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Understanding the impact of Brexit: the case of foreign software corporations in Scotland and
Southeast England

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ABSTRACT

Market and institutional shocks and upheaval, brought about by political, economic and social changes, have the potential to generate significant corporate restructuring. Foreign subsidiaries are particularly vulnerable to such impacts given the embeddedness of parent companies in their home countries, with the potential for disinvestment and regional decoupling. This paper examines the impact of the Brexit vote and negotiation period on UK-based foreign subsidiaries in the software and software-related sectors in Scotland and the Southeast of England. This firm-centric approach follows recent evolutionary thinking that restates the importance of examining the firm as a means in which to understand how regions respond to such disturbances. Rather than simply examine impact, the paper is concerned with why the scope and scale of impacts are mediated by particular corporate and GPN processes. Key to this is the examination of the importance of the value creation corporate role and degree of replication within the corporation (specificity), the GPN spatial configuration, and the markets that subsidiaries are mandated to serve. The paper concludes that a variety of impacts are evident, but that notable negative consequences have arisen for subsidiaries with low corporate specificity, working through EU-configured GPNs, and serving European markets. These negative impacts are more notable in Scotland, compared with the Southeast of England where a large minority have experienced no detrimental impacts.

BREXIT CORPORATIONS GLOBAL PRODUCTION NETWORKS SOFTWARE

INTRODUCTION

Corporations, and the global production networks (GPNs) through which they work, are embedded within disparate institutional environments (e.g. capitalist relations) and arrangements (e.g. regulatory configurations) that operate through multiple spatial relations (Coe et al., 2008). Market and institutional upheaval and shocks have the potential to produce corporate restructuring and ‘ruptures’ in GPNs (Szalavetz, 2016). Subsidiaries of foreign corporations are understood to be particularly vulnerable to disinvestment, closure and regional decoupling during such periods (Fisch and Zschoche, 2011). One such episode is that of Brexit, the decision by the majority of those that voted for the UK to leave the European Union in June 2016. The period following the vote has been one of negotiations regarding the nature of exit and the terms of a future trading agreement. This has led to substantial upheaval up to the first leave date in March 2019 and the on-going negotiations up to and following the eventual UK exit on the 31st January 2020.

This paper examines the impact of the Brexit vote and negotiation period (up to the 31st January 2020) on UK-based foreign subsidiaries in the software and software-related sectors in Scotland and the Southeast of England. While recognising the complex production networks through which foreign subsidiaries work, and the heterogeneous processes and actors constituting the (unbounded) regions in which they are (unevenly) coupled, this paper is explicitly concerned with the agency of foreign subsidiaries. In so doing, it seeks to build upon the argument that examining agency is an important part of understanding how regions experience and respond to ‘shocks’, but that agents such as subsidiaries operate within multi-faceted economic landscapes and networked organisational arrangements (Martin and Sunley, 2015). More specifically, the approach taken in this paper is one of not just examining impact,

but analysing how the scope and scale of such impacts are mediated by a range of factors. The corporate ‘specificity’ of the role and capabilities of a subsidiary, its GPN position and configuration, and the nature of the market that it serves, are all critical processes.

Subsidiaries in the software sector are examined, and this includes instances where software activities are undertaken in-conjunction with associated manufacturing tasks. This comprises the specific software sectors of Business and domestic software development (SIC 62012); Information technology consultancy activities (SIC 62020); and Data processing, hosting and related activities (SIC 63110). Scotland and the Southeast of England are the case study areas, with both locations having a relatively large number of foreign software subsidiaries. Scotland had a period of strong electronics manufacturing from the 1980s, concentrated in the area of ‘Silicon Glen’ (encompassing the area between Dundee, Inverclyde and Edinburgh), which subsequently went into decline with corporate exit from the mid-1990s. This area has benefited from the extensive indigenous growth of software firms since this period, accompanied by foreign inward investment (EY, 2018; Tech Nation, 2017). The contribution of the sector in Scotland represents 4.5% of the overall UK GVA in this sector. Total employment in 2018 was 91,000, up from 81,000 in 2014 (DCMS, 2018). In the Southeast of England there has been substantial investment and growth in this sector for some time. Total employment was 283,000 in 2018, representing an increase from 268,000 in 2014 (DCMS, 2018). Around 20.5% of UK GVA for the sector was generated in the Southeast in 2017, accounting for 9.9% of the total GVA in the region (DCMS, 2018).

More broadly, the Scottish economy functions within the context of devolved state apparatus to the Scottish Government and Parliament, which possesses primary legislative powers in relation to devolved matters, including economic development. This contrasts with the

Southeast of England which is governed through the UK nation state, and where economic development activities occur through a number of subregional Local Enterprise Partnerships, encompassing a number of local government areas (Pike et al, 2015). In relation to their economies, the Southeast has both a larger total GVA (2017) (£267,126m) and GVA per head (£29,415), compared with Scotland (total GVA: £138,231m; and GVA per head £25,485) (see Table 1).

[TABLE 1]

The sample includes 20 case studies, equally divided between both areas, and with response rates of 17% (Scotland) and 9% (Southeast England) for all foreign corporations in these sectors. Semi-structured interviews were conducted with the managing director or a senior manager with responsibility for Brexit planning at each subsidiary. The selection of the case studies is based on ensuring there is a representative sample of subsidiaries with both high and low corporate specificity, which is defined in terms of the importance and individuality of their roles and capabilities within a corporation. However, all such subsidiaries possess capabilities and roles that do not include low corporate value creation responsibilities (e.g. backoffice functions), and where they have forms of regional coupling that are ‘functional’ in nature, defined in terms of more positive forms of regional ‘value capture trajectories’ (Coe and Yeung, 2015). This includes the reliance on highly skilled workers, involvement in regional knowledge networks, and interdependencies with spatially proximate collaborators and competitors.

Given the stronger position of the Southeast economy compared with Scotland, six of the subsidiaries have high corporate specificity, compared with only 4 in the Scottish sample.

Identification of these case studies was undertaken by way of data acquired from FAME and corporate documents. The sensitivities around the impact and mediation of Brexit led to all case studies asking to be anonymised. Particular background data, such as overall employment levels, specific location, and establishment date, is also not included so as to ensure anonymity of corporations. In conclusion, subsidiaries that have low corporate specificity (but encompassing a diversity of GPN roles), work through GPNs configured through EU networks, and serve the European market, have been most negatively affected by Brexit. This is more widespread in Scotland, while a large minority of subsidiaries in the Southeast have experienced no negative consequences from Brexit.

CORPORATE ROLES, GPNS AND MARKETS

Economic shocks/upheaval and subsidiary agency

Current interest in the impact of upheaval and shocks on firms within economic geography largely takes place through evolutionary thinking, and with recent commentaries arguing for a greater emphasis on human agency (Martin and Sunley, 2015). In contrast, GPN studies have not been explicitly concerned with conceptualising upheaval and shocks, but recent GPN 2.0 thinking provides a framework in which to comprehend impacts based on a focus on agency. Such sensitivity to actual decision-making is key to the GPN 2.0 perspective. Firms within GPNs are subject to ‘causal dynamics’ (i.e. cost-capability ratio, market imperatives, financial and risk management), which drives firm strategies and GPN organisational arrangements. GPN 2.0 consequently views shocks in terms of risk management, but where impacts and reactions to shocks are also embedded within changes to other causal dynamics, such as in cost increases (Fromhold-Eisebith, 2015).

While GPN and recent evolutionary thinking emphasises the critical role of agency, there is a need to more fully explicate aspects of agency if we are to more fully understand its role in relation to the disparate impact of shocks and upheaval. Indeed, there has been an argument for GPN 2.0 to take greater account of the intricacies of the corporation, including further consideration of the complexities of subsidiary role and actions in relation to their corporate context (see Fuller and Phelps, 2018; Yeung and Coe, 2019). This is not to suggest that GPN 2.0 takes no account of the agency of the subsidiary, but that this is commonly defined in relation to a functional role within a GPN. Correspondingly, an exclusive focus on GPN role means limiting the explanatory power of causal dynamics, since subsidiaries have different production mandates, cost levels and capabilities (i.e. cost-capability ratios), market mandates, financial imperatives (e.g. HQ responsibility only) and abilities to risk manage (Cantwell and Mudambi, 2005; Dörrenbächer and Gammelgaard, 2016; Morgan, 2018). These causal drivers influence, constitute and are partly produced within a complex corporate form, meaning that the impact of shocks and upheaval are uneven within and between corporations (Author, 2020).

This does not mean an exclusive concern with subsidiary role, actions and decision-making. Following the arguments presented within recent evolutionary and GPN accounts, examination of firm actors needs to be undertaken in relation to broader political economies (Martin and Sunley, 2015; Whitfield and Staritz, 2020). For foreign subsidiaries, this would include consideration of their interaction with market dynamics and the GPNs through which they operate, which are configured through broader political economies (MacKinnon, 2011). Through such an approach it is possible to better understand the nature and impacts of particular causal dynamics on subsidiaries, and which are now explored in the next section.

The corporate roles and specificity of subsidiaries

As argued above, the impacts stemming from upheaval on foreign subsidiaries are directly associated with, and mediated by a range of processes and conditions relating to the social relations occurring through the corporation. Importantly, subsidiaries have a diversity of roles and capabilities that have varying degrees of value creation (Kleibert, 2016). Despite GPN 2.0 defining the roles of subsidiaries in terms of their GPN functions, it is possible to utilise GPN thinking to conceptualise subsidiary corporate roles through differential forms of value creation in the production process (Henderson et al, 2002). ‘Capabilities’, as defined through the GPN 2.0 ‘cost-capability ratio’ framework, can be operationalised to form the basis of the nature of value creation (see Baker and Sovacool, 2017). Following evolutionary thinking on the firm, capabilities are defined in terms of the capacity of a firm, as constituted by disparate actors and practices, to *innovate* and capture value by fostering long run competitive advantages, and which centres on the ability to *organise* and enact various capabilities and resources (see Teece, 2014; Whitfield and Staritz, 2020). The corporation is understood as seeking to internalise access to such capabilities across space, which provides the impetus for foreign direct investment (Teece, 2014). From this position, corporations formulate different roles for subsidiaries based on the uneven distribution of resources and capabilities across space and borders. As such, it is possible to advance GPN thinking by working through its focus on the agency of the subsidiary, but where there is a greater explication of the role of subsidiaries in terms of their capabilities.

A range of typologies have been developed to explicate the disparate nature of subsidiaries, typically focusing on their capabilities and the role of host regions (e.g. Cantwell and Mudambi, 2005; Dörrenbächer and Gammelgaard, 2016). The construction and utilisation of such categories of subsidiary role are important, but we should not produce closed quantitative

categories based on a limited number of predefined variables. A further problem with these typologies relates to subsidiary role and importance being defined in terms of the subsidiary alone, rather than in relation to the broader corporation. This is not to suggest that it is completely ignored, but that subsidiary role is co-constituted with the broader corporation, most notably in terms of relations with the headquarters (Morgan, 2018; Fuller, 2006). In essence, the corporation is heterogeneous in nature, constantly socially constructed through discourses, practices and social relations (Faulconbridge, 2010). Subsidiary roles and capabilities function, and are defined in relation to their position within the broader corporation, but that the disparate evolution of subsidiaries, and uneven distribution of regional resources and capabilities means that subsidiary role and corporate importance varies within corporations (MacKinnon, 2011; Kleibert, 2016; Dörrenbächer and Gammelgaard, 2016; Phelps and Fuller, 2016). They have, as such, varying degrees of ‘specificity’ within the corporation, represented by differing roles, capabilities and resources in corporations that are disparate in nature.

Subsidiaries with extensive capabilities, defined by scholars such as Cantwell and Mudambi (2005) and Coe and Yeung (2015) as ‘high’ capabilities, can mitigate market and institutional upheaval and impacts in a substantial manner. They possess, or have access to capabilities through functional coupling to be able to mitigate impacts (Szalavetz, 2016). In these particular instances, subsidiaries can acquire knowledge and expertise that is not the preserve of the corporate HQ (Yeung, 2014). Knowledge is typically territorialised within particular spaces or involves relational networks that subsidiaries are strongly engaged in, with these processes producing ‘high’ corporate specificity (Fuller and Phelps, 2018). A contrasting position is one in which subsidiaries have roles, capabilities and resources that are high or more rudimentary, such as in ‘competence exploiting’ role (Cantwell and Mudambi, 2005). Nonetheless, these are not unique within the corporation and the market the subsidiary is operating within. In such

instances the mandates of subsidiaries are duplicated at a number of sites, and where knowledge and other capabilities are ubiquitous (Hardy et al, 2011). Corporate HQs are more likely to limit the autonomy of subsidiaries through various disciplinary measures, with subsidiaries functioning within centrally coordinated ‘dependent’ relations (Pike, 2005; Dawley, 2007; MacKinnon, 2011; Kleibert, 2016). Lacking specific capabilities, these subsidiaries are more negatively impacted by market and institutional upheaval, with the potential for greater substantial negative impacts and ‘defensive’ corporate restructuring (Pike, 2005; Szalavetz, 2016).

Global production networks and markets

Subsidiaries are also situated within heterogeneous global production networks (GPN), undertaking various roles, and with diverse governing arrangements and forms of control (Ponte, 2014). Within the GPN 2.0 perspective, the production network role of a subsidiary, which is related to ‘causal drivers’, is an important factor influencing and thus mitigating the impacts arising from major market and institutional upheaval. However, following the argument made above, it is important to recognise that subsidiary production network role and corporate specificity are interwoven rather than being separate. A critical aspect of the subsidiary within the corporation, and through the GPN, is its capabilities in organising production, and which provides the basis for responding to shocks and upheaval. Subsidiaries function at a nexus between operating within the corporation and with other actors through production networks, but with both requiring the enactment of capabilities for organising production, and thus there is a need to examine these concurrently. This GPN position, and corporate specificity, is further related to the nature of their ‘coupling’ with regions, which provides various resources and capabilities that are interwoven with their production activities (Yang, 2009).

Coe and Yeung (2015) identify a range of roles that firms perform within GPNs, with these coupled with the regions in which they located in various ways, and meaning that the scope of the impact of market and institutional upheaval will vary with GPN role and the nature of coupling. ‘Lead’ firms typically have the ability to influence actors within the dispersed power relations of multipolar GPNs, and control segments of production networks within more unipolar configurations (Santangelo, 2009; Ponte and Sturgeon, 2014). Such ‘power to’ attributes derive from their possession of assets and capabilities that facilitate the organisation of production across national borders and through complex production networks (Yeung, 2016). The possession of extensive capabilities and resources makes such subsidiaries potentially less vulnerable to impacts (see Yang, 2017). However, in organising production networks they are exposed to potential problems that can arise at various stages of the production process, and which are intimately related to particular spatial relations (Coe and Yeung, 2015). Even across lead firm subsidiaries there is still variability in terms of their resources and capabilities, which is tied into their responsibilities (MacKinnon, 2011). Coupling can range from the more in-depth embeddedness of ‘functional’ forms, to that of ‘structural’ arrangements where regions are less integrated into subsidiary production activities. The actual impact of market and institutional upheaval will therefore be variable.

‘Specialised suppliers’ encompass subsidiaries providing critical inputs for lead and ‘strategic partner’ firms within GPNs (Yang and Chen, 2015). This typically involves specific high value creation activities in the case of ‘industry specific’ specialised suppliers, with subsidiaries possessing considerable capabilities and resources. Strong forms of coupling are typically associated with corporate suppliers possessing important capabilities and responsibilities (Coe et al., 2004; MacKinnon, 2011; Coe and Yeung, 2015). Such subsidiaries are dependent on

key assets, resources and capabilities from regions, with these having the potential to support subsidiaries in mitigating market and institutional upheaval (Pickles et al., 2006). A more variable situation is evident in relation to ‘multi-industry’ suppliers, producing generic intermediate inputs into GPNs. Here, there is greater variability in terms of their possession of capabilities and resources, and the degree of value creation they produce when compared with industry-specific firms (Blažek, 2016). Correspondingly, the nature and degree of coupling with regions will also differ depending on their specific supplier responsibilities (Pavlínek, 2018). Subsidiaries can experience extensive integration in supply chains with autonomy subsumed by the requirements of lead firms (and corporate HQs), and where these actors have high levels of control (Coe and Yeung, 2015). Where such subsidiaries have lower capabilities there is the greater potential for negative impacts arising from market and institutional upheaval (Pavlínek, 2015).

Market imperatives and GPN configurations

Markets are critical in the formation of GPNs, corporations and subsidiary roles (Yang, 2017; Coe and Yeung, 2015). The scalar configuration of subsidiary markets has a particularly important influence on the nature of the impacts arising from economic shocks (Filippov and Kalotay, 2011; Chung et al, 2010; Dikova et al, 2013). Markets are created through a negotiated landscape between various actors within and beyond GPNs and corporations, from producers to consumers, and which generates particular market imperatives for firms (Coe and Yeung, 2015). While the construction of market imperatives for corporations derives from a range of causal factors (e.g. consumer behaviours), of critical importance is the scalar configuration of the markets in which corporate subsidiaries operate (‘market focus’). Indeed, advancing GPN 2.0 by focusing more on the intricacies of the corporation requires greater consideration of the decision-making of subsidiaries, with this coming to characterise market

creation. Subsidiaries are mandated by corporate HQs to work to particular spatial market scales, either serving a consumer market or through GPN relations (Chung et al., 2010). Many corporations have sought to locate subsidiaries within the EU to gain access to the construction of the EU single market. In other instances, subsidiaries can also have scalar mandates that incorporate other macro-regional markets. Others still, often with high corporate specificity and as industry-specific specialised suppliers, work to a global market scale, serving all macro-regional markets in the world (Iammarino and McCann, 2013).

Brexit represents a major regulatory readjustment in the sense of a restructuring of scalar market relations (Bank of England, 2019; Holweg, 2019). The market orientation of a subsidiary, and the GPN through which it operates, forms part of the much broader spatial configuration of a GPN that encompasses different spatially configured segments. For the GPN 2.0 perspective, the organisational ‘configuration’ of a GPN arises through firm strategies, which are underpinned by the causal dynamics of cost-capability ratios, market imperatives, financial disciplines, and risk environments. Particular organisational arrangements arise from such processes (e.g. ‘interfirm control’), but the spatial configuration of GPNs is critical in regards to the impact of market and institutional upheaval (see Cattaneo et al., 2010). This returns us to the essence of corporations and their activities through GPNs, namely the intention to exploit spatial differences in ways that generate particular assets and capabilities, and which produces profit (Henderson et al, 2002; Teece, 2014).

The GPN spatial configurations of subsidiaries subsequently comes to significantly affect their role and responsibilities, and thus influence the impacts arising from market and institutional upheaval. There are potentially significant implications for the market imperatives and GPN configurations of UK-based subsidiaries, which arise from possible regulatory incongruence

being generated if there is a Brexit ‘no deal’, and with substantial regional effects (Chen et al, 2018; Holweg, 2019). Even before substantial regulatory changes, subsidiaries are having to address corporate HQ decision-making based on the perception of these market impacts in the future, within a context where they create market ‘scales’ for subsidiaries. For Szalavetz (2016), corporate responses that produce markets include defensive and offensive strategies. There is the possibility of HQs disinvesting/decoupling and investing in alternative subsidiaries and regions elsewhere as part of continuing cost-competitive market access, or GPN participation that avoids tariffs.

To summarise, the value creation capabilities of subsidiaries within a corporation (‘corporate specificity’), their GPN role and configuration, and market served are important but variable influences on the nature of impacts arising from such upheaval. The next sector now examines the impact of market and institutional upheaval arising from Brexit process, and the role of these mediating conditions on software and software-related subsidiaries in Scotland and the Southeast.

THE IMPACTS OF BREXIT ON CORPORATE SUBSIDIARIES

While the software sector is not potentially subject to the substantial impacts that could arise in manufacturing sectors from a final Brexit agreement/no-deal, many firms are engaged in global production networks that are being and will be effected after a final (dis)agreement. This includes suppliers and customers having to address contemporary regulatory and market upheavals, while contingency planning for an agreement that they are yet to know (TechUK, 2017; Social Market Foundation, 2020). In relation to the latter, there are many non-tariff and

market access barriers that will become prominent once an agreement is finalised, or a no-deal comes about. This includes adjustments as they anticipate problems with migrant workforce regulations, availability of skilled workers, recognition of qualifications, extra costs and disruptions to imported components, uncertainties surrounding a new regulatory regime for service activities, and legal and regulatory issues around data transfer and storage (HM Government, 2019; TechUK, 2017). More indirectly, reductions in firm competitiveness and profitability in other sectors (e.g. extra costs associated with tariffs), and accompanying disruptions and restructuring will potentially lead to reduced demand for software products and services (De Lyon and Dhingra, 2020). Leading up to Brexit and the final agreement/no deal, many subsidiaries are experiencing substantial impacts that they are having to mitigate, and which is the focus of this paper. This includes labour market issues, the need for stockpiling in software-manufacturing subsidiaries, market uncertainties, and investment deliberations and decisions.

Labour market issues

A skilled workforce is critical to software sectors, and particularly to the continuing presence of foreign subsidiaries in regions, as repeat investment is important to their continuing viability (Hollinshead, 2019). The economic upheaval of Brexit has the potential to have a major impact on the medium to long term sustainability of subsidiaries. A large minority of subsidiaries, predominantly located in Scotland (S1-6), but only SE2 and SE3 from Southeast England, have been effected by labour market impacts, including declining applicants and poor overall supply of workers (see Table 2 and 3). These are subsidiaries that are generally high capability industry-specific and multi-industry software suppliers. The majority of these subsidiaries have low corporate specificity, where subsidiaries perform tasks that are replicated elsewhere (suggesting there is little subsidiary and regional-specific knowledge and capabilities). They

encompass a range of sectors, including banking, consumer electronics, general manufacturing, pharmaceuticals, robotics and medical technologies.

[TABLE 2]

[TABLE 3]

There are differences between Scotland and the Southeast, with the former having a majority of specialist suppliers (industry-specific and multi-industry) experiencing labour market issues, while it only accounts for one-third of equivalent Southeastern subsidiaries. Correspondingly, only one lead firm experiences labour market issues, with this located in Scotland, and serving a European market. It is also generally the case that a majority of subsidiaries operate through EU-based global production networks, which are serving the European market, and where their corporate specificity is low. This is however far more prevalent in Scotland, with four such subsidiaries, compared with only two in the Southeast.

Of critical importance is the labour market impacts that occur at subsidiaries within corporations that have niche industry-specific market roles (with the exception of SE5). Particular labour force specialisms are critical at these subsidiaries, with workers that are highly skilled and relatively mobile. Regional coupling with local labour markets is supplemented by a dependence on skilled labour from other parts of the UK, Europe and the rest of the world, meaning that the uncertainty of the Brexit process has negatively affected these subsidiaries through much broader spatial relations. These subsidiaries have experienced a decline in mainland European applicants for positions, which has compounded an overall poor supply of labour. Managers blame the on-going uncertainties around the final trade agreement and labour

market regulatory regime. As the manager of SE2, a software producer for manufacturing sectors, argues: “They don’t know what the rules are going to be, they don’t know what the situation is going to be, so it’s hard to commit you and your family to move to the UK if you don’t know under what sort of rules you’re going to be operating.” (SE2, author’s interview).

The impacts that have occurred are embedded within broader political economies and accumulation strategies characterising the UK, with its reliance on low cost labour markets and uneven investment in training and education, but has negative consequences for functional coupling during upheavals (Lindstrom, 2019). In Scotland, there is poor supply of labour for these subsidiaries, suggesting that forms of functional coupling are under strain (see also, Skills Development Scotland, 2014). For S2, a US corporation working in software imaging in Scotland, they have not been “terribly impressed with the quality of the labour force in the UK”, largely because “the UK’s done a relatively poor job of investing in advanced software architecture and development, that goes beyond social media and app-based applications” (S2, author’s interview). One aspect of this is the supply of graduates into these regions by universities, as argued by S6: “Universities in Scotland seem to be placing undue emphasis on recruiting graduates from places like India and China, and a huge percentage of those end up going back to their home country. It doesn’t really benefit the economy in the longer term because most of them head back” (S6, author’s interview). The protracted lead up to Brexit has exacerbated these shortages and the instability in the labour market, with foreign workers not knowing what the final employment rules and regulations will be (author’s interview). As argued by S3, a software development corporation in Edinburgh: “I think Brexit exacerbates that whole problem, not just in Edinburgh but across Scotland. The tech industry is very dependent on bright young things from wherever you can get them, and if any part of that workforce dries up, it creates shortage” (S3, author’s interview).

This is a situation that contrasts with the majority of subsidiaries that do not operate in niche software markets requiring specialist highly skilled labour, be they industry specific or multi-industry. For such subsidiaries, there has been a suitable supply of skilled workers in Scotland (except for S1) and the Southeast, producing stronger forms of functional coupling, which forms the basis of their subsidiary capabilities and specificity, and which was the original impetus for investing in the region. This is particularly the case in Southeast England where only two subsidiaries (SE2 and SE3), both of which are industry-specific, have labour market issues following the Brexit vote, and where they are working through manufacturing and pharmaceutical GPNs that are mitigating considerable market upheaval. For all other subsidiaries it is the case that the parent company originally invested in these nations and regions because of the strong labour market. For SE8, a subsidiary conducting R&D and the manufacturing of power components and related software, “it’s not as if the parent company established the UK operation as a bridge into Europe. They acquired the business because of what we are and the skills the team have got” (SE8, author’s interview).

Subsidiaries engaged in niche software development that requires highly skilled workers have experienced non-UK EU citizens leaving and planning to return to mainland European countries. The response has been for these subsidiaries to increase wages and remuneration benefits to ward off losing highly specialist workers that are difficult to replace, with the impact of Brexit translated into greater costs. Such actions have been particularly evident at subsidiaries in Edinburgh where new software corporations have started to locate, including Amazon Web Services. In this landscape there is strong competition for software workers, but this is imbricated with much broader spatial tendencies of competition for workers that are highly mobile, as argued by S3: “Software is hyper competitive, any of these guys could go ...

they've been headhunted several times. They could go to Google for, you know, £200-250,000 a year tomorrow" (S3, author's interview). For S3, a software subsidiary in Edinburgh, there has been a 20 per cent increase in wages to prevent this occurring, which has led to other firms in the city raising wages so as to prevent a loss of workers. In a period where profits have been under strain because of a slow market, subsidiaries have had to internalise extra wage increases or push these on to customers, potentially making subsidiaries less competitive in the international marketplace.

As stated above, these tendencies are contingent on the nature of the subsidiary and its GPN position, which impacts on labour availability issues. Large scale lead corporations within particular sub-sectors are far less vulnerable, irrespective of their degree of corporate specificity. These corporations are able to pay above average salaries, irrespective of their degree of corporate specificity. Examples include S5, a subsidiary which forms part of a large Japanese conglomerate but where its role is duplicated elsewhere. S5 is involved in Software R&D for medical technologies, and employs c.150 scientists and programmers. The role of the subsidiary is to undertake R&D that forms of part of an 'intrafirm partnership' GPN arrangement, with all outputs returning to divisional operations in Japan (Coe and Yeung, 2015). In such a context, considerable support is provided to a subsidiary with high value creation capabilities, including the ability to increase salaries to maintain and attract workers. In contrast, smaller corporations (although they can be owned by a larger parent company) requiring specialist workers for specialised supplier roles in GPNs, are far more vulnerable, such as in the case of S2 and S4, both of which also have low corporate specificity.

This is not to suggest these lead corporations are unaffected. They are exposed to a disorderly Brexit over the medium to longer term because of the reliance on highly skilled workers and

their potential lack of supply from mainland Europe, and where the EU common market has facilitated ease of access and mobility. This means workers can easily leave before the end of the transition period. The latter compounds a software sector where, as argued by S5, “you’re really entirely dependent on the ability to attract and retain super smart people, and super smart people don’t respect international borders. Super smart people will work, fundamentally, where they want to work!” (S5, author’s interview). These take place within a context where, for all subsidiaries irrespective of size, “our future pipeline of talent is a concern”, since “without the people we’ve got is a bunch of desks and computers” (S6, author’s interview). The degree of functional coupling is therefore highly mediated by a broader EU regulatory regime that facilitates the mobility of highly skilled workers.

The response by ‘high corporate specificity’ subsidiaries in Scotland (S1 and S3) has been attempts at diversifying their labour force by seeking to employ non-EU workers. For these subsidiary managers, the impetus for such action is firmly embedded within their knowledge and experience of long having to address labour market software shortages, with one manager noting that it was the first issue they had to deal with at the subsidiary, and remains one of the most important issues as there is an annual c.20 per cent turnover of staff (S3, author’s interview). While functional coupling is strong in Scotland, the scope and scale of regional assets do not match subsidiary roles and responsibilities in these cases. An example is S1, operating within the audio and voice silicon and software sector in three sites across the UK, and where it has a high level of capabilities and corporate specificity. Previously a manufacturing subsidiary which started in Scotland, it has transformed into a software engineering establishment conducting R&D and design for various OEMs, and working through production networks in China where products are manufactured. Such niche market areas require highly skilled workers with expertise in an area where there is a finite supply of

workers and “Everybody knows everybody in this part of the electronics industry” (S1, author’s interview). The competitive advantage of the subsidiary has worked on the basis of having been successful over the last decade in acquiring workers from mainland Europe through attractive pay salaries, within a context of the lack of supply of suitable workers in the UK (representing 25% of the workforce).

Since the Brexit vote this supply of workers has reduced significantly. While the Conservative government of Teresa May sought to guarantee EU citizen rights, reducing uncertainty for the existing workforce, it has not prevented a reduction in applications. The response has been to target Chinese and Indian software engineers to fill this gap, around fifty per cent of which are already in the UK. While this strategy fills vacancies, the subsidiary manager is concerned at the medium to long term consequences. Whereas EU nationals tend to stay in the UK for the long term, they are often pulled back to China and India because of family commitments, producing a high turnover and greater instability at the subsidiary. In the medium term the subsidiary has not devised a “masterplan”, largely because there is already an extensive strategy for attracting UK and mainland European engineers, and because the company’s name is well known in a relatively niche area, there are few others avenues that can be explored (S1, author’s interview).

Production, market and investment impacts

Subsidiaries have experienced a breadth of different cost increases, accompanied by decreasing profits in certain cases. There are both differences and similarities across software sub-sectors, including congruence where subsidiaries possess responsibilities that include both software production and manufacturing. Importantly, however, there are four subsidiaries (SE1, SE6, SE8, and SE10) where there have been no major impacts from Brexit in both the production

process and market. These are all large software (and hardware in the case of SE1) corporations, operating in business software and consumer markets that remain strong, but where GPNs are not significantly configured through mainland Europe. Three of the four subsidiaries have high corporate specificity, meaning there are embedded capabilities and resources at the subsidiary and region that are not significantly duplicated elsewhere in the corporation. They are also not functioning within niche software sectors, meaning that they have not been affected by labour market supply and uncertainty issues. Moreover, functional regional coupling in the Southeast provides software engineers and managers, a breadth of region-based suppliers and knowledge networks, and strong market demand in the UK (SE1 and SE6) and global markets (SE8 and SE10). This contrasts with the vast majority of other subsidiaries within the software sector in Scotland, and a small majority in the Southeast.

One such example is that of SE1, a global software and hardware manufacturing corporation, that operates in all global markets. The subsidiary has high levels of capabilities, but corporate specificity that is based on UK and Irish market knowledge, since all subsidiaries are market-based across the globe, with relevant responsibilities devolved down to individual units. Manufacturing, supply chain management and related intracorporate technology systems and infrastructures are centrally controlled and globally configured, leaving subsidiaries with responsibility for creating or adapting software for their respective markets, and sales and marketing activities. As many of the customers are global, they expect a standard service across all countries, requiring central coordination but also high levels of capabilities at subsidiaries. In this corporate context, manufacturing takes place within GPNs configured through low cost locations such as Southeast Asia; while R&D takes place in the West coast of the USA, India, and China as they are large innovation hubs for the corporation. This means the subsidiary is very focused on the UK market through global products, and has benefited in

terms of supporting customers as they prepare for all possible eventualities arising from Brexit. Support comes in the form of redesigning supply chains into and out of the UK for all possible scenarios. This takes place within a context where these global software firms are working in a strongly performing marketplace as digitisation progresses, meaning that in relation to the direct (i.e. firm) and indirect (i.e. customers) impact of Brexit “it is a little bit more protected in that sense as technology is never going to be a declining market” (SE1, author’s interview).

Stockpiling in software-manufacturing subsidiaries

Beyond labour market costs, other cost-based impacts are most common for those subsidiaries engaged in both software production and elements of manufacturing, but restricted to only S7, SE4, SE7 and SE9 within the sample group. In both countries, functional forms of coupling are focused on strong links to local suppliers and a dependence on skilled software labour and semi-skilled production labour. These subsidiaries have been involved in ‘accretionary’ forms of subsidiary evolution that includes the addition of software tasks to manufacturing responsibilities (Phelps and Fuller, 2016). SE7 has acquired R&D and software activities in relation to its original mandate for the manufacture of fibre optic cable networks. In the case of S7, this has involved the introduction of software activities in relation to chemical engineering for electronic components that serve the European market, with the stockpiling of particular chemicals that have a long lead-in time for delivery from Southeast Asia. Finally, SE4 was originally established to manufacture components for airport security, but has acquired responsibilities for software customisation in the Europe, Middle East and Africa markets.

Extra costs are typically related to the stockpiling of supplies for their manufacturing processes and customers up to the previous Brexit agreement deadlines in 2018-19, and the expansion of

new logistical, exporting and tax capabilities (e.g. extra staff, new software) and systems in preparation for the final trading agreement. In the case of SE7, this included the addition of \$16m worth of supplies into the UK market in the anticipation that there could be potential delays to cross the EU border. For all subsidiaries, this represents a transfer from just-in-time to just-in-case production as a means in which to mediate uncertainties around the final agreement, with the scale of stockpiling varying with the scarcity of components and their lead in times. SE4 and SE7 subsidiaries are serving markets including and beyond Europe, and therefore have systems in place for exporting through tariff systems. In contrast, S7 and SE9, are having to invest in such capabilities, including new logistics workers and software systems. Of greater importance has been the extra costs associated with planning for all potential eventualities with customers, but in a context where this planning is working to a worst case scenario because of uncertainty. As argued by S7: “Our customers don’t expect to see any delays in material arriving to them so that’s quite a concern. Until we know what’s actually going to happen that’s a concern, that’s something that we just can’t plan for” (S7, author’s interview). These subsidiaries are also planning to internalise the costs associated with all forms of potential new trading arrangements. Working within markets characterised by many competitors, the overarching approach is one of absorbing extra costs (e.g. tariffs) rather than passing them on to customers.

Ultimately, it is subsidiaries that have evolved through upgrading but where the original manufacturing responsibilities remain that have been subject to greater cost increases, and the potential for disinvestment and closure in the future. Cost increases relating to their manufacturing responsibilities could be either transferred to an EU or lower cost non-EU site, but where the viability of the scope and scale of their software responsibilities will be critical in determining their survival. Within these possibilities lies the potential for a reconfiguration

of the relationship with regions, with the loss of manufacturing leading to functional decoupling in certain aspects, but survival ensuring continuing coupling, although the strength and nature of functional coupling could decrease.

Market uncertainties

Of critical importance is the nature of the market that the subsidiary serving, with this mediating the degree of severity (Filippov, and Kalotay, 2011; Dikova et al., 2013). Where subsidiaries are working to non-European markets, or a UK-only market with strong demand levels, the impacts have often been far less, such as in the case of SE4 which operates in the 52 countries included within its ‘Europe, Middle East and Africa’ market responsibility. This corresponds more broadly to studies suggesting that a large percentage of software firms serve non-EU markets, meaning that the impact of Brexit will not be significant (KPMG, 2017). As argued by S3: “We’re exporting to Australia, Canada, New Zealand, the US, Japan, Singapore, etc. but not much to the EU. So Brexit hasn’t hit our revenues much” (S3, author’s interview). For such subsidiaries, they are operating within technological and software sectors that have global customers, and where processes of digitalisation are ensuring strong market growth (SE1, author’s interview). The subsidiary managing director of SE5 describes this as a situation where “there’s an awful lot of hesitancy, but I think the fundamental demand for digital is probably at the moment recession-proof and Brexit-proof” (SE5, author’s interview).

This is a situation that contrasts with those dependent on mainland European markets, involving market uncertainties that are leading to reduced demand for goods and services. One key aspect of this is the predominance of GPN and market-based operations serving the European market, with local levels of corporate specificity, suggesting vulnerability arising from corporate configurations that are based on locating operations within individual macro-

regional markets (S2, S4-7, SE2 and SE3). The actual impact of reduced revenue is variable, but estimates by all subsidiaries suggest a reduced revenue stream of around 10-15%, such as in the case of SE3 which had an average turnover of c.£500k in 2014. For these subsidiaries it is a case of customers delaying decisions on big technological and software investment projects, but where “everyone’s using Brexit as the opportunity to say, ‘Well, we don’t need to do that yet, so we won’t’” (S4, author’s interview). This includes five Scottish subsidiaries and three Southeastern establishments, and across different sub-sectors.

Even where subsidiaries highlight market uncertainties as critical, these still take place through complex corporate processes that often mediate these conditions, and where the individual agency of subsidiaries remains important. In the case of financial software subsidiaries S8 and S9, both of which have high value creation roles within GPNs configured through the USA, the market impacts of Brexit have not been substantial because of the strong coupling with proximate customers and assets (e.g. skilled labour) in Edinburgh, combined with the corporate-wide strategic priorities of market expansion. In the case of the former, universities provide graduates, but more important is the co-location with competitors and customers. This creates a pool of ‘local talent’, with competitors providing a stream of experienced workers. In relation to the market, because both subsidiaries have specific high value creation capabilities, there is less intracorporate and specific capabilities in other markets, meaning that market growth in Asia and North America are possible, and with the corporate HQs seeking to disseminate capabilities and knowledge.

A further example where subsidiaries have sought to enact agency, thereby mediating market uncertainties, is that of SE3, a software packaging development subsidiary in Southeast England. The period since the Brexit vote has seen a downturn in their turnover from serving

pharmaceuticals lead firms, with considerable market uncertainties going forward. These large corporations have not so much lost market share, or are being dramatically affected by Brexit, but have responded to the uncertainties around the final agreement by reducing investment in the UK, which has subsequently reduced demand for SE3's products. Efforts at these corporations are targeted at mediating Brexit by "spending all their time taking care of Brexit related modifications to their software packaging and so on" (SE3, author's interview). The response by SE3 has been to pursue new markets and GPNs in Eastern Europe and the USA but with existing software products, and not developing new products for existing markets because of the considerable amount of resource and workforce investment this would require during a period of uncertainty.

Finally, and as mentioned previously, there are many Southeastern subsidiaries that are continuing to experience strong market demand and no impacts arising from uncertainties, but none in Scotland. One such example is SE1 (but also SE10), which serves the UK and Irish markets but with high corporate specificity arising from market knowledge. The subsidiary has experienced continuing 'natural growth' irrespective of Brexit, but the stance taken by the UK CEO is one in which the corporation is focused on corporate customers, irrespective of their location. As the CEO remarked: "the UK business is solid and growing because the technology markets are growing. If companies leave and set up businesses in the world, then that doesn't make any difference to us as a company globally, we'll just follow them to where they go" (SE1, author's interview). Despite being a subsidiary explicating strong forms of functional coupling with regions through access to regional assets, as global businesses they emphasise the ability to move to similar non-UK regions as the Southeast of England for the requisite high value creation assets. In effect, the business market is more important than functional coupling, with customers typically of a multinational corporate nature. If they divest

and/or exit the UK in large numbers, SE1 will follow them, irrespective of regional assets and subsidiary capabilities.

Investment deliberations and decisions

Investment processes within corporations are inevitably related to the economic uncertainties arising from Brexit (Bank of England, 2019). There is far less consolation and cost pressures in the software sector compared with manufacturing. Nonetheless, there is increasing competition between firms within niche and general software markets, which requires continuing investment in competences by specialised and general suppliers as a means of ensuring value capture and enhancement in the medium term. The broad overarching picture is one of continuing corporate investment at those subsidiaries without low corporate specificity, working through EU GPNs or serving the European market. Beyond these factors, investment decisions are based on the continuing importance of Scotland and the Southeast, largely in relation to the importance of labour market regional assets, proximity to competitors and involvement in knowledge networks. More broadly, the overarching investment trend relates to the differences between manufacturing and software corporate responsibilities. This is particularly tangible in instances where subsidiaries have transformed from manufacturing to software responsibilities, with managers emphasising a dichotomous situation between the two broad functions. For S6, a subsidiary that moved from the manufacture of consumer product components to corporate software and support functions, “it’s easier to move that [manufacturing] somewhere else when the next round of investment happens” (S6, author’s interview). This is a process they are aware of, having originally been a greenfield manufacturing investment as part of ‘Silicon Glen’ in the 1980s and 90s, but losing these functions to lower cost productions sites. Yet, having diversified into corporate software

support functions as they lost manufacturing responsibilities, they have continued to receive corporate investment during the Brexit process.

Correspondingly, subsidiaries experience less corporate investment where they are producing software for hardware (SE2), have manufacturing responsibilities (S7, SE7 and SE9), serve European markets and work through EU-based GPNs (SE2, SE9, S2, S4, S5, S6 and S7). For those serving European markets, corporate HQs have interpreted Brexit in terms of contemporary and potential future market upheaval, with this delaying investment decisions, or diverting investment to mainland European offices. Indeed, the common characteristic of all these subsidiaries, with the exception of SE7, is that they have low corporate specificity and are EU-based. In such cases, investment is being transferred to subsidiaries with comparable capabilities and regional assets in mainland Europe, and that are involved in the same GPNs. For those subsidiaries undertaking manufacturing activities, it has been a case of assessing the potential impacts from tariffs, with many undertaking analysis of various scenarios based on the possible future trading agreements that have been discussed in UK Government and EU negotiations. The overarching concern is the impact on just-in-time supply chains where these operate into mainland Europe, which includes the actual exporting of the final good, and where software firms are specialised suppliers into these GPNs.

What this has produced is considerable uncertainty in relation to future investment, with the result that investment discussions are leading to HQs examining whether to designate investment to sites within mainland Europe. As argued by S7, a producer of software and electronics components: “Nobody wants to make a decision anymore until it’s clear what’s happening. We’ll have to see how things pan out... we can’t commit to any future investment” (S7, author’s interview). Similar concerns and discussions are taking place at SE7, a subsidiary

producing software and manufacturing of fibre optic cable networks, where the managing director notes that:

“If Britain’s going to become a third country, why not move to, say, Poland or Morocco. It’s been talked about a lot, because at the end of the day if you’ve got borders you’ve got borders. You might as well go for the lower cost, low wage environments, possibly on a greenfield site and then you flog off your real estate in the UK, that’s what we would look at doing.” (SE7, author’s interview)

SE2 forms part of a much larger corporate conglomerate, with multiple divisions in the UK, and where all European corporate subsidiaries compete against one another for investment. In the past, production was moved from Germany to the UK on the basis of tariff free just-in-time access to EU markets, combined with the availability of skilled workers for R&D activities in the Southeast. Investment decisions are being delayed on the basis that senior corporate managers are constructing a scenario where they will be able to close UK plants within the next 5 years if the final trade agreement is not conducive to such production networks. The HQ is not therefore taking pre-emptive measures, such as disinvestment from the UK, before the final agreement is concluded. The offshoot of this is that all investment decisions relating to SE2 has been suspended, but this is not to suggest that the broader corporation has withdrawn all investment in the UK. Within its rail transportation division, continuing state investment in railways and the politically sensitive need for manufacturing to be in the UK, produces ongoing investment in the form of a new production facility. Without doubt, where subsidiaries are serving a strong UK market, such as in transportation or NHS spending on medical devices, there is a belief that investment will continue at subsidiaries, irrespective of extra costs. As such, this is a very complicated landscape as a range of contingent conditions impact on future investment and locational decisions, with SE2 subsidiary manager describing it as “not a binary

decision” between an impact or the non-impact of a new tariff regime, or between disinvesting or reinvesting.

CONCLUSION

The upheaval generated through the Brexit negotiation has negatively affected foreign software subsidiaries in Scotland and the Southeast of England in a number of ways. This includes labour market issues, market and production uncertainties, extra production costs and reduced/delayed corporate investment. Yet, there is a great deal of variability in terms of the scope and scale of such impacts, depending on specific corporate and GPN factors. Of notable importance is the tendency for subsidiaries with low corporate specificity, working through EU-based GPNs, and serving European (GPN and supplier) markets, to be most affected by Brexit. Interestingly, GPN role is of far less significance in such tendencies. Scotland has experienced these issues more extensively than the Southeast of England. Furthermore, there are four Southeast subsidiaries, encompassing different GPN roles, which have encountered no major issues. These subsidiaries are part of large corporations, operating within strong markets, and where their GPNs are not configured through the EU.

The importance of ‘functional’ coupling in relation to the impacts of Brexit upheaval is interwoven with corporate role, GPN configuration and market spaces. Niche software subsidiaries in Scotland struggle to recruit from Scotland and increasingly the EU, while ‘lead’ firms encounter no major problems. In relation to the former, such processes are generated through a software sector characterised by a workforce that is highly mobile and globalised, a belief that the UK does not produce enough workers, and that the EU single market regime

supports mobility which can go against firms seeking to retain workers. In other instances, subsidiaries in Southeast England, and particularly those unaffected by Brexit, have strong forms of functional coupling based on access to a highly skilled workforce and various business and knowledge networks. Of course, such processes have to be situated within a broader political economy of the UK that is characterised by uneven development (Jessop, 2018).

Finally, the paper provides important conceptual insights that can be deployed to understand the impacts arising from further shocks and upheaval relating to the post-Brexit trading arrangement and COVID-19. GPN and evolutionary perspectives have argued for greater consideration of the role of firm agency in relation to the impacts of economic shocks/upheaval and responses (Martin and Sunley, 2015). In particular, GPN 2.0 seeks to provide a framework in which to comprehend the impacts and responses to shocks and upheaval by focusing on the ‘causal dynamics’ influencing firm strategies and GPN organisation. While GPN and evolutionary perspectives recognise the importance of firm actors, there is a need for greater recognition of the intricacies of agency, including the nature of the subsidiary in relation to broader corporate processes, and the relational configurations through which they operate. Indeed, the subsidiary is interwoven with the market and global production networks through which they operate, and thus the impacts and mediation of shocks and upheaval effect subsidiaries in a relational manner (Cattaneo et al., 2010; Whitfield and Staritz, 2020). An aspect of this is greater explication of how the impact and mediation of shocks are shaped by processes, actors and relations beyond the region, including the role of foreign HQs and the GPNs that subsidiaries work through (see Martin and Sunley, 2015). More importantly, such an approach increases the appreciation of how GPN 2.0’s ‘causal drivers’ effect, organise and are partly created within complex corporate and GPN forms, producing the heterogeneous and uneven impacts on subsidiaries that derive from shocks and upheaval.

The agency of the firm also needs to be seen as not just having blurred boundaries with global production network actors and regional economies, but that these blurred boundaries link with and constitute the heterogeneous segments and tendencies of corporations. The role and responsibilities of the subsidiary have to be considered in relation to broader corporate (spatial) tendencies, and from this we get the notion of ‘specificity’. This specificity is then linked with processes and tendencies beyond the corporation, but which are interwoven with the corporation, including GPN role and configuration, and the scalar market through which a subsidiary operates. As such, the agency of the firm still needs to be conceptualised by way of the topological and topographical spatial relations that constitute its blurred boundaries, including its embeddedness within production networks and markets, and which follows GPN thinking. What such an approach does is to return us to Dicken and Thrift’s (1992) argument that firms have a ‘valuable role’ in understanding ‘how complex production systems are organized in time and space’ (288).

REFERENCES

- Bank of England (2019) *The impact of Brexit on UK firms*. London: Bank of England.
- Blažek, J. (2016) Towards a typology of repositioning strategies of GVC/GPN suppliers: the case of functional upgrading and downgrading. *Journal of Economic Geography* 16 (4): 849-869.
- Cantwell, J. and Mudambi, R. (2005) MNE competence-creating subsidiary mandates. *Strategic Management Journal*, Volume 26, 12, 1109-1128
- Cattaneo, O., Gereffi, G. and Staritz, C. (2010) *Global value chains in a postcrisis world: a development perspective*. Washington: World Bank.
- Chen, W., Bart, L., McCann, P., Ortega-Argilés, R., Thissen, M. and van Oort, F. (2018) The continental divide? Economic exposure to Brexit in regions and countries on both sides of The Channel. *Papers in Regional Science*, Volume 97, Issue1, 25-54.
- Chung, C. C., Lee, S.-H., Beamish, P. W., and Isobe, T. (2010) Subsidiary expansion/contraction during times of economic crisis. *Journal of International Business Studies*, 41, 500–516.
- Coe, N., Hess, M., Yeung, H. W.-C., Dicken, P., and Henderson, J. (2004) ‘Globalizing’ regional development: a global production networks perspective. *Transactions of the Institute of British Geographers*, 29: 468–484.
- Coe, N. Dicken, P., Hess, M. (2008) Global Production Networks: realizing the potential. *Journal of Economic Geography* 8: 271–295.
- Coe, N. and Yeung, H. (2015) *Global Production Networks: Theorizing Economic Development in an Interconnected World*. Oxford: Oxford University Press.
- Coe, N. and Yeung, H. (2019) Global production networks: mapping recent conceptual developments. *Journal of Economic Geography* 19, 775–801.
- Dawley, S. (2007) Fluctuating Rounds of Inward Investment in Peripheral Regions: Semiconductors in the North East of England. *Economic Geography*, Volume 83, Issue 1, 51–73.
- DCMS (2018) *DCMS Sectors Economic Estimates 2018: Regional Gross Value Added (GVA)*. London: DCMS.

- Dicken, P. and Thrift, N. (1992) The organization of production and the production of organization: why business enterprises matter in the study of geographical industrialization. *Transactions of the Institute of British Geographer* 17, 279–91.
- Dikova, D., Garretsen, H., Smeets, R. and van Ees, H. (2013) Immediate responses to financial crises: A focus on US MNE subsidiaries. *International Business Review*, 22, 201–215
- Dörrenbächer, C., and Gammelgaard, J. (2016) Subsidiary initiative-taking in multinational corporations: The relationship between power and issue-selling. *Organization Studies*, 37, 1249–1270.
- Faulconbridge, J. (2010) TNCs as embedded social communities: transdisciplinary perspectives. *Critical perspectives on international business*, Vol. 6 Issue: 4, 273-290.
- Filippov, S. and Kalotay, K. (2011) Global crisis and activities of multinational enterprises in new EU member states, *International Journal of Emerging Markets*, 6, 304–28.
- Fisch, J. and Zschoche, M. (2011) Do firms benefit from multinationality through production shifting? *Journal of International Management* 17(2):143-149.
- Fromhold-Eisebith, M. (2015) Sectoral Resilience: Conceptualizing Industry-Specific Spatial Patterns of Interactive Crisis Adjustment. *European Planning Studies*, 23(9), 1-20.
- Fuller, C. and Phelps, N. A. (2018) Revisiting the multinational enterprise in global production networks. *Journal of Economic Geography* 18(1), pp. 139-161.
- Hardy, J., Sass, M., and Fifekova M.P. (2011) Impacts of horizontal and vertical foreign investment in business services: the experiences of Hungary, Slovakia and the Czech Republic. *European Urban and Regional Studies* 18 (4), 427– 443.
- Henderson, J., Dicken, P., Hess, M., Coe, N., Yeung, H. W.-C. (2002) Global production networks and the analysis of economic development. *Review of International Political Economy*, 9: 4436–4464.
- Hollinshead, G. (2019) Global value chains in international knowledge work: networks, stratifications and labour markets. *Global Networks*, DOI: 10.1111/glob.12253
- Holweg, M. (2019) *Death by a thousand cuts: The strategic outlook for the UK automotive industry beyond Brexit*. Oxford: Said Business School, Oxford University.
- Iammarino S. and McCann P. (2013) *Multinationals and Economic Geography. Location, Technology, and Innovation*. Cheltenham UK: Edward Elgar.

- Jessop, B. (2018) Neoliberalization, uneven development, and Brexit: further reflections on the organic crisis of the British state and society. *European Planning Studies*, Volume 26, 1728-1746.
- Kleibert, K.M. (2016) Global Production Networks, Offshore Services and the Branch-Plant Syndrome, *Regional Studies*, 50:12, 1995-2009.
- MacKinnon, D. (2011) Beyond strategic coupling: reassessing the firm-region nexus in global production networks. *Journal of Economic Geography*, 12 (1): 227-245.
- Martin, R. and Sunley, P. (2015) Towards a developmental turn in evolutionary economic geography? *Regional Studies* 49 (5): 712–32.
- Morgan, G. (2018) Power relations within multinational corporations. In Nölke, A. and May, C. *Handbook of the International Political Economy of the Corporation*. Cheltenham: Edward Elgar Publishing Ltd.
- Pavlínek, P. (2015) The impact of the 2008–2009 crisis on the automotive industry: global trends and firm-level effects in Central Europe. *European Urban and Regional Studies* Vol. 22(1) 20–40.
- Pavlínek, P. (2018) Global Production Networks, Foreign Direct Investment, and Supplier Linkages in the Integrated Peripheries of the Automotive Industry. *Economic Geography*, 94:2, 141-165.
- Phelps, N. A. and Fuller, C. (2016) Inertia and change in multinational enterprise subsidiary capabilities: an evolutionary economic geography framework. *Journal of Economic Geography*, 16 (1): 109-130.
- Pickles, J., Smith, A., Bucek, M., Roukova, P. and Begg, R. (2006) Upgrading, changing competitive pressures, and diverse practices in the east and central European apparel industry. *Environment and Planning A*, 38: 2305–2324.
- Pike, A. (2005) Building a Geographical Political Economy of Closure: The Case of R&DCo in North East England. *Antipode* 2005, 37(1), 93-115.
- Pike, A. Birch, K., Cumbers, A., MacKinnon, D. and McMaster, R. (2009) A Geographical Political Economy of Evolution in Economic Geography. *Economic Geography*, 85:2, 175-182.
- Skills Development Scotland (2014) *Skills Investment Plan for Scotland's ICT & Digital Technologies sector*. Glasgow: Skills Development Scotland.

Ponte, S. and Sturgeon, T. (2014). Explaining Governance in Global Value Chains: A Modular Theory-Building Effort. *Review of International Political Economy*, 21(1), 195-223.

Szalavetz, A. (2016) Post-crisis developments in multinational corporations' global organizations. *Competition & Change*, Volume: 20 issue: 4, page(s): 221-236

Teece, D. J. (2014) A dynamic capabilities-based entrepreneurial theory of the multinational enterprise. *Journal of International Business Studies*, Volume 45, 1, 8–37.

Yang, D.Y.-R. and Chen, Y.C. (2015) The ODM model and co-evolution in the global notebook PC industry: Evidence from Taiwan. *Adv. Appl. Sociol.* 3 (1), 69–78.

Yang, C. (2009) Strategic Coupling of Regional Development in Global Production Networks: Redistribution of Taiwanese Personal Computer Investment from the Pearl River Delta to the Yangtze River Delta. *Regional Studies*, 43(3): 385–407.

Yang, C. (2017) The rise of strategic partner firms and reconfiguration of personal computer production networks in China: insights from the emerging laptop cluster in Chongqing. *Geoforum*, 84: 21–31.

Yeung, H. (2014) Governing the market in a globalizing era: developmental states, global production networks, and inter-firm dynamics in East Asia. *Review of International Political Economy*, Vol.21(1), pp.70-101.

Yeung, H. (2016) *Strategic Coupling: East Asian Industrial Transformation in the New Global Economy*, *Cornell Studies in Political Economy Series*. Ithaca, NY: Cornell University Press.

Table 1: Case study area attributes

Indicator	Southeast England	Scotland
Population (2017)	9,080,825	5,424,800
Total GVA (£ million) (2017)	267,126	138,231
Annual GVA total growth (1998-2017)	3.0	3.2
GVA per head (2017)	29,415	25,485
Annual growth in GVA per head (1998-2017)	2.3	2.8

Table 2: Impacts of Brexit and the role of mediating conditions in Scottish-based subsidiaries

Case study	Subsidiary roles	Corporate specificity	GPN role	GPN configuration	Market focus	Main impacts
S1	Silicon chip R&D, and design	High corporate specificity	Specialized supplier (multi-industrial)	GPN configured through SE Asia	Europe, Middle East and Africa	Attraction/retention of skilled EU/non-EU workers
S2	Image data management (biomedical sciences) design	Low corporate specificity	Specialized supplier (industry specific)	Configured through EU networks	Europe	Uncertainty for EU workers, market uncertainties, reduced/delayed investment
S3	Software/robotics R&D	High corporate specificity	Specialized supplier (multi-industrial)	Configured through EU/non-EU networks	Global	Attraction/retention of skilled EU/non-EU workers
S4	Banking software	Low corporate specificity	Specialized supplier (industry specific)	Configured through EU networks	Europe	Attraction/retention of skilled EU/non-EU workers, market uncertainties, reduced/delayed investment
S5	Software R&D for medical technologies	Low corporate specificity	Lead firm	GPN configured through EU networks	Europe	Attraction/retention of skilled EU/non-EU workers, market uncertainties, reduced/delayed investment
S6	Software for medical technologies	Low corporate specificity	Specialized supplier (industry specific)	GPN configured through EU networks	Europe	Attraction/retention of skilled EU/non-EU workers, market uncertainties, reduced/delayed investment
S7	Software and electronics components	Low corporate specificity	Specialized supplier (multi-industrial)	Configured through EU networks	Europe	Extra costs for stockpiling of supplies, new exporting procedure costs, market uncertainties, Reduced/delayed investment
S8	Financial services software	High corporate specificity	Lead firm	GPN configured through USA	Europe, Middle East and Africa	Market uncertainties
S9	Financial services software	High corporate specificity	Lead firm	GPN configured through USA	Europe, Middle East and Africa	Market uncertainties
S10	Software support functions for the Parent company	Low corporate specificity	Specialized supplier (multi-industrial)	GPN configured through USA	Europe, Middle East and Africa	New exporting procedure costs

Table 3: Impacts of Brexit and the role of mediating conditions in Southeast of England subsidiaries

Case study	Subsidiary roles	Corporate specificity	GPN role	GPN configuration	Market	Main impacts
SE1	Multi-industrial software products	High corporate specificity	Lead firm	Configured through EU/non-EU networks	UK and Ireland	Strong market demand
SE2	Software products for manufacturing sectors	Low corporate specificity	Specialized supplier (industry specific)	Configured through EU networks	Europe	Attraction/retention of skilled EU/non-EU workers, market uncertainties, Reduced/delayed investment
SE3	Software products for the pharmaceutical sector	Low corporate specificity	Specialized supplier (industry specific)	Configured through EU networks	Europe	Attraction/retention of skilled EU/non-EU workers, market uncertainties
SE4	Airport software and hardware production	High corporate specificity	Lead firm	Configured through EU/non-EU networks	Europe, Middle East and Africa	Extra costs for stockpiling of supplies, new exporting procedure costs
SE5	Software production for banking sector	High corporate specificity	Specialized supplier (industry specific)	Configured through EU GPNs	Europe, Middle East and Africa	Market uncertainties
SE6	HQ and corporate software and support functions – consumer electronics	Low corporate specificity	Lead firm	Configured through SE Asian and Turkey	UK and Ireland	Strong market demand
SE7	R&D and manufacturing of fibre optic cable networks, and related software	High corporate specificity	Lead firm	Configured through EU GPNs	Global	Extra costs for stockpiling of supplies, new exporting procedure costs, reduced/delayed investment
SE8	R&D and manufacturing of power components, and related software	High corporate specificity	Specialized supplier (multi industrial)	Configured through non-EU GPNs	Europe, Middle East and Africa	Strong market demand
SE9	Software development, European HQ and assembly of medical devises	Low corporate specificity	Lead firm	Configured through EU GPNs	Europe	New exporting procedure costs, market uncertainties, reduced/delayed investment
SE10	Software R&D and production	High corporate specificity	Specialized supplier (multi-industrial)	Configured through EU/non-EU networks	Global	Strong market demand