highlighted: one that could be called depot partnerships and another, the option contract.

The first option consists of the establishment of a network of woodfuel depots to control for transport costs in line with the research on the allocation questions developed in subsection 2.4.1 of Chapter 2. The organisational choice to develop the network is to establish partnerships to access space in strategic areas. This can be complemented by procurement arrangements that lower the intensity of dedicated assets in a given area.

The option contract, a novel organisational solution for woodfuel, not realised at the time of the main interviews was identified from a new sample of data collected for the FOREST project (Garzón Delvaux et al., 2010). The organisational characteristics of this new development clearly indicated that it was aimed at reducing the level of dedicated asset specificity linked to taking stock in a certain place (i.e. depot or tree station). The mechanism replaced the burdened option of having to take stock by developing a partnership at the upstream part of the supply chain with woodland owners. This can be conceptualised in terms of an option contract where the woodfuel broker pays an insurance premium to the woodland owner to ensure access to a certain volume of material. When the option is realised because the material needs to be mobilised, the broker buys the material at spot market price. The advantages are

\textsuperscript{10}Since 2000, South West Wood Fuels Ltd (SWWF) was a woodfuel cooperative aiming to bring together private and public woodland owners, contractors, woodfuel merchants. It used to be animated by an active woodfuel supplier (Clark and Clarke, 2011; Interview N°29). At the end of 2007, the researcher realised that the official web page of the SWWF ceased to produce new material, following the end of the financing from Exmoor National Park.

\textsuperscript{11}Members can be both users and suppliers.
twofold. One is organisational as it relieves some contractual hazard but it is also a technical one, as it allows for the seasoning of the material at lower costs than in a dedicated storage area borne by the woodfuel broker.

8.3 Determinants of governance choice

8.3.1 Dimensions of asset specificity

Following Palay’s (1984) classification of the degree of specificity, assets are divided into nonspecific, moderately idiosyncratic, and highly idiosyncratic. A physical capital investment may be special in the sense that it has a narrow purpose but it does not necessarily imply that it is idiosyncratic or specific to a transaction. Although in reality specificity deepens in a continuum from highly versatile to completely idiosyncratic, it is assumed that such a simple classification by bands does not affect its interaction with a given governance structure (Palay, 1984).

During the interviews and following the literature review of theory and empirical studies (i.e. Chapters 3 and 4), several dimensions prone to specificity were considered. A systematic enquiry was undertaken\(^\text{12}\) for i) investments in machinery and infrastructure directly related to woodfuel activities with their possible alternative uses; ii) special training and efforts in preparing staff as proxy of human capital specificity; and iii) site specificity through record of average distances between parties in transactions. The existence of dedicated assets and possible influence of temporal specificity was also captured through the open-ended questions about how transactions were carried out by participants. An additional question was also asked about planned future investments to try to capture some of the foreseen change by participants and to identify possible manifestations of transaction cost economising investments or management reforms.

Capital investments

Investments both in machinery and infrastructure have developed throughout the period reviewed with the overwhelming majority purchased to support emerging woodfuel activities. The changes recorded are presented in Table 8.5.

\(^{12}\)Recent refers to investments made within the last two to three previous years. Given the very recent development of woodfuel with a variety of fuel products, previous investments are assumed not be idiosyncratic and related to established forestry and agricultural activities with possible woodfuel uses. The deliberate choice was also influenced by the requirement that woodfuel should have been the driver to these new investments so to have more robust data to rely upon with respect to physical capital specificity.
Table 8.5: Investment in the last two-three years (percent, before 2009)

<table>
<thead>
<tr>
<th>Type</th>
<th>Increased</th>
<th>Unchanged</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery (N=22)</td>
<td>72.7</td>
<td>27.3</td>
<td>100</td>
</tr>
<tr>
<td>Infrastructure (N=19)</td>
<td>42.1</td>
<td>57.9</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 8.6: Machinery and equipment purchase (percent)

<table>
<thead>
<tr>
<th>Type</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipper</td>
<td>32</td>
<td>68</td>
<td>100</td>
</tr>
<tr>
<td>Log processor/ splitter</td>
<td>40</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Chainsaw</td>
<td>5</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>Container, tractor or forwarder</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Other, mainly specialised transport and delivery equipment</td>
<td>21</td>
<td>79</td>
<td>100</td>
</tr>
</tbody>
</table>

Machinery

Between 2006 and 2009, a range of potential machinery was acquired for woodfuel purposes by participants. These included chippers (communition machinery to turn round wood into woodchips), splitters and log processors (i.e. machinery designed to split logs and cut them to programme length if associated to a processor), chainsaws, containers for processed fuel. A few other types of equipment were mentioned by participants. The list of options in the questions also included a tractor and forwarder (a forestry vehicle designed to both haul and process timber) but none of these were purchased during the period covered by the research.

A similar proportion of chippers and log splitters were purchased by the interviewees, closely reflecting the relative proportion of logs producers and those with the capacity to offer chips, as described in Chapter 6. The details are presented in Table 8.6.

Infrastructure

Investments in infrastructure focused on creating or refurbishing storage spaces. Although potentially undertaken at high cost by professionally roofing or flooring large areas with concrete to isolate woodfuel, these provided simple and generally versatile structures. Investment cases were driven by woodfuel activities but were generally conceived to be compatible with other rural activities involving storage so to reduce their potential loss in case the bioenergy sector was not to prosper. As such, they can be generally described as non-specific. Although infrastructure preceded the development
of the woodfuel branch of the participating businesses, some had expanded their access to infrastructure rather than directly investing in improving or acquiring it. The few businesses that had developed the concept of depots or tree stations expanded infrastructure capacity and activity range through the development of various, and mainly informal, partnerships.

Future plans

To account for dynamic aspects of transaction costs and changes in governance structures in the spirit of Langlois (1992), participants were asked about their business plans for the next two to three years. To improve the quality of the responses, it was also requested to explain what steps had already been taken to realise such plans and the coded results are presented in Table 8.7.

From the responses gathered, in Table 8.7, woodfuel was generally seen as promising and worth investing in, with almost all thinking so. Much of the emphasis was on increasing volume traded but this was without clearly defined steps. However, what is more likely is that investment in new processing equipment was not perceived as a priority compared to restructuring operations and expanding storage space. Note that this storage is not necessarily increased through purchase and can be developed through organisational solutions such as partnerships, potentially requiring new forms of organisations with implications for the structure of the supply chain. Clearly, some businesses were expecting to develop more horizontal relationships to access storage in areas where they could take stock and answer the constraints of transport costs to their customers. However, this option was not widespread among businesses’ future visions.
8.4 Capital asset specificity

Capital asset specificity is not prevalent in the case of the main processing equipment for woodchips. Although asset speciality was present, particularly for the equipment dedicated to log production, it does not imply specificity as the log market was not governed by anything else than a simple and unassisted market based on reputation, as shown and confirmed by the interviews.

8.5 Site specificity

To explore the site specificity of a transaction, recorded distances can be used as a proxy to partially capture the variable. Distances between source and processing yard; and between processing yard and user were recorded by requesting participants to provide estimates. Of course, such averages are crude and relied on what participants recall and identify as averages but they provide a picture of the spatial dimension of this sector. However, this systematic procedure is not sufficient to fully capture our variable. Information from the logistical structure of the businesses involved completes it. This data emanated from the descriptions of participants and, although not as comparable as average distances, it allowed the construction of a more comprehensive explanation.

To make estimates representative, weighted averages were calculated, meaning that the influence of one particular business was proportional to its volume traded in dry tonne equivalent as estimated in Section 6.3.3. In addition, given the by-product nature of woodfuel, it that can be associated to a joint-production with a main timber product for which it is not possible to distinguish specific input in terms of transport costs. Given that the main timber product can be assumed have the full transport cost embedded in its production function, the actual “economic distance” from source to processing facility of woodfuel can be substantially smaller. The main example of these are sawmills, where off-cuts, slab wood and some round wood are generated on site, actually making the distance to source close to zero for woodfuel with all transport costs borne by the main product of the joint-production. Accounting with the volume coefficient alone, the average distance between source and yard was about 100 miles, suggesting that a large proportion of material ultimately to be used as fuel originates well beyond the simple average distance. However, what we could call the “economic distance” dropped to 20 miles as some businesses use wood originating as residues from other activities. When looking at some of the main products separately, the weighted averages ranged from 6.5 miles for logs and 16.5 miles for woodchips. Pellets tended to be imported from outside the region, if not the country. The details on distances can be consulted
in Subsection 6.3.5, Chapter 6.

Although logs were mainly local, woodchip also tended to be very limited in terms of range. This situation potentially makes them more vulnerable to site specificity but this depends on the presence of other factors of asset specificity as identified in Chapter 3.

8.6 Dedicated assets and temporal specificity

A probing question about the precedence of an agreement having prompted an investment in woodfuel processing did not indicate any evidence of explicitly dedicated assets. No machinery or infrastructure investment was made, or at least apparently in response to a promise. However and directly linked to the dimension of distances, a few examples of partnerships had developed to access storage space possessed by third parties in areas within range of new or promised new users. This is combined with taking stock with the promise of procurement from a user. Large volumes are mobilised but most importantly may be immobilised in a selected storage place near to the negotiated or promised user's location. In addition, the seasonality of wood harvesting, drying and comminution, particularly into woodchips makes the building up of stocks in a particular storage place or depot vulnerable to changes in timing. A fall in the demand or broken promise from the buyer would clearly affect the supplier through the combined effect of the dedicated assets (stock) and temporal specificity (long lead times for a specific volume of stock with expected moisture content). Additional transport costs incurred because of a change of delivery location will make the built up stock more immobile and therefore potentially vulnerable to opportunistic behaviour. This aspect may also be exacerbated by contractual requirements from public procurement which can entail the obligation to keep a minimum stock of material as reserve, potentially increasing the degree of dedicated asset specificity.

8.6.1 Discussion on asset specificity

Woodchip machinery is potentially less specialised than log processing equipment, as it can produce chips for several markets besides energy (i.e. gardening, animal husbandry). Logs, in turn, are specifically produced for the energy market and the equipment investment is special. However, the market for logs can be considered as a mature, thick market where a large number of players are involved, which is not the case for woodchips for energy. In the log market no Fundamental Transformation occurs whereas it may arise when trading woodchips.
In turn, woodchip for the energy trade tends to be associated with more complex governance structures than log transactions as it may be more prone to be used in more asset specific transactions. This illustrates the case where an investment is specialised but is not asset specific, as this depends on the relationships with the trading partner or customer. Other dimensions of asset specificity have more influence upon the nature of the transactions between supplier and user than asset specificity. An interaction between time specificity, site specificity and dedicated assets are the crux of the challenge facing woodchip suppliers in their transactions. An additional dimension identified by Pirrong (1993) is the degree of thickness of the market, understood as the numbers of (trans)actors in a market. When he assessed various shipping contracts, transactions occurring in thin markets were more likely to be governed by long-term contracts whereas the thick ones tended to be ordered through spot market arrangements. As an illustration, Pirrong (1993) noted that timber and woodchip shipping has since the 1960s been organised through long-term contracts or as part of fully integrated companies, contrasting with grain or coal\textsuperscript{13} which are traded through spot markets. A major factor identified is that wood-specialised vessels would only make a few voyages per year because they are feeding a thin market.

A certain degree of specialisation can be identified for woodchip equipment. Precise chipping equipment to produce a quality chip (i.e. constant quality output, according to energy conversion equipment standards) can be classified as specialised equipment. Irregular chips are not an issue for non-energy markets but are crucial for the energy market, so some specialisation is needed, as seen from the issues over standards in Chapter 7. However, this degree of speciality does not equate with specificity. The Fundamental Transformation where a market with an a priori large pool of qualified bidders becomes a small number supply relation through contract only develops in the case of specificity of equipment. It would be significant if such contracts are related to non-trivial investments in transaction specific assets. However, other sources of specificity have been identified, namely dedicated assets in the form of stock. This was combined with temporal specificity given the seasonal nature of handling wood. Of course, the handling of post-consumer waste reduces the seasonality factor\textsuperscript{14}, which in turn should be seen as the reason why less complex governance structures have developed around waste and recycled wood (i.e. waste management companies) and woodfuel suppliers handling forest material. Finally, the spatial dimension is the most important single factor in contributing to a Fundamental Transformation by limiting

\textsuperscript{13}Before the 1980s. After that period more long-term shipping contracts were registered for these commodities.

\textsuperscript{14}This does not mean that some business cycles could not be identified around the “production” of wood apt to be used as a renewable source of energy, according to the The Waste Incineration (England and Wales) Regulations (The Crown, 2002).
the number of potential users of the fuel sold locally. Although it does not reach the extreme textbook case of reducing it to only one potential partner, it has an effect in how woodchip for energy can be traded, beyond the logistical issues developed from the literature in Chapter 2. Although logs have a similar locality to the trade they do not share the other factors. In the case of wood pellets, this is not an issue given their higher density which provides them with higher mobility. Basically, wood pellets are still a tradable commodity even in small volumes, which is not the case for woodchips.

The factors of dedicated asset (stock), temporal specificity (seasonality) and site specificity clearly explain the difference between logs, woodchips and wood pellets governance structures. These basic factors are then exacerbated according to the degree of dependence of the stakeholder to the supply of woodchips, as suggested from the evidence from the US (Altman and Johnson, 2008; Altman et al., 2007). However, not all woodchip producers engage in more complex structures such as long-term supply contracts. The discussion of this apparent mismatch with what is expected from theory is developed in sub-section 8.6.2 below.

### 8.6.2 Woodfuel match and mismatch in TCE

From the theoretical point of view more complex governance structures along the Contract Diagram were expected to be identified from the evidence. A simplified representation of the expected map of fuels, as proxies of the more or less idiosyncratic or specific assets is presented in Figure 8.4 where woodchips appeared on option A “unassisted market”.

Not all organisations seemed to follow the predictions with regards to woodchips, as logs and wood pellets were not expected to be as complex as woodchip supply, given the respective characteristics of their transactions (i.e. degree of asset specificity, etc.). Although both examples of vertical structures and long-term contracts were recorded from the interviews (Options C and D in the Figure 8.4), several suppliers deal with woodchips on the spot market (Option A in the Figure 8.4) with the risk of sliding into Option B “unrelieved hazard”. This apparent misalignment can however be attributed to three factors which reinforce each other. The first aspect to highlight is that the theory has generally been used in more mature and stable contexts. As such the evidence did provide clues about clearly opportunistic behaviour linked to the uncertainty of the policy support. This has to be distinguished from a general uncertainty as it not about the unknown unknowns that are part of the theoretical underpinnings along with asset specificity and the frequency of transactions. Stakeholders at the time of research were waiting for important changes in the way wood energy could be fostered, reducing the
incentives to engage in long-term contracts based on out of date circumstances, despite the nature of the transactions which can be qualified as asset specific for woodchips from forest material. According to the few explanations gathered from the interviews, stakeholders were expecting an increase in the support of wood energy with important repercussions on prices and did not wish to commit for long periods time under prevailing but lower prices. This fostered spot trading instead of the expected rise in long-term contracts or developments of heat entrepreneurship, as detailed in Chapter 4.

In turn, the second aspect is related to the degree of involvement of the business in this sector. The less involved or dependent upon woodfuel as a core product, the less it is expected to be inclined to manage its relationships through contracts or other stable platforms. This is in line with the concept that core activities are more likely to be vertically coordinated than marginal ones, as shown by Jantunen et al., (2009).

The third reason could be linked to the nature of demand. Although more structured governance is expected the higher the dependence on woodfuel supply as a core of the business, the same applies to the user which has invested in a relatively site specific energy conversion device. If the user is not very dependent\(^\text{15}\) (i.e. has kept a back-up heating system)\(^\text{16}\), less interest in long-term contracts is to be expected. This is similar to what was shown by Altman et al., (2007) for the biopower industry in the US.

\section{Summary}

Distinct governance structures can be observed for woodfuel supply with clear differences between logs, woodchips and pellets. Each type of product can be associated with transactions that have different characteristics. Logs were overwhelmingly exchanged using arm’s length relationships representing the archetypal spot market transaction with the promise of repeated business. These exchanges did not seem to suffer from transactional failures except for remaining quality measurement problems in assessing “seasoned logs” but this seemed to be satisfactorily dealt with by the market. Several suppliers also traded woodchips and wood pellets on the spot market. There were examples of vertically integrated extraction, processing and use of woodfuel by land owning estates. However, as seen in Chapter 6, transaction cost economising had little to do with this specific governance. Rather woodfuel adoption by these organisations was the result of a combination of skills, space and resources availability, following the

\textsuperscript{15}\textsuperscript{15}I thank Dr Eshien Chong, Université de Paris Sud XI, for also pointing out this possibility.

\textsuperscript{16}\textsuperscript{16}This negative appellation is used here to highlight the weakness of woodfuel development, instead of using the more positive term “peak load” heat system.
Figure 8.4: Businesses represented by principal fuel and associated governance option on contractual diagram.

Source: Adapted for woodfuel in the South West of England from Williamson (2007)
explanation of RBV. The remaining of woodchips were traded under long-term contract to supply a given quantity and quality of material where the price would be indexed each year. However, only a very small proportion of businesses sold material under formal long-term contracts and even less so were governing their procurement under the modality of long-term contracts. The question of being interested in an hypothetical constraining contractual framework that would favour lower but guaranteed prices in an contract over agreed quantities interested less than 50% of the interviewees, including those that are already involved in contracting.

A comparative analysis of templates for existing contracts was undertaken to understand woodfuel transactions governed by contracts. All sampled contracts had a take-or-pay structure. This implies that buyers are required to take in scheduled deliveries, incurring penalties otherwise. In terms of Saussier (2000), these contracts appear to be fairly complete in the sense that they cover the main aspects of fuel deliveries. However, when the buyer was drafting the contract, in addition to the take-or-pay there seemed to be a take-or-leave spirit to it as well, something absent from the ones developed by sellers. The analysis explores the implication of the type of quantity, quality and price clauses of each. The very clear message from available contracts, associated comments and comments from discussions, is the transaction implications of reliable price statistics and relevant price index are not provided for. Being a public good, this is an existing and very concrete transaction costs that points at the opportunity of market building intervention from the government.

With respect to the governance of the supply chain, institutional diversity is the norm from simple spot market transactions to vertically integrated operations that harvest, process and use woodfuel in their own facilities. However, some clear trends along the lines of the type of fuel traded can be identified. Logs were almost exclusively traded on the spot market without much governance structure around transactions. Pellets were also extensively traded on the spot market but can also be found to be subject to long-term contracts. Woodchips can be found to be traded all along the governance spectrum from spot markets to vertical operations (i.e. woodland owning estates). It is important to note that woodchip is potentially the fuel that can be subject to the most influential asset specificity, particularly when dealing with forest material but less so when dealing with waste. Forest woodchip tends to steer specialised organisations towards more structured governance modes. This is not unheard of when looking at heat entrepreneurship in Scandinavia (Alankangas, 2003; Kokkonen, 2005; Okkonen and Suhonen, 2010) or Austria (Rakos, 2005). Although the South West supplying businesses fall short of vertical integration because of transaction cost economising, the businesses actually dependent on woodfuel trading to support their supply through
long-term contracts with partnerships to alleviate the effects of dedicated assets (i.e. stock) and site specificity linked with the supply of (forest) woodchips. The formally vertically integrated structures (i.e. Estates) seem to be following the RBV model based on their own capabilities, as identified in Chapter 6.
Part IV

Concluding
Chapter 9

Summary, thesis conclusions and recommendations

9.1 Summary

This study analysed the structure and development of the woodfuel supply chain in the South West region of England through the lenses of Transaction Cost Economics (TCE). This perspective on the organisation of the supply chain allowed the analysis of governance options chosen by a variety of stakeholders engaged in this nascent market.

The thesis is based on the general hypothesis that are defining factors structuring the woodfuel supply chain, by both hindering its development when causing friction but also in shaping it into (more successful) modes of governance.

The existence of barriers to exchange or transaction costs has been identified as an important non-technical barrier to the development of renewable energy technology implementation (Altman et al., 2007; Bohlin, 2001; McCormick and Kåberger, 2007; Roos et al., 1999) but only with limited development of what it specifically implies for woodfuel. A major weakness identified by the accounts covering the untapped potential of woodfuel is traced back to to its poor supply chain.

The study was divided into four Parts to the build up the thesis from the background, to the approach, the evidence and the conclusions and recommendations.

Along with the introduction, Part I presented the basic definitions of woodfuel and energy conversion options. This was followed by a context which showed that woodfuel only provided about one percent of the space heat in the country and less than one percent at regional level (Rawson, 2010). This does not reflect its undisputed potential at regional level (Forest Research and RDI, 2009; Hammond et al., 2008; McKay et
al., 2003). The woodfuel market remains nascent despite a growing policy interest and the fact that biomass heat conversion technologies are mature (Foxon et al., 2005; Roos et al., 1999). The chapter reviewed some of the main critical factors for the development of this market and the current policy response mobilised to foster it. Non-technical or institutional factors have been identified with transaction costs among them. However, the most studied factor so far is the lack of competitiveness of wood as a source of energy when compared to fossil fuel alternatives (DTI and DEFRA 2007), mainly due to positive externalities not being recognised by the market (Allen et al., 2008; Stern, 2006). Response to date had not significantly changed this. However, a policy influencing woodfuel through its adoption of heat, as a subject of policy, is turning a page on the nature of the type of support provided for decades. A shift from the usual support through grants towards an incentive-based system is being set up to specifically foster the development of renewable heat through the Renewable Heat Incentive (RHI). This new policy instrument is expected to steer support through the internalisation of the benefits of renewable energy. This initiative was not yet a reality when this thesis was conceived or when the fieldwork was undertaken but has now being passed. However, the evidence gathered for the thesis captured the effects of its absence while awaiting potential development, effectively acting as a factor of uncertainty influencing transactions in the sector with various implications for its governance. Now that this economic policy instrument is getting into place and is expected to enhance demand, it is important to identify that it does not respond to all the challenges identified in Part III of the thesis, particularly with the need to support market governance.

Part II developed a theoretical chapter which introduced transaction cost economics by emphasising the importance of the organisation problem, beyond the allocation problem generally dealt with by the literature studying wood energy supply. The aim of this chapter was to provide an overview of the new institutional economics approaches followed their historical origins and limitations. Although strongly anchored on TCE tradition, the analysis also draws from complementary, although sometimes competing theories such as the RBV. An extended TCE framework was the base for the analysis and interpretation of the project. This was followed by a review of existing specific TCE and related empirical applications that were relevant to the forestry and bioenergy sectors. This exercise enabled the formulation of three hypothesis of would guide the study, namely i) TCs are defining factors structuring the woodfuel supply chain; ii) economic agents need to embrace institutional diversity and shape the market into a purposely structured platform, such as value-preserving governance structures to infuse order; and iii) apparently misaligned transactions with governance structures persist because of institutional environment uncertainty. The answers to these statements are
developed in the Thesis conclusions below.

The methodological path followed was that of a case study, given the small-N sample but also by the need to develop a context to the nascent woodfuel sector in the region. To provide a more robust interpretation, the evidence was presented through an “*analytical narrative*” in the sense that it uses a theoretical framework (i.e. TCE) in a narrative using various sources of data. Data gathering mainly consisted of in depth semi-structured interviews of woodfuel supply businesses and to supporting organisations. The strategy of interviews as a data gathering instrument revealed itself to be logistically demanding in order to successfully adapt to business activities. However, it proved to be the most effective way to reach involved businesses and supporting organisation with 42 formal interviews along with additional informal ones. It is important to highlight the general openness, interest and generosity of participants in sharing their experience and time.

**Part III** presented the evidence gathered from the interviews but also from key documents, such as contract templates. The first section presented the actors of the supply chain and their activities to highlight their diversity. In the South West of England woodfuel is generally portrayed as a "*by-product*" of processes related to a core activity; so it is a side-line undertaking for the majority of businesses. The motivations for engaging in woodfuel explicitly mentioned by participants can be grouped into three recurrent main themes interacting with the emerging business opportunity for woodfuel, namely: i) personal drive and interest; ii) need to manage waste; and iii) resource-based know-how and capital to invest in new ventures. These motivations and their various combinations partially explain why these businesses have engaged with woodfuel. As the overwhelming majority sees woodfuel as a side-line, this was expected to translate into lower interest in developing long-term relationships along the supply chain.

Although only one third owned woodland, businesses tend to be close the source of their material as about two thirds were also involved in harvesting, both purposely or generating material as a by-product of a management service. Log processing was the most common activity. However, woodchip production capacity was almost as common but that data represented businesses involved in harvesting with at least some chipping capacity. Actual production and sales of woodchip for the energy market was only recorded for a third of the organisations contacted. Only a marginal part of the sample contacted was active in pellets. However, some important overlap in offering different types of fuel was recorded from the sample. As expected, log sales tended to be much localised and were developed within an average\(^1\) 15 miles radius. Conversely, woodchip

\(^1\)This mean was calculated for illustrative purposes and provide a sense of magnitude although it may not be statistically representative.
sales reach 45 miles when calculating the average of the sample gathered during the field work. In turn, pellets go well beyond that as they could be viably shipped using courier services to almost anywhere in the UK.

The following core of available evidence focused on analysing the main critical factors discussed with participants during the interviews to provide a background on the governance of the supply chain and identify the presence of transaction costs. This chapter aimed at drawing a perspective of the most critical factors identified by participants in the interviews, both businesses and supporting organisations’ personnel. The exploration followed three main axes. First an account of the potential difficulties around the different dimensions of material availability, whether physical or socio-economic. The second part focused on information related issues and factors. Finally, a brief look at the institutional context was also developed. Under physical terms, material availability is not seen as a barrier. As such, this confirms anecdotal accounts (Forest Research and RDI, 2009) and more structured assessments for the potential of the region (Hammond et al., 2008). More significant comments centred on economic scarcity and competition. First, there was competition among different users of the material with “traditional” or non-energy users and the newer energy suppliers. A second dimension of competition existed between sources of the material such as forest residues and recycled wood. Availability extended well beyond a matter of quantities and physical access. Variability of the supply in general and the existence of alternative users created competition and therefore potential instability in supply, which required a response by the actors. In turn, these characteristics of the physical supply influenced the degree of flexibility of suppliers in answering the needs of their customers, with implications in the way relationships were managed. Quantity restrictions may ultimately influence future development but quality issues were a daily challenge with the implications ranging deep into the supply chain. Product quality standards remained a weakness with consequences for information and how the supply chain was perceived, although improvements were clearly acknowledged by participants. In terms of the perception gathered during the interviews, both from businesses and supporting organisations, the issue of standards was developing beyond the quality of the product itself and now is more related to service than to product. Installers’ practices have been widely criticised. For some, however the problems attributed to standards were to do with the limitation in ensuring the compatibility between boilers and the locally available resource. Such comments suggested that overly specified boilers were promoted, despite the great variability of resources among locations, creating tensions and

\footnote{This view was contrasted at the same level with the experiences of installers. However, some information was gathered at meetings and after the field work phase in the framework of the IEE FOREST project.}
disappointments with respect to the actual savings in operating costs associated with a conversion to woodfuel. A fundamental and recurring weakness of the wood energy sector expressed by fuel suppliers was the lack of experience of the designers and installers with both conceptual and technical flaws in the development of the infrastructure. The friction tended to appear at the interface between the location of the storage of the fuel, its road access and the requirements of the device. A possible explanation could be that they were not organisationally integrated, with only a few fuel providers also involved in boiler installation. Finally, the institutional context focusing on access to grant funding and credit from the private sector was also explored alongside the degree of awareness that the business had about different existing initiatives to support bioenergy. Of several options mentioned, the support programme more widely known was attached to the England Rural Development Programme (ERDP). However, the directly relevant Woodfuel Strategy or the regionally focused BioHeat programme was not unanimously known. In the case of the Woodfuel Strategy, this may be due to the fact that it had still to have its Implementation Plan launched at the time\(^3\). Some importance was given to grants for investment in supporting the development of the supply chain. However, the actors engaged from the forestry sector seemed to have a lower reliance on subsidies, in contrast with the agriculture sector. Several participants highlighted their independence from public funding, even if about two thirds of all businesses benefited from a grant for woodfuel development. In turn, accessing credit and the financial market was not unanimously identified as decisive barrier. However, the picture around credit was somehow more complex from the comments and experiences shared. This aspect requires a comparison to credit access in agriculture. Farmers as land owners can offer collateral assets when applying for credit. However, in the woodfuel sector, collateral was more difficult to provide by many in the business as only a third owned land. When submitting projects the production of significant contracts related to the loan requested for investment was practised but such contracts were hard to come by, as developed in Chapter 8.

Distinct governance structures can be observed for woodfuel with clear differences between logs, woodchips and pellets. Each type of product can be associated with transactions with different characteristics. Logs were overwhelmingly exchanged on arm’s length relationships representing the archetypal spot market transaction with the promise of repeated business. These exchanges did not seem to suffer from transactional failures. Several suppliers also traded woodchips and wood pellets on the spot market. There were examples of vertically integrated extraction, processing and use of woodfuel by land owning estates. However, as seen in Chapter 6, transaction cost

\(^3\)Only launched in June 2011.
economising had little to do with this specific governance option. Rather woodfuel adoption by these organisations was the result of a combination of skills, space and resources availability, following the explanation of RBV. The rest of woodchips were traded under long-term contract to supply a given quantity and quality of material where the price would be indexed each year. However, only a very small proportion of businesses sold material under formal long-term contract and even fewer were governing its procurement under the modality of long-term contracts. Assuming an increasing trend towards longer-term relationships along the supply chain, hypothetical questions about the interest in long-term contracts were asked to participants, along with the conditions that such contracts should possess. Controlling for biased answers, the question was reformulated to participants in terms that would require a choice. By doing so, all businesses trading woodchip, if not both logs and woodchip were consistently interested in future long-term contracts to trade woodchips with only one exception.

With respect to the governance of the supply chain, institutional diversity is the norm from simple spot market transactions to vertically integrated operations that harvest, process and use woodfuel in their own facilities. However, some clear trends along the lines of the type of fuel traded can be identified. As said, logs were almost exclusively traded on the spot market without much governance structure around transactions. Pellets were also extensively traded on the spot market but can also be found to be subject to long-term contracts. Woodchips can be found traded all along the governance spectrum from spot markets to vertical operations (i.e. woodland owning estates). It is important to note that woodchip is potentially the fuel that can be subject to the most influential asset specificity, particularly when dealing with forest material but less so when dealing with waste wood. Forest woodchip tends to steer specialised organisations towards more structured governance modes. This is not unheard of when looking at heat entrepreneurship in Scandinavia (Alankangas, 2003; Kokkonen, 2005; Okkonen and Suhonen, 2010) or Austria (Rakos, 2005). Although the South West supplying businesses fall short of vertical integration, the specialised businesses support their supply through long-term contracts with partnerships to alleviate the effects of dedicated assets (i.e. stock) and site specificity linked with the supply of (forest) woodchips.

9.2 Thesis conclusions

The conclusions of the thesis are gathered around the originally formulated hypotheses that guided the thesis. The capacity of the methodology developed and the size of the sample were not in a position to confidently confirm or reject any of them. However, the various sources and, in cases, the opportunity of triangulation do provide rich material
from which to envisage reinforced hypotheses and more refined hypotheses. That said, some messages can be extracted from the strongest aspects and are formulated as recommendations in section 9.5.

**Hypothesis 1**: Transaction costs are defining factors structuring the woodfuel supply chain, by both shaping its modes of governance and by hindering its development when friction is present.

This hypothesis focused on a reason, generally overlooked, as to why wood energy in the context of the South West of England is still in its infancy. Besides the fundamental weakening effect of externalities over the competitiveness of woodfuel compared to alternative energy sources, the metaphor of the “chicken and egg” widely used in the sector (Booth, 1994) can be illustrative of the difficulties of woodfuel development but it only conveys the symptoms, therefore oversimplifying the mechanisms at play. Looking at transaction costs highlighted converging examples that even in their simplest, frictious and ex-ante form, such costs are influential in hindering the market with basic price and volume statistics still needing to be established as reliable references for the stakeholders. The other information dimension, namely the tensions around the clear adoption of adequate quality standards was also recurrently raised as a pending issue by the woodfuel suppliers and the supporting organisations contacted.

With respect to the ex-post transaction costs, the examples identified from the sample that had transactions characterised by a certain degree of asset specificity as the case of forest woodchips (as opposed to woodchips from waste), logs or pellets seem to have shaped, but potentially are still shaping the modes of governance. The thinness of the market (Pirrong, 1993) and the degree of dependence of the business (Jantunen et al., 2009) for woodfuel also seems to reinforce the trend towards more structured governance, mainly through long-term supply contracts. However, other factors such as the skills and resources of businesses seem to be at the origin of currently operating integrated organisations, rather than transaction costs. Nevertheless, transaction costs have also probably induced hybrid options such as cooperatives and partnerships, if falling short of full integration of the type of heat entrepreneurship model (Okkonen and Suhonen, 2010).

The different sources gathered generally support Hypothesis 1 with potential direct practical implication for the public and private sectors, as suggested in Section 9.5 below. However, given the type of evidence gathered and its inherent limitations (small N), the sources also suggest that transaction only one factor structuring the woodfuel supply chain among other critical factors are relevant in explaining such structure, in
which, the “resources” of the actors appear to have an important role, in line with RBV predictions.

Hypotheses 2a and 2b:

To develop the woodfuel market, economic agents need to shape it into a purposely structured platform such as “value-preserving governance structures to infuse order, thereby to mitigate conflict and realize mutual gain” (Williamson, 2002: p. 176).

The regional stakeholders need to embrace “institutional diversity” (Ostrom, 2005) to develop wood-based bioenergy.

All the material gathered points to a certain level of institutional diversity of the woodfuel supply market. However, the dominant model is closer to spot market operations than “value-preserving governance structures” infusing order. Nevertheless for the stakeholders more dependent on woodfuel for their activity, this is the case through long-term contracting and emerging partnerships. More recent information gathered after the end of the programmed field work phase, indicated that heat entrepreneurship models are now emerging⁴, something unheard of during the interviews. As such this potentially reinforces the likelihood of changing structures, that transaction costs are still shaping the modes of governance perceived in looking at the elements gathered around Hypothesis 1.

Hypothesis 2a is likely when woodfuel is at the core of the activity of the business. This is not contrary to theory as Williamson insisted that governance is shaped only if asset specificity is significant. The probable mechanism at play here however, is that the effect of an intrinsically milder asset specificity identified for woodfuel is exacerbated by a higher level of dependence of a particular business on the activity, therefore prompting more articulated transaction platforms (i.e. contracts, partnerships, integration).

With respect to Hypothesis 2b, the actual potential of woodfuel can only be unlocked through more sophisticated structures around energy service provision (e.g. Heat entrepreneurship, ESCo). Although there was some interest voiced about these models, the general reception was skeptical from the interviewees, showing either a very good knowledge of its potential or the need to raise awareness about more diverse organisational solutions. However, the type of evidence gathered does not allow to establish which possible explanation is the more probable one. That said, other experiences in Europe have embraced these models for woodfuel with documented success.

⁴Contacts with recent ventures in the framework of the authors’ contribution to the European IEE FOREST project.
Hypothesis 3: Apparently misaligned transactions with governance structures (i.e. apparently inefficient solutions) persist because of a combination of “lock in” effects of past organisational culture, learning costs and underrated influence of the uncertainty of public support.

Business engaged in woodchip supply do not systematically trade under long-term contracts or other governance options, despite the two types of asset specificity identified for these transactions: dedicated assets and temporal specificity. Building up on the reflexions from Hypotheses 1, 2a and 2b, one potential explaining factor is the degree of dependence of the business on this specific product. If marginal, it was simply sold under spot market conditions. However, additional aspects were identified as to possibly explain why there is this apparent misalignment between transaction characteristics and expected governance mode.

Learning costs about a new organisational solution (e.g. experience in developing a public procurement contract for woodfuel) could be involved in this apparent misalignment in adopting new modes of governance, however they turned out to be an unlikely major reason. However, what seems more likely, according the material gathered, is that the degree of asset specificity of the transaction requires more detailed analysis. As introduced above, there are two types of woodchips, those produced from forest material and those extracted from waste material which is less influenced by asset specificity.

The second major aspect is the unstable policy and regulatory environment which created periods of void, opening the door to opportunistic behaviour and speculation, while more stable policies were set up. The boom and bust cycles criticised by businesses was attributed to the somewhat unpredictable policy cycles of rounds of support. The future implementation of the RHI, if appropriately deployed with enabling measures, as suggested in Section 9.5, is expected to favour organisational forms more predictable in terms of TCE in situation of asset specificity. Moreover, and in responding to Hypothesis 2b, more sophisticated platforms are also expected to more likely develop in a stable environment. However, the uncertainty remaining around the RHI continued to hinder investment and interest in structuring the governance of trade relationships.

Hypothesis 3 embodies a complex set of relationships and can only be seen as asking the right question but cannot be confirmed or rejected with the data available. However, the evidence gathered did not indicate a presence of a “lock in” effect of past organisational culture embedded either on forestry or waste management. Although the roots of businesses, whether they are in forestry, waste, land management or other, do matter for their motivation in engaging into woodfuel it seemed to define their initial level of engagement into the activity, rather than preventing them to embrace new organisational forms. However, it remains a possibility as it cannot be ruled out either given
the methodology used. The same could be said about learning costs. So the limited manifestation of long-term contract use and of other more sophisticated structures is probably more strongly linked to an uncertain policy environment.

9.3 Implications and limitations

The detail of the analysis of the governance structures for woodfuel in an English Region suggests similar explanatory mechanisms in the UK but also to other biomass renewable energy sectors (i.e. energy crops), although it is not possible to make direct statistical inference. The study’s contributions to generalisation are threefold.

First, it aimed at framing theoretically non-technical barriers to the development of bio-energy markets that have been simply identified or only weakly related to a priori models.

Then, it focused the analysis on the modes of governance (i.e. spot markets, hybrids, vertically integrated firms) developed in other geographical and/or institutional settings as economizing alternatives for the exchange in a woodfuel market.

Finally, the thesis was an adaptation of a TCE framework generally used at firm level in established markets to inform the construction of a nascent bio-energy market as an effort to circumvent and economise on transaction costs.

However, the thesis is exploratory in nature with three main factors limiting its reach. The first is methodological by the limiting effect of having followed a case study approach as detailed below. The nature of the object of study also humbles its reach because the shape, size and structure of the woodfuel sector changed rapidly during the observation period and continues to do so. Finally it is important to highlight that a focus on the suppliers with less focus to users and other relevant stakeholders (i.e. installers) reduces the reach of its conclusions. The implications of these elements are developed below.

Methodology and approach The degree of generalisation possible is defined by the reliance on a case study approach with its inherent limitations derived from the analysis of a small sample. Moreover the approach has limited power in directly testing the formulated hypothesis.

The approach did not consider calculating and estimating the transaction costs per se for each transaction. A simple reason for this is that the thesis followed Williamson’s comparative institutional approach that does not require it. The purpose of the research
was not to quantify transaction costs but was looking at their effect over the governance structure of the woodfuel sector, the main focus of the analysis. An absolute estimate for transaction costs would not have particularly informative with respect to the choices of the governance modes. At the time of the field work phase it did not seem relevant but not practical either because the sample size would have been far too small for very dispersed numbers. That said however, the sector would benefit with an estimation of how such cost may tend to evolve through time and situation (i.e. major policy change) and it can be suggested for the near future. In this sense, a proposal is formulated in the Section 9.4.

**Context** The specific context of the study was shaped by the fact that i) the object of study is young and changed rapidly during the research; and ii) the period in which the study was conducted did not have the basic regulatory and policy environment fully established. Both had implications for the development of the analysis.

The thesis was an adaptation of a TCE framework generally used at firm level in established markets to inform the construction of a nascent bio-energy market as an effort to circumvent and economise on transaction costs. In its original form, TCE is static and implicitly assumes a stable sector as its object of study. However, concepts such as “*dynamic transaction costs*” (Langlois, 1992) introduce explicitly the possibility of evolution towards a stable structure with the development and phasing out of certain transaction costs, something that is expected to happen with the woodfuel sector. Some elements of a process in transition were identified but a thorough examination of a possible evolution was not possible in the framework of this thesis. Also, the relative modest size of the woodfuel activity means that the suppliers can relegate woodfuel to a marginal output, not justifying any transaction economising effort. However, it is this very distinction between the businesses that had woodfuel as a core activity and those that had not that appeared as key to the development of more elaborate governance structures, particularly around woodchip.

Although the second element raised of an unstable public support blurs the picture of the effects of transaction costs in the development of the modes of governance and therefore limits the explanatory power of the theory, it also provides a crucial explanatory factor of the difficulties in developing a market in a very uncertain policy context.

Reflecting on the context and the current characteristics of woodfuel not only showed the limits of the approach but confirmed the need, identified by Langlois (1992), to include “dynamics” into the analysis, beyond a framework that can be static. This addition to the TCE framework is very important if it is to be used in new and/or rapidly changing sectors. Concrete suggestions for developing this for woodfuel are
presented in Section 9.4 below.

**Type of actors of the woodfuel chain researched**  Woodfuel users are always present in the analysis but mainly through the lenses of the woodfuel suppliers\(^5\). Only a few users were contacted either formally or informally (e.g. users only but also producers that also use woodfuel for their own heating purposes). The choice of favouring contacts with suppliers implied some limitation as to better grasp the possibilities for different options to govern the transactions (e.g. type and length of contracts, user-supplier cooperatives, etc.) and more elements for comparison to the suppliers’ perspective. This is particularly the case with respect to woodchips and wood pellets users, more important in the conversion to woodfuel heating systems. Three aspects would significantly support the evidence presented in the thesis, had they be explore through a more extensive and direct contact with the users.

The first is related to the actual expectations of (recent) users with respect to woodfuel and the assessment of what they actually got from the transition to woodfuel. One key question is related to their expectations about medium-term woodfuel prices compared to alternatives, fossil-based or other renewables.

In turn, the identification of what would the users have preferred to govern their woodfuel supply and what actually does so would have allowed to i) more precisely categorise the type of transaction that surrounds woodchips, identified as the more prone to transaction complications and ii) to more firmly confirm the importance of contracts and other ordering of the transaction. The information of whether it is a contract, other arrangement (e.g. cooperative), only informal agreements, the spot market that are favoured and under which conditions could not be assessed from the users’ perspective.

Finally, it would have been also helpful to understand the importance of a subsidy or other economic instrument in place (e.g. the RHI in the future) in favouring their conversion to woodfuel. This may have provided additional evidence to favour intake of this technology rather than to support the expansion of the supply of woodfuel, although both sides of the equation remain important.

Another group that was not directly contacted is that of the installers. Although not directly part of the supply and procurement transactions, they have been reported by fuel suppliers as having an effect on the transaction. Their contact could have provided

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\(^5\)Although the direct contact with users offer a richer and more reliable picture of how they experience transactions, it is important to value the vision of suppliers who negotiate and are in contact with the potential users as well, which cannot not be reached by contacting actual users. This type of (non)actors also provide information about the barriers to the uptake of woodfuel for heating systems and reduces the influence of the “survivor’s” bias.
material to corroborate and contrast the suppliers’ views with respect to the quality of their work and customer service.

9.4 Future research implications

Given the orientation of this thesis and its result, the following leads for further research were are identified:

After two or three years into the implementation of the RHI, a quantitative survey could look at the determinants of developing i) more stable platforms such as long-term contracts, ii) more complex ones such as heat entrepreneurship and ESCos so to better support their establishment in view of making the woodfuel energy a mature sector and iii) calculating the transaction costs associated with the establishment of specific supply contracts to compare fuel procurement and heat procurement governance modes. This survey should be conducted at least at the level of England and not be restricted to a region in particular. Regional differences could be easily controlled for in the chosen model.

Following a similar methodology, an assessment of the relative performance of each governance modes could be developed, as this was not really possible in this thesis given the level of maturity of the sector as mentioned in Chapter 5. A first possibility could be to assess it following the option followed by Poppo and Zenger (1998) in simply measuring performance of the organisations with respect to their targets, in this case for woodfuel transactions. In the scenario of mature sectors, more refined measures of performance such as profit would be appropriate but given the youth of the woodfuel market, there was a better case for using expectations to measure performance. This cross-reference is compatible with Williamson option to evaluate remediable inefficiency “in relation to feasible and implementable alternatives” (Emphasis in the original, 2008: p. xxxvi). Otherwise, an evaluation against an ideal efficiency would not provide much insight as it would inevitably under-perform (Dixit, 1996 in Williamson, 2008).

If the development of more complex platforms is confirmed, the question of ownership of the energy conversion system should be assessed in the light of the RHI to better understand how an incentive base scheme of this sort influences the inner workings of the governance modes chosen.

More definitive information of transaction costs and governance solutions could be informed by a survey to woodfuel users with the support of boiler retailers and installer (although its administration will need to be carefully defined to protect the confidential aspects of their relationship to users). This should ideally be conducted i) one or
two years after the installation of the energy conversion devices and ii) 5 years after installation, mainly to identify the stability in the governance structures or its changes. Changes that could be attributable to the evolution of transaction costs through time as highlighted by Langlois (1992). For this to be informative it would important to ensure that the experiences and information collected accounts for the test of one or two of the crucial heating seasons.

Finally a nationwide appraisal of the evolution of modes of governance from early development to a situation in a stabilised policy context (e.g. RHI) would be most valuable. This would orientate public policy on what kind of mode to favour without having to wait for and “evolutionary” process. The appraisal would be conducted following Langlois’ (1992) concept of dynamic transaction costs. Potentially this could be complemented by a more direct evolutionary approach, bearing in mind that this approach is more limited to study the changes in whole populations rather than looking at dyadic relationships (Douma and Schreuder, 1992), something possible in TCE while accounting for the “dynamic transaction costs”.

9.5 Lesson learned and recommendations

The thesis aimed at providing targeted recommendations emerging from the conclusions. As such the ideas are first presented for their relevance to the public sector from general to specific. In addition, some recommendations have also been identified and are aimed at the woodfuel supply sector itself, following the same structure from general to particular, when relevant.

The sources of the recommendations partly emanates from using the TCE framework to read the organisational structure of the supply chain, the context review and related suggestions made by participants during the rich interviews.

9.5.1 Public sector and supporting organisations

General

The recommendations from this thesis for the public sector are influenced by the recent adoption of the Renewable Heat Incentive (RHI). Although anticipated, this change to the policy landscape favouring the development of biomass energy is expected to be “transformational” (Forest Fuels, 2010). The first aspect to highlight is that policy influencing woodfuel through its adoption of heat, as a subject of policy is turning a
page on the nature of support provided in the preceding decades. The RHI is expected
to shift policy from a support mainly spearheaded through (sporadic) grants towards
an incentive-based system to specifically foster the development of renewable heat.
However, several aspects analysed by this thesis are not necessarily tackled by this
new incentive mechanism. The evidence gathered for the thesis captured the effects
of the absence but potential development of the RHI, effectively acting as a factor of
uncertainty characterising transactions in the sector with various implications for its
governance. This policy instrument is designed to break the “chicken and egg” cycle
and to provide volume of activity. However, the findings highlight the fact that not
only support for the demand and supply of the bioenergy supply chain is necessary but
also support for the governance to their interface. Although such need was identified
in other settings (Helby et al., 2004), only a few examples have supported this type of
intervention through the analysis of ex-ante, ex-post and friction transaction costs in
the bio-energy sector (Altman et al., 2007; Bohlin, 2001; Plieninger et al., 2009; Roos
et al., 1999).

The new instrument per se does not answer to the need for clear information and data
on prices of the fuel but, may be more important to its volume flows. Whatever the
instrument in place, a fundamental message shared by participants was the need to en-
sure that woodfuel and related energy policies projected regularity and continuity in
the support provided by the different bodies engaged in woodfuel promotion. Two illustra-
tive examples of what is reproached to the support provided was that the regularity and
nature of grants was not sustained producing periods of extended uncertainty and that
personnel on the ground coordinating different activities suffered from recurrent turn
over, generally following the pattern of financial support. This created destabilising
boom and bust cycles in the sector.

An additional result to highlight here is that businesses supported almost unanimously
more support to stimulate demand to the expense of supply and therefore the uptake of
woodfuel heating systems. This would potentially go against their short-term interest
but they are aware that only a strong demand will allow them to thrive. So if they
had to choose between the two, as the question was framed during the interviews, they
would make sure to favour demand.

**Specific for support 1**

The development of a systematic statistical record of wood energy volumes and prices
traded is a basic requirement for the development of the market and its sketchy current
existence is currently felt throughout the supply chain. The specific transaction costs
associated with this information gap should be tackled by the competent authorities. Aggregated data will be useful in following general trends but regional data is more important for the sector to develop by economising on transaction costs and avoiding scenarios similar to the Swedish pellet experience of 2001-2002 (Helby et al., 2004).

Specific for support 2

The rising issue of competition for the use of the resource has been highlighted in the UK and abroad. However, less energy seems to have been devoted to identifying the opportunities for synergies between potential users. A directly relevant example is Sweden where the forest industries are already a large producer of energy both for internal and external use (Lundmark, 2006). As such, the potential level of conflict in terms of uses can be managed, although not eliminated, by promoting synergies through a realistic account of the interaction in public policy (Berndes et al., 2003; Bolkesjö et al., 2006; Lundmark, 2006). This could be both parts of a research agenda but should also start to position itself as part of the public policy agenda.

Specific for support 3

In addition to recommendations directly linked to market transactions and the TCE analysis, several participants voiced the need for support to improve access to woodlands through better infrastructure. This aspect is not new or specific to woodfuel and has been identified by the traditional forestry sector. However, this would decrease the costs of transport, so important in woodfuel production; hence it is included in this section. However, it is so with a caveat with respect to the potential environmental impact of such opening.

Specific for support 4

Although most effort has been dedicated to adapting to certain energy conversion technologies standards by promoting the production of homogeneous woodfuel (mainly in woodchips and pellets), less reflection has been developed around how to improve the usability of the currently more abundant but lower grade material. This material may not be viably homogenised. England has important resources that are less adapted to small and medium sized energy conversion systems (i.e. boilers), inviting initiatives to circumvent this limitation through organisational solutions, in contrast to the technical solution advocated by the standardisation of fuel. Both strategies are not mutually
exclusive. A possible organisational avenue is look at District Heating systems, not only for their potential economies of scale and integration possibilities but also as more flexible outlets for heterogeneous material because of using larger, more resilient boilers.

9.5.2 Suppliers of woodfuel

The focus of the thesis being the governance of the supply chain, the following recommendation can be drawn from the evidence gathered:

Specific for suppliers 1

An important instrument governing significant transactions is the supply contract. Although there have been several attempts and exercises at creating templates (e.g. RegenSW, 2008c), these documents are expected to govern relationships and the evidence shows a great variety of them, reducing the value of the template exercises. More constructively, the negotiation of contracts have been facing negotiation challenges as suppliers are looking to secure future sales while users are looking at decoupling themselves from the fossil-based energy prices. As biomass and fossil-based energy sources are related through inputs for biomass production but also demand trends, a middle ground to reduce tension and negotiation costs would be to more readily discuss the option which consists of agreeing upon a formulaic and automatic redetermination until prices would reach a certain lower and upper limit, after which some sort of renegotiation is required. This could offer some protection to suppliers if prices were to decrease and allow some weathering for users with respect to potentially rocketing energy prices if wood energy prices are too closely indexed on fossil-fuel prices. Although possibly considered, renegotiation over prices seems overridden by preoccupations for manifestations of ex-post opportunism. On a more speculative level, negotiations over a mutually acceptable price index mechanism is probably more difficult than it should be if redetermination is limited to a band outside which a renegotiation clause is allowed to take effect.

Specific for suppliers 2

In addition to the long-term supply contract, the research did identify a variety of governance options for both supply and procurement that can be considered by businesses interested in developing woodfuel as a core activity. The suggestion is to consider options such as heat entrepreneurship and woodfuel ESCo in the (potential) future context.
of the implementation of the RHI. As this mechanism is expected to tackle the economic condition barrier (i.e. internalising the externalities of woodfuel in comparison with fossil-fuel alternatives), these governance modes integrating supply and demand heat systems have better prospects that offer new development options for businesses.
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Appendix A

Information letter
Dear Mrs X,

As part of my PhD project at the University of Exeter, I am hoping to interview people like yourself to share your experience in the development of the woodfuel supply chain in the South West. Therefore, I am writing to invite you to participate in my research study.

The project aims at identifying key drivers, opportunities and constraints to the development of woodfuel (wood as energy source) in our Region. It focuses on how engaged organisations supply woodland biomass in a sustainable way to the South West energy market and how the structure of such supply chain can be supported. The project is sponsored by a joint effort between the Great Western Research, funded by the Regional Development Agency, and Lord Clinton’s Trust Fund along with the Clinton Devon Estates.

I will contact you by telephone in advance to set up a convenient appointment if you are interested in participating. With your permission, interviews will take place in June 2009.

The information you provide will be treated as strictly confidential. Interview data will be held and used on an anonymous basis, with no mention of your name, but we will refer to the general role you have in the woodfuel supply chain, such as contractor, landowner, broker, local or national public servant, etc.

The information will be retained indefinitely since woodfuel is a fledging bioenergy market and this information could stand as a baseline for future studies and evaluations. As the base for my PhD thesis, your contributions will be analyzed along with other participants’ answers. The results will prove invaluable in understanding how woodfuel is developing in our Region and will be used to formulate recommendations to support such development to local and national organisations. It is also possible that part of the result may be published in academic journals for a larger audience.

The details for the interview are provided by the Information Sheet on the reverse of this letter.

In the meantime, if you have any queries, please contact me:
07948419768 / pag206@exeter.ac.uk
For more details you may visit my University Web Page:
www.eprofile.exeter.ac.uk/andresgarzon-delvaux

Thank you in advance for your collaboration,

Sincerely,

Pedro Andrés Garzón Delvaux
PhD candidate, Centre for Rural Policy Research
The Project:
This project aims at identifying key drivers, opportunities and constraints to the development of woodfuel (wood as energy source) in the South West Region of the United Kingdom.

It focuses on how businesses are organised to supply woodland biomass in a sustainable way to the South West energy market and how such organisation can be strengthened by public support.

This policy-relevant research is looking to respond to both a need of the local economy and an opportunity brought about by climate change policies within a regional context.

The results will prove invaluable in understanding how is woodfuel developing in our Region and will be used to formulate recommendations to support such development to local and national organisations. It is also possible that part of the results may be published in academic journals for a larger audience.

The project is sponsored by a joint effort between the Great Western Research, funded by the Regional Development Agency, and Lord Clinton’s Trust Fund with the Clinton Devon Estates.

Your participation:
Your contact details were gathered from professional directories, published by the South West of England Energy Agency (SWRegen) and the Woodland Renaissance partnership / or / through personal contact.

Your participation is entirely voluntary.

The information you provide will be treated as strictly confidential. Interview data will be held and used on an anonymous basis, with no mention of your name, but we will refer to the general role you have in the woodfuel supply chain, such as contractor, landowner, broker, local or national public servant, etc.

The information will be retained indefinitely since woodfuel is a fledgling bioenergy market and this information could stand as a baseline for future studies and evaluations.

If you agree to, your interview will be tape/digitally recorded for accuracy purposes.

If you are interested, a summary report of the interviews can be sent to you.

The Interview:
The questions will develop around your experience in the woodfuel market as a business / OR/ support organisation, its constraints and prospects.

The estimated time for the interview is about 60mins, depending on its development and your specific interest in certain questions.

May I remind you that non-response to specific question is acceptable and that you may, at anytime, withdraw from the interview.

THANK YOU FOR YOUR COLLABORATION.
Appendix B

Consent form
CONSENT FORM FOR IN-PERSON INTERVIEWS

Title of Research Project

Developing Woodfuel in the South West: Opportunities and Constraints

Details of Project

This project aims at identifying key drivers, opportunities and constraints to the development of woodfuel (wood as energy source) in the South West Region of the United Kingdom. It focuses on how businesses are organised to supply woodland biomass in a sustainable way to the South West energy market and how such organisation can be strengthened by public support. This policy-relevant research is looking to respond to both a need of the local economy and an opportunity brought about by national and global environmental and energy issues such as climate change.

The project is sponsored by a joint effort between the Great Western Research, funded by the Regional Development Agency, and Lord Clintons Trust Fund with Clinton Devon Estates.

The research is conducted by Pedro Andrés Garzón D., PhD student at the University of Exeter.

Contact Details

For further information about the research or your interview data, please contact:

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If you have concerns/questions about the research you would like to discuss with the main supervisor of the research at the University, please contact:

Professor Michael WINTER, Director, Centre for Rural Policy Research, Department of Politics, University of Exeter, Devon, UK. Tel 01392 263837, d.m.winter@exeter.ac.uk

Confidentiality

Interview tapes and transcripts will be held in confidence. They will not be used other than for the purposes described above and third parties will not be
allowed access to them, except in the case of legal subpoena. However, if you request it, you will be supplied with a copy of your interview transcript so that you can comment on and edit it as you see fit. Your data will be held in accordance with the Data Protection Act and will be held indefinitely on an anonymous basis.

**Anonymity**
Interview data will be held and used on an anonymous basis, with no mention of your name, but we will refer to general role you have in the woodfuel supply chain, such as contractor, landowner, broker, local or national public servant, etc.

**Consent**
A) I voluntarily agree to participate and to the use of my data for the purposes specified above. I can withdraw consent at any time by contacting the interviewers.

**TICK HERE:**
□ Yes □ No    DATE........................................

*Note: Your contact details are kept separately from your interview data*

B) I authorize my interview to be recorded for accuracy purposes

**TICK HERE:**
□ Yes □ No

C) I authorize *in-situ* review of a sample of woodfuel sale agreements/contracts under strict commitments to confidentiality

**TICK HERE:**
□ Yes □ No □ N/A

_Name of interviewee:__________________________________________________________

_Signature: ________________________________________________________________

_Email/phone:______________________________________________________________

_Signature of researcher:______________________________________________________

2 copies to be signed by both interviewee and researcher, one kept by each
Appendix C

List of variables
List of variables (and expected influence on governance structure)

List of transaction cost variables identified as reference for the subsequent development of questionnaires and outline for interviews. The table also includes “transport costs”, which are not transaction costs *sensu stricto*, but interplay with “site specificity” and are one of the most important production costs of woodfuel.

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>Type of governance structure ruling the transaction</th>
<th>To be defined as a rising variable when rising level of coordination</th>
<th>Expected effect on dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDEPENDENT VARIABLES</td>
<td>Proxy / Question</td>
<td>Can the investments required to harvest woodfuel be re-deployable to other lucrative activities if energy market fails to develop?</td>
<td>+</td>
</tr>
<tr>
<td>Asset-specificity</td>
<td>Physical Capital Specificity</td>
<td>What is the salvage ratio value of the assets if this activity does not prosper (50%, 20% of total)?</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Human capital</td>
<td>Does it take more time than usual for a knowledgeable (forestry) worker to be at ease handling woodfuel than other new forestry related task?</td>
<td>+</td>
</tr>
<tr>
<td>Site Specificity</td>
<td>Effect?</td>
<td>Is the transaction based on previous commitment for future transactions or any other promise?</td>
<td>+</td>
</tr>
<tr>
<td>Dedicated Assets</td>
<td>N/A</td>
<td>Are you dependent on timely purchase?</td>
<td>+</td>
</tr>
<tr>
<td>Component product effect</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>(Not clearly defined yet)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport costs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Haulage</td>
<td>Is organising transport a problem?</td>
<td>+</td>
</tr>
<tr>
<td>Haulage</td>
<td>Do you think that a transaction depends too heavily on transport?</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>Is distance to potential contractors or brokers a defining aspect of your decision with respect to woodfuel</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Information costs (&amp; policing costs)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Price * Uncertainty</td>
<td>Is it a problem not to know the price of woodfuel previous to harvest?</td>
<td>+</td>
</tr>
<tr>
<td>Standards</td>
<td>Are specifications in moisture and matter difficult to measure?</td>
<td>+</td>
</tr>
<tr>
<td>Standards * Uncertainty</td>
<td>Do you trust the estimates given?</td>
<td>-</td>
</tr>
<tr>
<td>Standards</td>
<td>Are specifications in moisture and matter difficult to meet?</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bargaining cost</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>How long do you have to wait for payment (days) Is it a specific problem or common to your other activities as well?</td>
<td>+</td>
</tr>
<tr>
<td>Quantities</td>
<td>Are quantities more important than price in your bargaining?</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search costs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential suppliers / buyers</td>
<td>Do you think you need more time to find suitable partners for woodfuel than for other activities? What proportion of your time is devoted to this aspect ('market development')</td>
<td>+</td>
</tr>
<tr>
<td>Potential suppliers / buyers</td>
<td>Do you think difficult to reach a comfortable deal with your suppliers?</td>
<td>+</td>
</tr>
</tbody>
</table>
### Enforcement costs

**Enforcement**

What allows you to rely and make commitments on your own based on your partners’ commitments to you? (i) fear of being left out of the market, (ii) there are alternatives and the partner knows that you would retaliate with no more business, (iii) you know that both benefit from a healthy relationship, (iv) you both benefit from a healthy AND coordinated relationship, (v) not very clear idea)

### Opportunity costs

**Opportunity costs**

What protects you if your partner fails? Do you have alternatives to depend upon? (The more alternatives, the less dependent is the transaction, negative relationship with complex governance structure)

### Re-negotiation and adaptation costs

**Adjustments**

How do you adjust previous commitments and agreements to new/changed circumstances? What is a changed environment?

(Ask to define) Attitude: i) Keep course or ii) be flexible and when (if it brings zero-sum advantage, mutual advantage, long-term advantage for the relationship). What way: unilateral or negotiated? Negotiated to achieve present or future gains and future formal adjustments?

### Planning short-term

Do you exchange information for coordinated activities? If yes, what?

### Planning long-term

Do you plan in coordination with your partner? If yes, what?

### Breach of contract costs

**Liability**

Have you been through a legal procedure to settle a breach of contract for woodfuel or related investments? Why?

**Attitude**

What do/would you do if there is a dispute over a previous agreement?
Appendix D

Questionnaire to businesses
CODE: 

DATE: HOUR: 

QUESTIONNAIRE:
Woodfuel supply chain / Businesses

SECTION 1: Details of yourself and your business

1. Could you describe your business? (OPEN)

   Record:-Main Activity / -Secondary activities / -How long in the trade?

<table>
<thead>
<tr>
<th>If business is not land ownership related Go→Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2b</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2c</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

3a. What activities do you have in your woodland? (OPEN)

3b. Do you think there is or they may be a potential clash between
the activities you have in your woodland and woodfuel production? (OPEN)

4 In this business, are you:

- Sole trader 1
- Partner 2
- Salaried manager 3
- Other: 4

5 Including yourself, how many employees are active in this business

<table>
<thead>
<tr>
<th>Options</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full time</td>
<td>1</td>
</tr>
<tr>
<td>Part-time</td>
<td>2</td>
</tr>
</tbody>
</table>

Before continuing, I would like to ask a few questions about you.

6 Which age range do you fit into / What is your age?

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 25</td>
<td>1</td>
</tr>
<tr>
<td>25-35</td>
<td>2</td>
</tr>
<tr>
<td>36-45</td>
<td>3</td>
</tr>
<tr>
<td>46-55</td>
<td>4</td>
</tr>
<tr>
<td>56-65</td>
<td>5</td>
</tr>
<tr>
<td>66-75</td>
<td>6</td>
</tr>
<tr>
<td>Over 76</td>
<td>7</td>
</tr>
</tbody>
</table>

7 Gender

- Male 0
- Female 1

8a Have you had any education or training after leaving school?

<table>
<thead>
<tr>
<th>Option</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

8b If YES record the type and how many diplomas?

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postgraduate degree, MA/MSc, PhD</td>
<td>1</td>
</tr>
<tr>
<td>Degree level qualification including foundation degrees, graduate membership of a professional institute, PGCE, or higher</td>
<td>2</td>
</tr>
<tr>
<td>BTEC / other higher education qualification below degree level</td>
<td>3</td>
</tr>
<tr>
<td>A-level/ Vocational A-level or equivalent</td>
<td>4</td>
</tr>
<tr>
<td>Other:</td>
<td>5</td>
</tr>
</tbody>
</table>
9a  Have you attended any specific course / seminar on woodfuel or biomass energy?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

9b  If so, which one and which institution provided the course?

9c  Have you been interviewed or participated to a survey on the woodfuel aspect of your business before?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

SECTION 2: Activities in Woodfuel:

10a  What prompted you to get started in the woodfuel business? (OPEN)

Record:
- What triggered it and when client request / event / experience / public grant / cheap resource available / good combination with other new activity / good combination with old activity
- Time in the activity
- What have been the hurdles
- Is it a distinctive business
-Feels isolated or on the contrary

10b  What processes are centred around woodfuel, indicate all relevant
(Indicate following answers from 10a and PROMPT IF NECESSARY)

<table>
<thead>
<tr>
<th>Option</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td>1</td>
</tr>
<tr>
<td>Seasoning /Storage</td>
<td>2</td>
</tr>
<tr>
<td>Split Logs</td>
<td>3</td>
</tr>
<tr>
<td>Produce Chips</td>
<td>4</td>
</tr>
<tr>
<td>Produce Pellets</td>
<td>5</td>
</tr>
<tr>
<td>Activity</td>
<td>Code</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Retail to users</td>
<td>6</td>
</tr>
<tr>
<td>Sell to broker / aggregator</td>
<td>7</td>
</tr>
<tr>
<td>Transport to buyer</td>
<td>8</td>
</tr>
<tr>
<td>Consulting / Advice</td>
<td>9</td>
</tr>
<tr>
<td>Boiler Installation</td>
<td>10</td>
</tr>
<tr>
<td>Other:</td>
<td>11</td>
</tr>
</tbody>
</table>

10c Is there an activity or process that you would rather conduct yourself (as a company) instead of relying on somebody else’s services? If this is the case, WHY so? (OPEN)

<table>
<thead>
<tr>
<th>11a How frequent does your business engage in woodfuel handling activities?</th>
<th>Optio</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Once a week</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Once a monthly</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Only occasionally</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

11b Do such activities are conducted year round?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

12 What is the *full-time equivalent* of manpower dedicated to wood fuel related activities?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours:</td>
<td></td>
</tr>
</tbody>
</table>

13a What are you plans for the future regarding woodfuel? (NEXT 2 years) (OPEN)

13b What steps have you already taken into that direction? (OPEN)
According to your experience, how important are the following barriers in developing your woodfuel business opportunities?

On a scale of 1 to 4, 1 being: Not relevant, 2 Minor, 3 Important and 4 Very important.

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Not relevant</th>
<th>Minor</th>
<th>Important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enough wood available</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not enough financial support to producers invest from public bodies/charities</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty in finding long-term and stable commercial partners (either to buy / sell the material)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of experience and know-how in this business</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential users lack of information about woodfuel</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty in establishing long-term contracts</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty of suppliers in accessing credit to buy equipment</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of quality standards</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition from imports</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition from wood from post-consumer waste giveaways</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient grants to support the installation of boilers</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning requirements for boiler installation</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If I had asked you to rank them one year ago, before the credit crunch, would it have been different?

No 0
Yes 1

If Yes, what? (OPEN)

For woodfuel, is it difficult to find suitable: -----? (OPEN)

Prompt: Do you find it very time consuming, compared to your other activities?

15a) Suppliers

15b) Customers

What is your relationship with boiler installers? (OPEN)
15b What is your relationship with woodland owners around woodfuel? (OPEN)

16a What kinds of relationship do businesses that provide the same kind of services as you, have between each other? (HORIZONTAL) Cooperation / Competition (OPEN)

16b If you consider it necessary, what kind or mechanisms of cooperation between competitors would make the sector and your business more profitable? (OPEN)

16c Are you aware of any collaboration around depots OR shared facilities / machinery / inventories between suppliers to ensure security of supply for a defined area? If so, how did it develop? (OPEN)

16d What kinds of relationship exist between the different levels of the supply chain? (VERTICAL) (OPEN)

16e If you consider it necessary, what kind or mechanisms of cooperation between the different levels of the supply chain would make the sector and your business more profitable? (OPEN)

16f According to your experience, what are the barriers to a more cooperation around woodfuel supply? (OPEN)

Prompt: Not a tradition / lack of know-how, not seen as necessary, history of lack of commitments, shirking, etc.
Now, I would like to ask you a few questions about investments and growth of your woodfuel business.

17a In the last two years, have you increased, reduced or not changed the machinery invested to handle woodfuel?

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unchanged</td>
<td>0</td>
</tr>
<tr>
<td>Increased</td>
<td>1</td>
</tr>
<tr>
<td>Reduced</td>
<td>2</td>
</tr>
</tbody>
</table>

17b What has increased /* reduced?

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipper</td>
<td>1</td>
</tr>
<tr>
<td>Logger</td>
<td>2</td>
</tr>
<tr>
<td>Chain saw</td>
<td>3</td>
</tr>
<tr>
<td>Containers</td>
<td>4</td>
</tr>
<tr>
<td>Tractor</td>
<td>5</td>
</tr>
<tr>
<td>Forwarder</td>
<td>6</td>
</tr>
<tr>
<td>Other:</td>
<td>7</td>
</tr>
</tbody>
</table>

17c What pushed you to increase /* reduce your machinery investment? (OPEN)

*Prompt: Prospect of contract, other business success, perceived support from government... Details to look for: Obsolete plant renewal / Rationalisation (More productive) Productive capacity enlargement / Environmental protection – Regulation / Other destinations*

18a In the last two years, have you increased, reduced or not changed your buildings / storage / loading spaces to handle woodfuel

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unchanged</td>
<td>0</td>
</tr>
<tr>
<td>Increased</td>
<td>1</td>
</tr>
<tr>
<td>Reduced</td>
<td>2</td>
</tr>
</tbody>
</table>

18b What infrastructure did change? (OPEN)

18c What pushed you to increase /* reduce your buildings? (OPEN)

*Prompt: Prospect of contract, other business success, perceived support from government... Details to look for: Obsolete plant renewal / Rationalisation (More productive) Productive capacity enlargement / Environmental protection –*
19a  In the last two years, have you hired more personnel to handle / trade woodfuel

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unchanged</td>
<td>0</td>
</tr>
<tr>
<td>Increased</td>
<td>1</td>
</tr>
<tr>
<td>Laid-off</td>
<td>2</td>
</tr>
</tbody>
</table>

19b  If hired /*/ laid-off personnel, in which proportion? No.

(Full-time equivalent / number of employees):

19c  Why was this necessary? (OPEN)

19d  Have you or your employees spent time in learning how to successfully handle and trade woodfuel?

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No, it was straightforward</td>
<td>0</td>
</tr>
</tbody>
</table>

19e  If yes, what was the most demanding aspect of the learning process? (OPEN):

19f  Can the investments made for woodfuel be used for other purposes, if the energy market fails to develop?

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>I don’t know</td>
<td>2</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

19g  What is the next best alternative use of such investment, if not for woodfuel? (OPEN):

19h  How would the benefits derived from alternative machinery uses compared to original purpose?
19i How would the benefits derived from alternative building uses compared to original purpose?

<table>
<thead>
<tr>
<th>Option</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than half</td>
<td>1</td>
</tr>
<tr>
<td>About half</td>
<td>2</td>
</tr>
<tr>
<td>Similar</td>
<td>3</td>
</tr>
<tr>
<td>I don’t know</td>
<td>4</td>
</tr>
</tbody>
</table>

19j What is the salvage or scrap value of the machinery investment mentioned earlier?

<table>
<thead>
<tr>
<th>Percentage of total value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don’t know</td>
<td>0</td>
</tr>
<tr>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>20%</td>
<td>2</td>
</tr>
<tr>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>80%</td>
<td>4</td>
</tr>
</tbody>
</table>

20a Some say that the single key to a successful woodfuel business is to control for transport costs. How would you identify with this statement?

<table>
<thead>
<tr>
<th>Agreement Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree (Go 20c)</td>
<td>5</td>
</tr>
<tr>
<td>Agree (Go 20c)</td>
<td>4</td>
</tr>
<tr>
<td>Neither agree nor disagree (Go 20b)</td>
<td>3</td>
</tr>
<tr>
<td>Disagree (Go 20b)</td>
<td>2</td>
</tr>
<tr>
<td>Strongly disagree (Go 20b)</td>
<td>1</td>
</tr>
</tbody>
</table>

20b If neutral or disagree, what do you think is the main cost to this business (OPEN)?

20c If agree, what do you think is the other main cost to this business (OPEN)?

21 What are your current average prices for:

<table>
<thead>
<tr>
<th>Volume /specifications</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs</td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td></td>
</tr>
</tbody>
</table>
Woodchips

Miscanthus

22a Two years ago, were prices the same?

Yes (GO Q23) 1

No 0

22b What was the price 2 years ago for:

<table>
<thead>
<tr>
<th></th>
<th>£</th>
<th>Volume /specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Woodchips</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Miscanthus</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

22c How important were the following in the evolution of prices:

<table>
<thead>
<tr>
<th></th>
<th>OPTION</th>
<th>Not relevant</th>
<th>Minor</th>
<th>Important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in demand for woodfuel</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in transport costs</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in other costs</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in demand of wood for competing uses</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

23 What should be the price of woodfuel before you would consider investing more into this activity?

<table>
<thead>
<tr>
<th></th>
<th>£</th>
<th>Volume /specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Woodchips</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

24a In the past 2 years did you meet the expectations you had when trading woodfuel?

<table>
<thead>
<tr>
<th></th>
<th>OPTION</th>
<th>Dissatisfied</th>
<th>Slightly dissatisfied</th>
<th>Satisfied</th>
<th>I exceeded my expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall cost of operations</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of the woodfuel offered</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsiveness to buyers’ requirements</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24b Why is it so?(OPEN)

Overall cost of operations:
SECTION 3: The material and sourcing.

25a What are the sources of the wood you have offered this year (including last winter):

<table>
<thead>
<tr>
<th>Option</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscanthus</td>
<td>1</td>
</tr>
<tr>
<td>Private Clients residues (parks and garden only contracts)</td>
<td>2</td>
</tr>
<tr>
<td>Public, Local authorities arising</td>
<td>3</td>
</tr>
<tr>
<td>Post consumer Waste / Pallets</td>
<td>4</td>
</tr>
<tr>
<td>Mill residues / slab wood</td>
<td>5</td>
</tr>
<tr>
<td>Commercial forestry residues from thinning and harvesting contracts</td>
<td>6</td>
</tr>
<tr>
<td>Residues and material from <strong>own</strong> commercial forest</td>
<td>7</td>
</tr>
<tr>
<td>Residues and material from <strong>own</strong> non-commercial woodland</td>
<td>8</td>
</tr>
<tr>
<td>Imports from outside the region.</td>
<td>9</td>
</tr>
<tr>
<td>Short Rotation Forestry (Poplars, Willow)</td>
<td>10</td>
</tr>
<tr>
<td>Short Rotation Coppice</td>
<td>11</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
</tr>
</tbody>
</table>

25b How do you source your material? Do you have to pay for it or are you paid to remove?
the material /*/ part of another activity?

<table>
<thead>
<tr>
<th>Material Source</th>
<th>Select</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buy material</td>
<td>1</td>
<td>________%</td>
</tr>
<tr>
<td>Receive material as part of payment activity</td>
<td>2</td>
<td>________%</td>
</tr>
<tr>
<td>Collect material for free</td>
<td>3</td>
<td>________%</td>
</tr>
<tr>
<td>Free residue from own activity</td>
<td>4</td>
<td>________%</td>
</tr>
</tbody>
</table>

25c When involved in harvesting / thinning does the potential use as a fuel of the material gathered changes the way you operate?

<table>
<thead>
<tr>
<th>Select</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>N/A</td>
<td>3</td>
</tr>
</tbody>
</table>

25d How does it influence the way you operate? (OPEN)

25e When sourcing your material from third parties what kind of influence do you have on the way they operate, in order to have a material more suitable to be sold on the energy market? (OPEN)

25f Is this a typical year?

<table>
<thead>
<tr>
<th>Select</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

25g Why is this not a typical year? (OPEN):

26a What makes you think that your current sources are reliable?(OPEN)

AFTER...Prompt “Sustainable?”

26b With respect to sourcing, do you think it is difficult to access wood that is grown in the South West Region?

<table>
<thead>
<tr>
<th>Select</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>
26c If so, why? (OPEN)

Record:
- Cost and origin (i.e. distance)
- Land owners unwillingness to manage / disturb their woodland
- Quality
- Demands in terms of processing, drying and storing

26d Do you think there are any ways to have more access to wood grown in the South West? (OPEN)

Prompt: Woodland that is not currently managed.

27a Do you think that people in your community are weary of a more systematic exploitation of woodlands for woodfuel?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

27b Why do they support /OR / are not supportive of woodfuel development? (OPEN)

27c As far as you know, what are your woodfuel users do with their ashes? (OPEN)

28 How much volume of fuel have you traded this year (including last winter)

<table>
<thead>
<tr>
<th></th>
<th>Option</th>
<th>Volume</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscanthus</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logs</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodchips</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t know</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

29a What volumes do you keep in stock at any given time?

<table>
<thead>
<tr>
<th></th>
<th>Option</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option</td>
<td>Percentage</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td>Miscanthus</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Logs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Woodchips</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Pellets</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>I don’t know</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>As little as possible</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

29b Why is it so? (OPEN)

<table>
<thead>
<tr>
<th>30</th>
<th>What proportion of softwood and hardwood do you trade?</th>
<th>Option</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hardwood</td>
<td>1</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Softwood</td>
<td>2</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>I don’t know</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

31a What is the approximate average distance between the source of material and your centre of operation / storage facility? | Miles | Km |
| Average        | 1                                                         |        |            |
| Maximum        | 2                                                         |        |            |
| N/A            | 0                                                         |        |            |
| I don’t know   | 3                                                         |        |            |

31b How far are you prepared to go to collect a full load of material for free? | Miles | Km |
| Logs           |                                                         |        |            |
| Woodchips      |                                                         |        |            |
| N/A            | 1000                                                     |        |            |

32 What is the approximate average distance between your centre of operation / storage facility and a customer? | Miles | Km |
| Average        | 1                                                         |        |            |
| Maximum        | 2                                                         |        |            |
| N/A            | 0                                                         |        |            |
| I don’t know   | 3                                                         |        |            |

33a Are moisture & calorific content standards difficult to meet? | No (Go Q34) |   |
|                                                             | 0           |   |
|                                                             | Yes         | 1  |

33b Why are standards difficult to meet? (OPEN)

33c In your opinion and following your experience, is there anything that could be developed to make it easier to meet such standards? (OPEN)
### 34a What kind of woodfuel clients do you supply?

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage in terms of volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediaries / Processor / Broker</td>
<td>1 %</td>
</tr>
<tr>
<td>Individual domestic users</td>
<td>2 %</td>
</tr>
<tr>
<td>Farm / Estate business users</td>
<td>3 %</td>
</tr>
<tr>
<td>Urban business users</td>
<td>4 %</td>
</tr>
<tr>
<td>Public organisations (i.e. schools, hospitals)</td>
<td>5 %</td>
</tr>
<tr>
<td>CHP / Power station</td>
<td>6 %</td>
</tr>
<tr>
<td>Charities</td>
<td>7 %</td>
</tr>
<tr>
<td>District heating users</td>
<td>8 %</td>
</tr>
<tr>
<td>Other</td>
<td>9 %</td>
</tr>
</tbody>
</table>

### 34b Do you think that you had some influence on whether your clients are currently using woodfuel as an energy source? (OPEN)

*Prompt: You were close to them, informed them of the benefits of woodfuel over fossil fuel systems...*

### 34c Who else do you think had influence on whether your clients are currently using woodfuel as an energy source? (OPEN)

### 35a If your orders for woodfuel were to surge and double, would you be able to find enough material to meet such demands? (OPEN)

*Prompt: Easy access to an abundant resource without consideration of storing capacity*

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, {GO}</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

### 35b How swiftly?

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than a week</td>
<td>1</td>
</tr>
<tr>
<td>1 week</td>
<td>2</td>
</tr>
</tbody>
</table>
2 weeks 3
1 month 4
More than 1 month 5

35c What would be the most abundant source to which you would have extra access to?

<table>
<thead>
<tr>
<th>Source</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscanthus</td>
<td>1</td>
</tr>
<tr>
<td>Private Clients residues (parks and garden only contracts)</td>
<td>2</td>
</tr>
<tr>
<td>Public, Local authorities arising</td>
<td>3</td>
</tr>
<tr>
<td>Post consumer Waste / Pallets</td>
<td>4</td>
</tr>
<tr>
<td>Mill residues / slab wood</td>
<td>5</td>
</tr>
<tr>
<td>Commercial forestry residues from thinning and harvesting contracts</td>
<td>6</td>
</tr>
<tr>
<td>Residues and material from <strong>own</strong> commercial forest</td>
<td>7</td>
</tr>
<tr>
<td>Residues and material from <strong>own</strong> non-commercial woodland</td>
<td>8</td>
</tr>
<tr>
<td>Imports from outside the region.</td>
<td>9</td>
</tr>
<tr>
<td>Short Rotation Forestry (Poplars, Willow)</td>
<td>10</td>
</tr>
<tr>
<td>Short Rotation Coppice</td>
<td>11</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
</tr>
</tbody>
</table>

35d Do you think that such source is reliable? (OPEN)

AFTER...Prompt “Sustainable?”

SECTION 4: Woodfuel business and agreements

36a Some say that the main reason why it is difficult to develop this market is the unstable flow of business. How do you identify with this view?

<table>
<thead>
<tr>
<th>Identification</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree (Go Q40a)</td>
<td>5</td>
</tr>
<tr>
<td>Agree (Go Q40a)</td>
<td>4</td>
</tr>
<tr>
<td>Neither agree nor disagree (Go Q40a)</td>
<td>3</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>1</td>
</tr>
</tbody>
</table>

36d If agree, what could bring more stability in the way woodfuel is produced and exchanged? (OPEN)
<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>37a  Do you have deals that go beyond a single / one-off sale?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prompt: Some kind of agreement for future deals with same buyer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37b  Do you have deals that go beyond a single / one-off procurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deal? Prompt same as above: Some kind of agreement for future deals with same seller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38a  Would you be interested in a formal long-term contract to supply a given quantity and quality of material where the price would be indexed each year?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38b  Why are you NOT interested in this kind of contract?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am not be in a position ensure long-term supply</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t think that the other party would be able to realistically commit</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would rather keep my flexibility to take advantage of future opportunities</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38c  Would you be interested in a formal long-term contract to buy a given quantity and quality of material where the price would be indexed each year?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (Go ➔ Q46)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38d  Why are you not interested in this kind of contract?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am not be in a position ensure long-term supply</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t think that the other party would be able to realistically commit</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I would rather keep my flexibility to take advantage of future opportunities

Other:

<table>
<thead>
<tr>
<th>39</th>
<th>What would be an ideal length for supplier and customer contracts?</th>
<th>Years</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>40a</th>
<th>What are the 1st and 2nd most important conditions that you expect from a long-term contract agreement:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The agreement is flexible enough to be renegotiated if your business condition /and/or the business environment dictates so</td>
</tr>
<tr>
<td>2</td>
<td>The agreement has enough formal guarantees and penalties</td>
</tr>
<tr>
<td>3</td>
<td>You trust the customer/supplier personally</td>
</tr>
<tr>
<td>4</td>
<td>You trust her / his company</td>
</tr>
<tr>
<td>5</td>
<td>Other: (Specify)</td>
</tr>
</tbody>
</table>

| 40b | Why is it so? (OPEN) |

<table>
<thead>
<tr>
<th>41a</th>
<th>Are you dependent on a timely purchase / delivery of material?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No, I am rather flexible (Go ➔ Q50a)</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>41b</th>
<th>Why are you dependent on precise timing? (only one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somehow disruptive of process and storage operations</td>
<td>1</td>
</tr>
<tr>
<td>Disruptive of own commitments to other partners</td>
<td>2</td>
</tr>
<tr>
<td>Other (Specify)</td>
<td>3</td>
</tr>
</tbody>
</table>
42a  How long do you have to wait for payments for woodfuel?  

<table>
<thead>
<tr>
<th>Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
</tr>
</tbody>
</table>

42b  Is the timing of payments similar to your other activities?  

<table>
<thead>
<tr>
<th>Yes (Go → Q51a)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

42c  If NO why? (OPEN)

43a  When bargaining over a deal, are prices or quantities more important to you?  

<table>
<thead>
<tr>
<th>Prices</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantities</td>
<td>2</td>
</tr>
</tbody>
</table>

43b  Why is it so? (OPEN)

43c  If you had to choose from the following trade-offs, which ONE of the following would you prefer:  

| Possibly higher than current, but unstable price and quantity for your main woodfuel product | 1 |
| Lower than current, but guaranteed price and quantity over an agreed period of time for your main woodfuel product | 2 |

44a  Are you aware of specific business models for developing the woodfuel sector? (OPEN)  

Prompt if not aware of any:  

Have you heard of the following?:

**Investment by customer**, where a user of woodfuel invests in boiler(s) but has an agreement with an independent company to manage the boiler(s) and ensure fuel supply either by producing it or buying it from other sources (Community heating systems)
**Investment by companies** (small or large), as a company it owns boilers and run them selling heat to users. It offers a heat selling service, as a utility company. (Community / District heating systems)

**ESCO – Energy Service Company:** It is a leasing scheme between a user and an experienced investor. The agreement generally covers the installation of the woodfuel boiler, energy saving programme for the user accompanying the replacement of older boiler, provision of heat with the option to buy the equipment by the user (Any user without enough financial capacity to invest upfront)

44b If you are interested in being involved in one of these arrangements, which one AND Why? (OPEN)

45 Are you willing to share contact of suppliers or sources (woodland owners) that would be interested to share her/his views on woodfuel?

<table>
<thead>
<tr>
<th></th>
<th>No (Go→ Q46)</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

**DETAILS:**

SECTION 5: Support to woodfuel:

46a Has the branch of your business dedicated to woodfuel benefited from government or charity support?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>----</td>
</tr>
<tr>
<td>46b</td>
<td>If the business benefited, through which programme(s) it did so?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>List:</td>
<td></td>
</tr>
<tr>
<td>46c</td>
<td>How has it benefited from the programme(s)? (OPEN:)</td>
<td></td>
</tr>
<tr>
<td>46d</td>
<td>Over which period were you beneficiary?</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td>1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3)</td>
<td></td>
</tr>
<tr>
<td>47a</td>
<td>Are you currently applying / or/ awaiting acceptance for support</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>47b</td>
<td>What programme(s) are you applying for:</td>
<td>List:</td>
</tr>
<tr>
<td>47c</td>
<td>How do you expect to benefit from this/ these schemes? (OPEN)</td>
<td></td>
</tr>
</tbody>
</table>
Have you heard about the following initiatives and policies with implications in the Region? (Select ALL relevant)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Woodfuel strategy for England</td>
</tr>
<tr>
<td>2</td>
<td>BioHeat Programme</td>
</tr>
<tr>
<td>3</td>
<td>The Community Sustainable Energy Programme</td>
</tr>
<tr>
<td>4</td>
<td>The New Energy Crops Scheme</td>
</tr>
<tr>
<td>5</td>
<td>England Rural Development Programme 2007-13</td>
</tr>
<tr>
<td>6</td>
<td>Bio-energy Capital Grants Scheme</td>
</tr>
<tr>
<td>7</td>
<td>Bio-energy Infrastructure Scheme (Round 2)</td>
</tr>
<tr>
<td>8</td>
<td>Energy Aid Payments</td>
</tr>
<tr>
<td>9</td>
<td>Microgeneration Certification Scheme</td>
</tr>
</tbody>
</table>

Do you feel you are well positioned to access support? (If not who do you think is or what part of the supply chain is?) (OPEN)

Do you feel that there is government support to integrate producers, supplier, brokers, boiler installers and customers? (OPEN)

What about private initiatives? Are they providing support for the development of an integrated supply chain? (OPEN)

Should priority for grants be given to boiler installation over suppliers?

For future programmes, what do you think could be provided to bring a sense of stability in your woodfuel business? (OPEN)
We have come to the end of this very interesting interview. Before closing, would like to make any other comment?

Thank you for your time and much enriching interview.

If you are interested, I will send you a summary of the results from the interviews.

Yes, send: 1
No, thank you: 0

SECTION 4b: Contracts

Now, I would like to go more in depth with respect to your existing agreements and deals around woodfuel

<table>
<thead>
<tr>
<th>51a</th>
<th>What is the general time span of such agreements?</th>
<th>Years</th>
<th>Month s/ days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procurement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boiler installers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>51b</th>
<th>Are your long-term agreements oral or written contracts?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oral {Go → Q38a} 1</td>
</tr>
<tr>
<td></td>
<td>Written {Go → Q38a} 2</td>
</tr>
<tr>
<td></td>
<td>Both 3</td>
</tr>
</tbody>
</table>

| 51c | Doing business with both kind of contracts, what Optio Percen |

299
is their relative financial importance (percentage)   n  tage

Oral: 1
Written: 2

51d Has this proportion been changing in the last year?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

51e Why is it so? (OPEN)

52a Recalling total sales and sourcing what proportion is under long-term contract?

<table>
<thead>
<tr>
<th></th>
<th>Optio n</th>
<th>Percen tage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sourcing:</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sales:</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

52b What is the average value of a deal over a year of supply? £

Amount:

52c Are large deals more likely to be written agreements?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No {Go → Q52e}</td>
<td>0</td>
</tr>
</tbody>
</table>

52d What is the minimum value for this to occur? £

Amount:

52e Is there any other reason (other than the size of a deal) why you would try to have a written contract? Is so, which one?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No (Go → Q53a)</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

52f What are these reasons? (OPEN)

53a What makes you think that you can rely on a supplier/customer? (Only ONE)

<table>
<thead>
<tr>
<th>Reason</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Your partner’s fear of being left out of the market</td>
<td>1</td>
</tr>
<tr>
<td>There are alternatives and the supplier/customer in question knows that you would retaliate with no more business</td>
<td>2</td>
</tr>
<tr>
<td>You know that both benefit from a healthy relationship</td>
<td>3</td>
</tr>
<tr>
<td>You both benefit from a healthy AND coordinated relationship</td>
<td>4</td>
</tr>
</tbody>
</table>
53b What protects you if your suppliers/ customers’ fails to honour a commitment? (OPEN)

Prompt: Alternative sources / alternative and readily buyers

53c How do you adjust previous commitments and agreements to new / changed circumstances?

NOTE: Understanding circumstances as the business environment, competition etc...

<table>
<thead>
<tr>
<th>Option</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep course</td>
<td>1</td>
</tr>
<tr>
<td>Be flexible and revise agreement because it is beneficial for me</td>
<td>2</td>
</tr>
<tr>
<td>Be flexible and revise agreement because it is beneficial for the partnership formalised in the agreement</td>
<td>3</td>
</tr>
</tbody>
</table>

53d How would revise the terms of the agreement?

<table>
<thead>
<tr>
<th>Option</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilaterally</td>
<td>1</td>
</tr>
<tr>
<td>Negotiating to achieve present gains</td>
<td>2</td>
</tr>
<tr>
<td>Negotiating to achieve a better terms in a future agreement</td>
<td>3</td>
</tr>
</tbody>
</table>

53e In general, which of the following terms/ features are included in your agreements? (Categories drawn from Saussier, 2000 & ReGen 2008)

<table>
<thead>
<tr>
<th>Term</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum quantities that have to be purchased / sold</td>
<td>1</td>
</tr>
<tr>
<td>Minimum quantities that partner must provide</td>
<td>2</td>
</tr>
<tr>
<td>Standards of the fuel</td>
<td>3</td>
</tr>
<tr>
<td>Location / Origin of Source</td>
<td>4</td>
</tr>
<tr>
<td>Penalties in case of default</td>
<td>5</td>
</tr>
<tr>
<td>Penalties in case of default of partner</td>
<td>6</td>
</tr>
<tr>
<td>Price indexation mechanism (which one)</td>
<td>7</td>
</tr>
<tr>
<td>Terms of payments</td>
<td>8</td>
</tr>
<tr>
<td>Provisions for negotiations between the parties in the event of conflict</td>
<td>9</td>
</tr>
</tbody>
</table>

53f If there are provisions for negotiations in case of conflict, what procedure is agreed upon? (OPEN)
Prompt: With or without third parties, in one or several rounds, with an exchange of letters, etc.

53g What do/would you do if there is a dispute over a previous agreement? (OPEN)

54a In general, are you satisfied with the level of guarantees offered by these agreements?

<table>
<thead>
<tr>
<th></th>
<th>Yes, {Go to → Q54a}</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

41b If NO, Why so? (OPEN)

Prompt: It there a special reason why accept such contracts in the first place then?

54a Have you been through a legal procedure to settle a breach of contract for woodfuel or related investments?

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

54b If YES, under what circumstances? (OPEN)

Recorder story and if problem was about:

i) Time ii) Price, iii) Quantity and/or iv) Quality

54a Do you routinely exchange information to coordinate activities with suppliers or brokers/ fuel aggregators

Prompt: Short-term coordination such as specifics of delivery, moisture contents etc.
54b  If so, what short-term coordination activities? (OPEN)

55a  Do you plan activities in coordination with your suppliers/customers’?

Prompt: Long-term planning of business

55b  If so, what kind of long-term coordination activities do you undertake? (OPEN)
Appendix E

Interview guide to supporting organisations
Interview guide:
Support organisation:

1. What is the specific involvement of your programme in supporting the development of woodfuel in the region?

2. With respect to sourcing, do you think it is difficult to access wood that is grown in the South West Region for woodfuel?

3. What kind of development of the woodfuel market have you witnessed in the last two years or so?

4. What development and dynamics are you foreseeing?

5. Do you feel that the support that the government has provided, both at regional and national levels, has helped the integration of the supply chain?

6. According to your experience, how important are the following barriers in developing your woodfuel business opportunities?

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Not relevant</th>
<th>Minor</th>
<th>Important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enough wood available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not enough financial support to producers invest from public bodies/charities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty in finding long-term and stable commercial partners (either to buy / sell the material)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of experience and know-how in this business</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential users lack of information about woodfuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty in establishing long-term contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty of suppliers in accessing credit to buy equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of quality standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition from imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition from wood from post-consumer waste giveaways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient grants to support the installation of boilers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning requirements for boiler installation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On a scale of 1 to 4, 1 being: Not relevant, 2 Minor, 3 Important and 4 Very important
Appendix F

Support for renewable electricity generation: The Renewables Obligation (RO)

The Renewable Obligations (RO) enacted in 2002 “requires licensed electricity suppliers to ensure specified amounts of the electricity they supply are from renewable sources” (DTI, 2007b: p. 48). For 2008, the proportion required is 7.9% and will have to be 15.4% by 2015. Without the financial support provided by the mechanism, most renewable electricity initiatives would not be economically viable. (DTI, 2007b)

This type of mechanism was first developed to contribute to the diversification of energy sources by the, then, Department of Energy. This experience is worth considering, when appraising the new momentums promises for woodfuel development. Critics of the initiative insisted that several lessons are to be learned from the predecessor of the RO, the Non-Fossil Fuel Obligation (NFFO) that had more to do with the support of farmers and the development of potentially exportable technologies without focusing on the strengthening its viability as a market (van der Horts, 2005) with well publicised failures with respect to woodfuel and SRC (Thornley & Cooper, 2008).

However, it is notable that the NFFO was technically specific and, although the bidding process tended to favour the cheapest of options such as biogas at the expense of wood-fuelled power plants, 7 wood-fuelled plants effectively contributing to the grid were set up from 1989 to 2002 (Thornley & Cooper, 2008: p. 908). The modern RO was “technologically blind” or “neutral” and, despite creating an increasing financial incentive to electricity generators, has not favoured the more expensive renewable systems either (DTI, 2007b). Almost no wood-fuelled plant was built as a direct result of this mechanism since its introduction in 2002. The scheme has been through its sec-
ond period of revision under the leadership of the BERR, and after consultation (The Crown, 2009) has been reformed and enacted through the new Renewables Obligation Order 2009 (Oxera, 2007; The Crown, 2009)

The most important element introduced in this revised version of the RO for woodfuel are (The Crown, 2009):

- The banding of the ROCs which requires that “the amount of electricity to be stated in each ROC depends on the way in which the electricity in respect of which it is to be issued has been generated (Art. 27 (2))” (Oxera, 2007). This allows for adapting the level of support granted through the ROC to each different technology (Allen et al., 2008), reversing the neutrality of the mechanism in place since 2002. It is expected that ROCs will be more likely to support traditionally marginalised and more risky systems, such as wood-based ones. With the new mechanism, each technology will be able to compete within its band and not against all technologies (BERR, 2008).

- The new system also to controls for the natural evolution of the price of ROCs and therefore for its ability on incentive investment in renewable electricity generation. Such a mechanism makes them less likely to significantly drop in value over time as increasing renewable capacity is installed.

- Clearer options for microgeneration to benefit from the scheme, although capacity level will remain an obstacle to make the income from ROCs profitable. Now, renewable microgeneration schemes will be awarded 2 ROCs per MWh generated, instead of one previously (Forestry Commission, 2005: p. 2). However, the general additional benefits are expected to be marginal, as it is not fully acknowledged as a “technology” but simply as a different capacity, although full implications are yet to develop.