Pop-Up Production: Flexible Capacity Deployment in Additive Manufacturing for Short-Term Opportunistic Production

Daniel R Eyers (eyersDR@cardiff.ac.uk)
Cardiff Business School, Cardiff University, UK

Yuan Huang
Cardiff Business School, Cardiff University, UK

Anthony J Soroka
Cardiff Business School, Cardiff University, UK

Aris A Syntetos
Cardiff Business School, Cardiff University, UK

Andrew Lahy
The University of Buckingham, UK

Stephen M Disney
Exeter University, UK

Abstract

This study examines a novel strategic approach to very short-term opportunistic production, capitalizing on a short (but intense) flash demand that cannot be fulfilled by existing supply chain players. We term this *pop-up production*, inspired by the notion of a *pop-up store* that is well-established in temporary retail operations. Employing a dynamic capabilities perspective, two 3D printing operators were studied as they entered the market for medical equipment supplies during the outbreak of the worldwide Covid-19 pandemic in 2020. Based on these observations, this paper highlights the characteristics of this strategy that may be successfully employed in other markets.

Keywords: Responsive Production, Flexibility, 3D Printing

Introduction

The ability to respond to changing customer demands is a fundamental capability in supply chains. Particularly in markets where multiple firms vie for customer orders, manufacturers have adjusted their offerings to be competitive without resorting to lessening their sales price. Common examples include providing increased variety within their product ranges (Lancaster, 1990), increasing levels of product customization (Fogliatto et al., 2012), providing more responsive order fulfilment (Holweg, 2005), and offering innovative procurement solutions such as servitization (Baines et al., 2009). These are but a few of the approaches being taken every day by manufacturers in practice. Achieving these capabilities within manufacturing operations is, in many cases, attained through the experience acquired through decades of research and practice in how operations can *change*. Agile and leagile strategies have long been established as a means to deal with requirements for change within operations (Naylor et al., 1999); more recently research emphasis has been given to ambidexterity within operations (Tamayo-Torres et al., 2017).

What is notable is that, in most cases, manufacturers tend not to stray from their core product expertise in the short-term. Breweries tend to make beer; coin manufacturers continue to make coins; high-fashion garment manufacturers persist in the production of catwalk-friendly clothing. Each might change some aspect of their product in the short term (e.g., varying designs or materials etc.), but fundamentally they will usually continue to operate in the same market. They will have invested in appropriate manufacturing infrastructure for their products, built a suitably skilled labour force, established a presence in the market, and developed suitable supply chains. In essence, they will have created a *focused factory*, where "such a plant can become a competitive weapon because its entire apparatus is focused to accomplish the particular manufacturing task demanded by the company's overall strategy and marketing objective", (Skinner, 1974, p. 114). Focused approaches prioritize competitiveness through expertise and excellence; dipping in-and-out of manufacturing wholly different products for different markets in the short-term would normally be considered slipshod and destined to failure.

Normality is, however, increasingly rare in competitive manufacturing operations. It is notable that the disruption to manufacturing brought about by the outbreak of Covid-19 altered normal operations, at least temporarily. Breweries such as Brewdog switched from beer to hand sanitizer production within fourteen days (Brewdog, 2020), coin manufacturer The Royal Mint developed and began manufacturing protective face visors within three days (Royal Mint Museum, 2020), and Burberry swiftly moved from high-end clothing to making hospital gowns and facemasks (De Klerk, 2020). None of these example organizations had long-term strategic objectives to enter these markets, nor were they optimally equipped like the incumbents within the market. However, they saw an opportunity where a demand was unfulfilled, and redirected their manufacturing efforts accordingly. Their relative lack of focus compared to the incumbents would have meant they were not the most efficient operators in the market, but nevertheless they were now in the market. Whether they continued in the longer-term is another matter; fundamentally though it was their ability to responsively deploy manufacturing capability that provided the market-entry opportunity in the first place.

This study examines a novel strategic approach to very short-term opportunistic production, capitalizing on a short (but intense) flash demand that cannot be fulfilled by existing supply chain players. The technologies of Additive Manufacturing (sometimes termed *3D printing*) are often linked to responsive production, however scant consideration has been given to the strategic deployment of these technologies for dynamically accessing markets. We show how an Additive Manufacturing company that

has a range of flexible capabilities can enter a previously inaccessible market to restore supply of equivalent products, and then either quickly exit the marketplace, continue with Additive Manufacturing, or switch to a conventional fulfilment strategy. We term this *pop-up production*, inspired by the notion of a *pop-up store* that is well-established in retail operations, whereby firms temporarily open a physical retail space for brand promotion or to sell products that have very short-term demand. Such flash retail also extends to novelty and fad products, where firms capitalize on demand lasting only for a few weeks before consumers lose interest and move onto something else. Timing is essential in flash retail – the opportunity is temporary, but the outcomes can be very positive. Building on dynamic capabilities (Teece et al., 1997), we explore whether the same benefits can be applied through the combination of resources, capabilities, and management acumen in a manufacturing context. In the next section, we review the pop-up concept, bringing the retail to the operations, before examining challenges in flexible capacity deployment, and then develop linkages with dynamic capabilities. Subsequently we explain the methods employed in this study, before articulating the pop-up concept within the results and discussion. We close the paper with an overview of contributions, and pertinent directions for future extension of the work.

Literature Review

Pop-Up in Retail

Named after the pop-up windows that appear on the screens of internet users (Rosenbaum et al., 2021), a pop-up shop is "a temporary shop, stall or brand experience used to sell goods and services for a limited period of time" (Centre for Economics and Business Research, 2014). There are a multitude of reasons for their establishment, and research into pop-up retail straddles both marketing and strategy research domains. Sometimes pop-up stores exist to satisfy seasonal demand such as Halloween or Christmas (Klein et al., 2016), or they may serve as a physical presence to promote brand awareness and customer loyalty (Lowe et al., 2018), which is particularly useful for firms that normally operate in online transactions. They may be used to generate demand, or as *sales* locations where excess inventory can be sold (Spitzkat and Fuentes, 2019). Pop-up stores may also be used as an opportunity to evaluate the feasibility of the new retail offering within a given geography (Jones et al., 2017), but without the commitment of a long-term lease arrangement.

The pop-up concept is an extension of temporary retailing that has been established for centuries; periodic fairs and markets have long existed for farmers and crafters to sell their wares (Warnaby and Shi, 2019). By comparison, short-term leasing of retail space is a relatively recent phenomenon which Mittelman and Gardner (2018) identify as starting in the late 1970's, though its popularity was increasingly evident in the 1990s. Pop-up shops typically make use of existing vacant retail capacity for a defined short-term period; this may be a matter of hours, but more commonly extends into durations of a month or more (Mittelman and Gardner, 2018). It is this ephemerality that defines the pop-up store (Robertson et al., 2018); it won't exist for long.

For leaseholders who own the retail stores, pop-up stores may offer some useful opportunities. In many cities there is an excess of retail capacity (Jones et al., 2017; Warnaby and Shi, 2019), and so pop-up stores can be a useful opportunity to generate revenue from their underutilized assets by offering cost-competitive short-term leases (Rosenbaum et al., 2021). In turn, this may offer societal benefits compared to leaving shops vacant (Warnaby and Shi, 2019). Worldwide, the pop-up retail industry has been estimated to be worth $50bn USD (Novellino, 2015). Increasing uptake of the pop-up

concept has led to various intermediary companies being established to connect prospective pop-up tenants with existing leaseholders (Jones et al., 2017).

Flexibility in capacity deployment

In manufacturing, the need to ensure best utilization of plant assets and other resources is a fundamental concern; underused resources are costly. These available resources are known as the manufacturing systems' capacity, defined as "the total productive capability of all utilized productive resources including workforce and machinery" (Alp and Tan, 2008). Within Lean Manufacturing, concepts such as Overall Equipment Effectiveness (OEE) provide opportunities to explicitly measure how well resources are being utilized (Jonsson and Lesshammar, 1999).

Adaptively managing capacity within a given manufacturing operation can be challenging. Many authors (e.g. Narasimhan and Das, 1999; Sethi and Sethi, 1990) consider capacity flexibility in terms of expansion of the system (i.e., with increasing demand); however, contraction in leaner times is also an important requirement for many manufacturers. Capacity flexibility therefore concerns how the production system may either expand *or* contract in response to the demands being placed on it; a high range of capacity flexibility is considered where a significant change (increase or decrease) in overall capability is achieved (Eyers, 2015). Capacity tends to be 'sticky', with capital investments (e.g., for machinery) having long lead-times in terms of approval, procurement, installation, and integration within the manufacturing system (Eyers et al., 2018). Similar issues exist with labour, where legal obligations and other staffing issues affect the ability to readily acquire and divest of staff as demand fluctuates.

Given the constraints of adjusting the capacity of assets within the factory, various innovative approaches have emerged to enable opportunities within the supply chain to match capacity needs. Simple outsourcing is probably the most familiar, whereby the capacity challenge becomes someone else's problem. However, this comes with many risks including loss of control over manufacturing processes (Quinn and Hilmer, 1994), and potential loss of Intellectual Property (Roy and Sivakumar, 2011). Strategic choices such as the adoption of SpeedFactories (Boute et al., 2022) support dual-sourcing models where base demand is satisfied through conventional production, and fluctuating (or surge) demand is handled by responsive facilities situated close to the end customer. Technology can also offer potential for supporting more flexible approaches to meeting changeable customer demand. For example, Additive Manufacturing/3D printing has long been associated with so called 'on-demand' printing (Ryan et al., 2017), but this necessitates the inefficient practice of reserving manufacturing capacity in anticipation of demand (Eyers et al., 2018). As Additive Manufacturing is a general-purpose technology, Hedenstierna et al. (2019) proposed a bidirectional outsourcing solution allowing firms to seamlessly offload excess work to a network of supply chain partners at busy times, and take on additional work to utilize spare internal production capacity as required.

Dynamic capabilities for pop-ups and capacity deployment

There are three fundamental attributes to dynamic capabilities: sensing opportunities and threats within the marketplace, seizing those opportunities and threats, and then reconfiguring/transforming to maintain sustained superior performance (Teece, 2007; Teece et al., 1997). In turn, this is linked to the strategy of the organisation and its business models, all of which combine to enable competitive positioning for the firm (Teece, 2018). Dynamic capabilities go beyond optimality in processes, procedures, and practices; instead they emphasise achieving and sustaining ongoing congruence with

customer needs, changing opportunities within the market, and strategic movements by competitors (Teece, 2014).

Dynamic capabilities provides a helpful way to consider the management of resources. In the Resource Based View (RBV), Barney (1991) identifies competitive advantage comes from resources that are valuable, rare, imperfectly imitable, and non-substitutable. In other words, firms can create a unique position through their resources; dynamic capabilities extend this premise around effective management of these resources in changing business environments (Teece, 2018), though still places much value on the non-imitability of the resources and capabilities of the firm as a key ingredient in a competitive strategy (Teece, 2014).

In general, pop-up retail is under researched (Spitzkat and Fuentes, 2019), and it is notable that existing research has made little explicit connection between pop-up retail and the opportunities afforded through dynamic capabilities. Indeed, from the perspective of the asset owner, pop-up shop environments do not naturally suggest a competitive alignment when considered with either RBV or dynamic capabilities. A leasehold on a given retail unit might be valuable, but they are seldom rare; they are typically readily imitated by neighbouring units, and easily substituted for other units, where the growth of e-commerce has led to overcapacity in the marketplace (Jones et al., 2017; Spitzkat and Fuentes, 2019). Such homogeneity is unlikely to support a strong competitive position. Indeed, whilst the dynamic term within dynamic capabilities emphasises the changing of competences to align them with changing business environments, offering the retail unit on a temporary basis is often seen as a means of recovering contribution costs on an asset that would otherwise be unutilised (Rosenbaum et al., 2021), rather than proactively aiming to compete in the market.

An alternative perspective would be to consider the asset-user; the renter of the retail resource that will employ it to seize an opportunity. Here, whilst formal linkage to dynamic capabilities research remains absent in the literature, multiple papers espouse the use of pop-ups as part of a brand's strategy. In terms of sensing opportunities, firms may use pop-ups to get a better understanding of customer requirements, build customer connections, or to test new geographic regions (Rosenbaum et al., 2021). In seizing opportunities, pop-up offers a rapid opportunity to open a new store by exploiting currently-available retail space, which usually require minimal reconfiguration and will have many operating permits already in place (Jones et al., 2017). The final tenet of dynamic capabilities concerns the achievement of sustainability through transformation; however, the 'here today, gone tomorrow' (Spitzkat and Fuentes, 2019) nature of pop-up retail extends to the research, where this ephemerality means the literature seldom explores events occurring after the demise of the pop-up store.

Method

Data collection commenced in March 2020 as the Covid-19 pandemic began to take hold in the UK and continued for twelve months. From this, two exemplar case studies were developed: alpha and beta. In both cases the focal manufacturers had no previous experience of manufacturing for medical applications, nor had they previously established themselves within the medical marketplace.

Case alpha concerned the production of Covid-19 visors for the NHS by a university research institute, in conjunction with a commercial partner. An action research approach is taken to inform this case, using detailed notes made as the project progressed, along with production data and correspondence with a range of stakeholders including doctors, hospital workers, academics, industrialists, and government policymakers.

Case beta also concerned the production of visors for the NHS by a manufacturer of 3D printers located in the England. Interviews with the Managing Director and other senior managers were conducted, along with a plant tour and reference to the company's internal process documents and production data.

To better understand the context in which the cases were operating, we complimented case-specific data with information gained from broader market-related research. During the early months of the study, we conducted interviews with volunteers working to produce visors independently (so-called 'garage-based production') and collected news stories and academic papers concerning the pandemic. Later we were able to look back and retrospectively build a timeline of national events, which provides additional data to explain the context in which manufacturing occurred.

Results

Context for the cases

The Covid-19 pandemic has frequently been described as 'unprecedented', and many governments enforced strict lockdowns on their populations, affecting the ability of manufacturing firms to resource their factories. This was further exacerbated by constraints in supply chains, where raw materials for production became more difficult to source, and transportation networks were significantly affected.

As Covid-19 took hold, hospitals and other care-based facilities changed the way the healthcare of the population was managed. Many non-emergency procedures were cancelled, and dedicated facilities (including 'Covid wards' and field hospitals) were established to manage the increasing numbers of patients either infected with Covid-19, or suspected of infection. Medical staff required Personal Protective Equipment (PPE) to reduce their own risk of infection; this commonly took the form of face masks, gloves, gowns, and protective visors. Visors place a non-permeable acrylic thermoplastic barrier between the face of the wearer and aerosols emitted from the patient (through breathing and coughing); to avoid cross-contamination these are usually discarded after each patient has been treated by the healthcare professional. In UK hospital environments, PPE should be made to approved standards and is purchased through the procurement division of the National Health Service (NHS) from a range of approved suppliers. As Covid-19 hospitalisations increased, stocks of PPE (including visors) were quickly depleted, and replenishment of supplies was very difficult. Existing manufacturers (mainly in Asia) struggled to meet an enormous spike in global demand; this was exacerbated by sickness in their labour affecting production, and international transportation constraints limiting deliveries to the UK.

Additive Manufacturing technologies were identified by many manufacturers as providing an important quick-response capability to produce PPE in emergency situations. Their principal advantage over many other manufacturing processes is their 'frictionless' approach to manufacture, with no requirement for upfront tooling or many of the other traditional constraints inherent in conventional manufacturing (Hedenstierna et al., 2019). This offers considerable product flexibility (Eyers et al., 2018), allowing for the quick introduction of new products. Normally these technologies are employed in low volume and customized manufacturing, however there are also many examples of higher-volume production (Eyers et al., 2022). Notably, Additive Manufacturing equipment availability extends beyond traditional factories, and can often be found in many hospital environments, as well as schools and colleges. As transportation links became problematic during covid, Additive Manufacturing offered the opportunity for more localised production.

Sensing the opportunity

As Covid-19 cases began to spread, member states of the European Union (EU) identified a potential need for PPE on 31st January 2020, issuing a procurement call for PPE on 28th February, though the UK government did not participate in this process. During this time increasing media attention focused on PPE, and awareness of a potential increase in demand was apparent to the case companies. In the UK there was limited government emphasis on PPE sourcing; the first significant appeal was 16th March seeking help from businesses to make ventilators.

In both cases seeing events unfold in Europe highlighted the likelihood of increased demand by early March 2020. Neither case company operated in the PPE industry, and so sensing of the market was largely inferred from materials published by news outlets. For beta, seeing a media story about ventilator valve printing in an Italian hospital sparked its initial interest; for alpha it was a combination of news stories and a telephone call from a government department to help ventilator part production (17th March). In both cases the initial involvement was intended to be altruistic; there was no commercial motivation. However, there were many uncertainties for both cases: the potential demand volume was unclear, the likelihood of securing long-term supply contacts not guaranteed, and the timelines for existing manufacturers to restore normal supply unknown.

Seizing the opportunity

Alpha and beta both diverted their Additive Manufacturing production capabilities, together with design, assembly, and managerial staff to producing visors for NHS hospital use. This presented three key challenges: 1) developing a viable design compliant with NHS requirements, 2) efficiently manufacturing to achieve cost and responsiveness requirements, and 3) successfully entering the internal NHS market.

It took alpha a month to be able to supply products to the NHS in Wales, initially in small quantities. The lockdown of 23rd March 2020 had closed alpha's facilities, and staff were working remotely on a multitude of competing activities. Production equipment was sent to alternate locations for operation, however this was affected by transportation issues and was slow to be set up. By 7th April small-scale machines were ready to produce; the industrial 3D printers became operational 27th April. Most significantly, concerns over product liability constrained the operations, and supply could not be undertaken until a waiver was received from NHS (9th April).

Beta was able to respond far quicker to the demand for visor production. It designed, printed, and tested its first visor iteration within a day; for each of its 3D printers 135 face shields could be printed per hour. By 30th March 2020 it was producing thousands of visors per day for NHS hospitals in England.

Transforming for superior performance

Taking a month to become established was detrimental to alpha's position within the market. Its 3D printed visors, whilst of high quality and offering the potential to be sterilised for reuse, were also significantly more expensive than conventional manufacturing processes. Whilst it was supplying to the NHS at cost, visors ranged between £8.88 and £18.42 depending on process choice. In mid-March such costing was tolerable, but by the end of April the feedback was that there were far cheaper options available, with £6.50 being the maximum acceptable price. By late June the NHS confirmed there was oversupply of PPE, and thus alpha terminated its involvement in visor production.

By comparison, beta's swift establishment of itself in the market led to much interest in its visors, and recognizing this demand the firm optimized its processes for volume production. It revised its product design over thirty times; several to improve the product itself, but most to improve its manufacturability – increasing speed, and decreasing costs. It developed its own materials to the application, optimized a fleet of low-cost printing resources, and ensured flow was the focus of all aspects of production. Through these interventions beta reduced its production costs to the same level as conventional manufacturing, and it won a contract for 7.2 million visors from the UK government at the beginning of June 2020.

Discussion

The two cases provide an interesting comparison concerning how different firms may respond to the same opportunity in the market in different ways, and with the benefit of hindsight it is possible to critically evaluate the approaches taken. Focusing on the Welsh market served by alpha, Figure 1 highlights the number of hospitalized patients with (or suspected to have) Covid-19, and the number of visors issued to the hospitals from all sources. In the first weeks of the pandemic, visor supply was inadequate, and this was supported by alpha being contacted by hospital staff pleading for PPE. However, by late April 2020 several traditional manufacturing operations had reconfigured their operations for conventional visor production, and combined with the potential of imports restarting, buyers were more confident of being able to source longer-term supply at more preferential rates. Taking a month to set up a new manufacturing facility, and get a product from design through to manufacture would traditionally be considered rapid; however, for alpha the market was moving faster than expected. The realistic window of opportunity for alpha's pop-up production is shaded blue in Figure 1. Beta's more rapid entry to the market, together with its emphasis on transformation was key to its success in securing longer-term sales of its product.

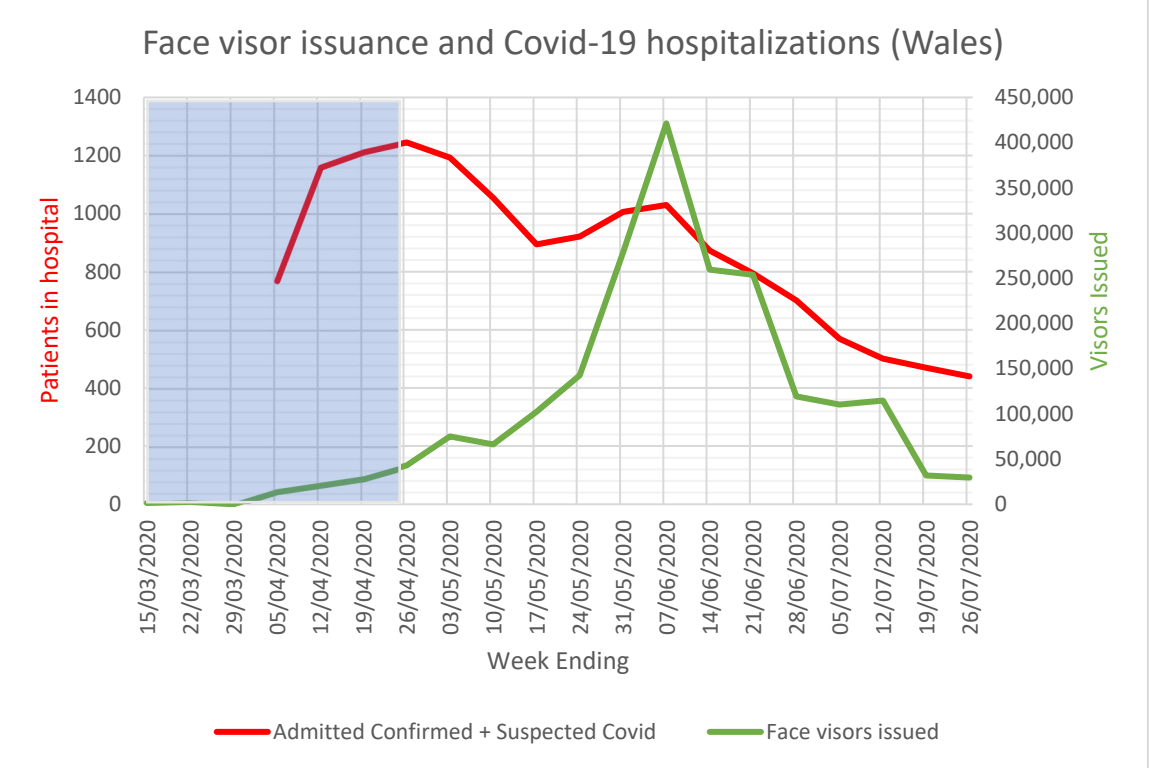

Figure 1: Covid-19 Hospitalizations and Face Visor Issuance (Data Source: Welsh Government)

The general-purpose nature of Additive Manufacturing technologies was shown to offer a key advantage in both cases for market entry. Alpha took four days to produce its first visors; beta did this in a day. Having these capabilities within a pop-up production environment offers the potential to support the initial seizing of the market opportunity, however this needs to be considered within the wider organizational offering. As shown through beta, dynamism in teams, strong management acumen, and the ability to quickly make decisions and gain approvals is key to capitalising on this manufacturing advantage.

Where pop-up runs somewhat counter-intuitive to conventional thinking in both agile manufacturing and dynamic capabilities is its potential for transient approaches to being a manufacturer. Entering a market usually necessitates significant investments, and so is not undertaken lightly. For alpha, once the opportunity to produce in the market was over, it simply set its Additive Manufacturing machines back to their original purpose. There was no cost to market exit, and unlike conventional approaches (e.g. injection moulding), no real setup costs to lose. Likewise for beta, having gained a large order it could hone its production for optimality, and even consider using conventional manufacturing processes to support its Additive Manufacturing approach; at the end of the contract, it could stay in the market or redeploy its manufacturing capabilities to their normal role without penalty.

Conclusion

Within this paper we have set out the principles of pop-up production, highlighting how the benefits found in temporary retail can be extended through the application of flexible manufacturing systems to offer a unique competitive position. Our study offers insights into how manufacturers can move between markets without making significant commitments, offering the opportunity of new market potentials, but with a low-cost roll-back option. Further work is needed to explore this concept in more markets that are not influenced by Covid-19 disruptions, particularly in terms of understanding more about the characteristics of management that underpin success.

References

Alp, O. and Tan, T. (2008). "Tactical capacity management under capacity flexibility". *IIE Transactions* 40(3), pp. 221-237.

Baines, T. S., Lightfoot, H. W., Benedittini, O. and Kay, J. M. (2009). "The servitization of manufacturing: A review of literature and reflection on future challenges". *Journal of Manufacturing Technology Management* 20(5), pp. 547-567.

Barney, J. (1991). "Firm resources and sustained competitive advantage". *Journal of Management* 17(1), pp. 99-120.

Boute, R. N., Disney, S. M., Gijsbrechts, J. and Mieghem, J. A. V. (2022). "Dual Sourcing and Smoothing Under Nonstationary Demand Time Series: Reshoring with SpeedFactories". *Management Science* 68(2), pp. 1039-1057.

Brewdog. (2020). *Sanitizer: Sharing what we have learned* [Online]. Available at: https://www.brewdog.com/blog/sanitiser-sharing-what-we-have-learned [Accessed: 20 Febraury 2023].

Centre for Economics and Business Research (2014). "Britain's Pop-Up Retail Economy".

De Klerk, A. (2020). *Burberry to make hospital gowns and masks for the NHS* [Online]. Available at: https://www.harpersbazaar.com/uk/fashion/fashion-news/a31973231/burberry-coronavirus-gowns-masks/ [Accessed: 20 February 2023].

Eyers, D. R. (2015). *The flexibility of Industrial Additive Manufacturing Systems.* Cardiff University.

Eyers, D. R., Potter, A. T., Gosling, J. and Naim, M. M. (2018). "The flexibility of industrial additive manufacturing systems". *International Journal of Operations & Production Management* 38(12), pp. 2313-2343.

Eyers, D. R., Potter, A. T., Gosling, J. and Naim, M. M. (2022). "The impact of Additive Manufacturing on the product-process matrix". *Production Planning & Control* 33(15), pp. 1432-1448.

Fogliatto, F. S., Da Silveira, G. and Borenstein, D. (2012). "The mass customization decade: An updated review of the literature". *International Journal of Production Economics* 138(1), pp. 14-25.

Hedenstierna, C. P. T., Disney, S. M., Eyers, D. R., Holmström, J., Syntetos, A. A. and Wang, X. (2019). "Economies of collaboration in build-to-model operations". *Journal of Operations Management* 65(8), pp. 753-773.

Holweg, M. (2005). "The three dimensions of responsiveness". *International Journal of Operations & Production Management* 25(7), pp. 603-622.

Jones, P., Comfort, D. and Hillier, D. (2017). "A commentary on pop up shops in the UK". *Property Management* 35(5), pp. 545-553.

Jonsson, P. and Lesshammar, M. (1999). "Evaluation and improvement of manufacturing performance measurement systems - the role of OEE". *International Journal of Operations & Production Management* 19(1), pp. 55-78.

Klein, J. F., Falk, T., Esch, F.-R. and Gloukhovtsev, A. (2016). "Linking pop-up brand stores to brand experience and word of mouth: The case of luxury retail". *Journal of Business Research* 69(12), pp. 5761-5767.

Lancaster, K. (1990). "The economics of product variety: A survey". *Marketing Science* 9(3), pp. 189-206.

Lowe, J., Maggioni, I. and Sands, S. (2018). "Critical success factors of temporary retail activations: A multi-actor perspective". *Journal of Retailing and Consumer Services* 40, pp. 74-81.

Mittelman, H. M. and Gardner, G. A. (2018). "Pop-Up leasing". *Probate & Property* 32(5), pp. 11-15.

Narasimhan, R. and Das, A. (1999). "An empirical investigation of the contribution of strategic sourcing to manufacturing flexibilities and performance". *Decision Sciences* 30(3), pp. 683-718.

Naylor, J. B., Naim, M. M. and Berry, D. (1999). "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain". *International Journal of Production Economics* 62, pp. 107-118.

Novellino, T. (2015). "How pop-up retail exploded into a $50B business". *New York Business Journal*.

Quinn, J. B. and Hilmer, F. G. (1994). "Strategic Outsourcing". *Sloan Management Review* 35(4), p. 43.

Robertson, T. S., Gatignon, H. and Cesareo, L. (2018). "Pop-ups, Ephemerality, and Consumer Experience: The Centrality of Buzz". *Journal of the Association for Consumer Research* 3(3), pp. 425-439.

Rosenbaum, M. S., Edwards, K. and Ramirez, G. C. (2021). "The benefits and pitfalls of contemporary pop-up shops". *Business Horizons* 64(1), pp. 93-106.

Roy, S. and Sivakumar, K. (2011). "Managing Intellectual Property in Global Outsourcing for Innovation Generation". *Journal of Product Innovation Management* 28(1), pp. 48-62.

Royal Mint Museum. (2020). *Royal Mint visor project* [Online]. Available at: https://www.royalmintmuseum.org.uk/journal/news/royal-mint-visor-project/ [Accessed: 20 February 2023].

Ryan, M. J., Eyers, D. R., Potter, A. T., Purvis, L. and Gosling, J. (2017). "3D printing the future: scenarios for supply chains reviewed". *International Journal of Physical Distribution & Logistics Management* 47(10), pp. 992-1014.

Sethi, A. K. and Sethi, S. P. (1990). "Flexibility in manufacturing: a survey". *International Journal of Flexible Manufacturing Systems* 2(4), pp. 289-328.

Skinner, W. (1974). "The focused factory". *Harvard Business Review* 52(3), pp. 113-121.

Spitzkat, A. and Fuentes, C. (2019). "Here today, gone tomorrow: The organization of temporary retailscapes and the creation of frenzy shopping". *Journal of Retailing and Consumer Services* 49, pp. 198-207.

Tamayo-Torres, J., Roehrich, J. K. and Lewis, M. A. (2017). "Ambidexterity, performance and environmental dynamism". *International Journal of Operations & Production Management* 37(3), pp. 282-299.

Teece, D. J. (2007). "Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance". *Strategic Management Journal* 28(13), pp. 1319-1350.

Teece, D. J. (2014). "The foundations of enterprise performance: Dynamic and ordinary capabilities in an (economic) theory of firms". *Academy of Management Perspectives* 28(4), pp. 328-352.

Teece, D. J. (2018). "Business models and dynamic capabilities". *Long Range Planning* 51(1), pp. 40-49.

Teece, D. J., Pisano, G. and Shuen, A. (1997). "Dynamic Capabilities and Strategic Management". *Strategic Management Journal* 18(7), pp. 509-533.

Warnaby, G. and Shi, C. (2019). "Changing customer behaviour: Changing retailer response? The potential for pop-up retailing". *Journal of Customer Behaviour* 18(1), pp. 7-16.