



Industrial diversity and innovation spillovers: dynamic innovation and adoption

Working Paper no 45

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November 2013



EUROPEAN COMMISSION
European Research Area



Funded under Socio-economic Sciences & Humanities

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Work Package 306

***MS68 "Research paper on industrial diversity and innovation
spillovers"***

Working Paper no 45

This paper can be downloaded from www.foreurope.eu

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THEME SSH.2011.1.2-1

*Socio-economic Sciences and Humanities Europe
moving towards a new path of economic growth
and social development - Collaborative project*

Industrial diversity and innovation spillovers: dynamic innovation and adoption

Philip Amison (COVUNI), David Bailey (COVUNI)

Contribution to the Project

This milestone paper looks at what industrial policies are needed in Europe to build diverse, resilient and adaptable economies; this means looking at the role of "phoenix industries" and "hybrid" industries. The paper looks at regional hotspots of phoenix and hybrid sector development to understand policy needs for the recombining and re-integration of competencies through cross-sector spillovers. In particular it looks at the West Midlands low carbon vehicles sector as a 'Phoenix industry' and what can be learned in terms of industrial and regional policy requirements.

Keywords: Clusters, ecological innovation, high road strategy, industrial policy, innovation policy, new technologies, post-industrialisation

Jel codes: O3, O31, O32, O33

Industrial diversity and innovation spillovers: dynamic innovation and adoption

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November 2013

Abstract

This paper explores the links between open innovation and the emergence of a phoenix industry – the low carbon vehicles sector - in the UK's traditional automotive heartland, focusing on the West Midlands region. It highlights three major factors in driving the development of this 'phoenix' industry at a regional level. Firstly, it highlights the role of 'open innovation' approaches in driving the sector, for example noting that smaller firms can sometimes innovate more quickly/more cheaply than the major auto firms; the increased interaction across technologies, up and down supply chains and between larger and smaller firms. In so doing, it also notes the role of hybrid firms providing services, plus prototyping/low volume manufacturing (largely in niche vehicles) and the transferability of these competences across industrial sectors. Secondly, it points to the role of historic (and relatively immobile) investments in the region, for example the past/ongoing importance of established mass producers, the depth of skills and experience in suppliers and in the local workforce; and cross-overs with the overlapping motorsport cluster. Finally, it stresses the role of public-private sector cooperation, such as: the establishment of the Automotive Council UK and its work in developing technology roadmaps, informing regulation, and supporting development of the UK supply chain (a type of industrial policy as a discovery process and in line with 'smart specialisation' principles); the R&D funding programmes developed with industry input; and the earlier role of the Regional Development Agency. Overall, it points to the possibilities of building smart specialisation strategies and industrial policies which are aligned with 'high-road strategies'.

1. Introduction

The UK Midlands and the West Midlands in particular has suffered significant deindustrialisation since the 1970s, particularly in the automotive sector. It retains, however, an important presence in automotive design and engineering, particularly among small and niche firms. More recently, the automotive industry in the UK – and in the West Midlands in particular – has begun to see an upturn in its fortunes.

It is argued that open innovation has become increasingly important in the automotive industry, particularly in the context of new and emerging technologies with the potential to allow for a radical shift away from existing approaches. Examples include replacements for the internal combustion engine and advances in ICT that are opening the way for developments such as ‘mobility-as-a-service’ (MAAS) which challenge traditional views of the automobile.

This paper explores the extent to which the development of a ‘low carbon vehicles’ sector in the Midlands can be understood as an example of a phoenix industry and the role that open innovation in the wider automotive industry has played in its development. The report also identifies the associated implications for industrial policy.

The paper is structured as follows. Section 2 outlines the results from a review of the relevant literature. This begins with a brief summary of recent thinking on industrial policy before looking in more detail at the literature relevant to industrial diversity and innovation spillovers in the context of phoenix industries. Section 3 provides the background and context to the case study of the ‘low carbon vehicles’ sector in the UK Midlands. Data was gathered through a series of structured interviews with firms and other stakeholders (a copy of the structured interview guide used with firms is attached as Appendix I). Section 4 presents a summary analysis of the results from the interviews (a full question by question analysis of the interview results is attached as Appendix II). In section 5, some comparisons are made with previous studies of phoenix industries. Conclusions from the work are presented in section 6.

2. Literature review: Industrial policy, diversity and specialisation, open innovation and phoenix industries

Industrial policy

Thinking about industrial policy – and, indeed, industrial policy itself – has evolved over time. The nature of a country’s industrial policy changes with the level of

national income, with the stage of industrial development and with the degree of openness of the economy. Industrial policy thinking and practice has also, more recently, been influenced by the economic downturn and by the challenges associated with climate change and changing demography. Changes in technology have also influenced the nature of industrial policy – because of the associated changes in the nature of products and services and how they are produced and consumed. In particular, the shift from a resource-based towards a more knowledge-based economy has been a significant influence, with the role of knowledge institutions enabling the *“construction of regional advantage as never before”* (Cooke and De Laurentis (2010, p 4).

The term ‘industrial policy’ can potentially encompass a wide range of interventions, with intended or unintended impacts on firms. Measures falling under this general heading can range from, for example, taxes and subsidies, the attraction of foreign investment, policies related to education and training, and science and innovation policy, through to the provision of infrastructure, regulation, competition policy and procurement. Such measures may be targeted towards individual industries or groups of industries (vertical); applied on a more general cross-industry (horizontal) basis; or used in combination (matrix) (Aiginger and Sieber, 2006). Rodrik (2004, p 29) provides a usefully succinct definition - *“Anytime a government consciously favors some economic activities over others, it is conducting industrial policy.”*

Furthermore, industrial policy can be driven by an essentially market-based (‘reactive’) approach or from a more interventionist (‘proactive’) perspective. According to the former approach, the state’s role is to intervene solely to correct failures of the market. According to the latter view, the state must also play a more strategic role in helping to shape the industrial landscape (see, for example, Cowling (1990); Bailey and Cowling (2006)). In their work on general purpose technologies, Lipsey et al (2005) distinguish between neoclassical and structuralist-evolutionary views of economic processes. The structuralist-evolutionary approach is developed to analyse long-term growth using dynamic evolutionary concepts. In the context of a growing economy operating under uncertainty, they argue the case for government intervention, for example to support the development of specific technologies.

More recently, the important role of the state is also emphasised by Rodrik (2004; 2008), who sees industrial policy as a process of strategic collaboration between the private sector and government. As both sides have imperfect knowledge he characterises this as a discovery or learning process. There are parallels, here, with the state’s role in the ‘smart specialisation’ strategy proposed by Foray et al (2009)

(covered in more detail below) and in the construction of regional advantage (for example, see Cooke et al (2006)).

Traditionally, industrial policy has been associated with relatively narrow policy objectives, for example the promotion of one or more industrial sectors; or increasing regional or economy-wide 'competitiveness' (productivity, in practical terms) (Bailey and Driffield, 2007). More recently, industrial policy has been seen in a broader context in which it can contribute toward the pursuit of a wider range of economic, social and environmental objectives. Aiginger (2007, p 299), for example, sets out a vision of what a 'systemic industrial policy' might look like in the future. The latter would foster the dynamic competitiveness of a country or a region where competitiveness is, *"defined by a welfare function with a set of goals in which social innovation and environmental progress also play important roles."* Aiginger's work has been developed further as part of the WWWforEurope project. Pages (2010, p 680) describes innovation policy under President Obama as being about more than just the stimulation of key industries or sectors. Innovation is seen, *"as a solution to many pressing challenges, such as improving healthcare and enhancing environmental sustainability."* Meanwhile, Brinkley (2010) emphasises the importance of another dimension of industrial policy - its distributional impact. In particular, he argues the need to ensure that future growth avoids creating greater economic and social divides.

Industrial diversity

Work by Jacobs (1969) on cities suggested that sectoral diversification was important in inducing cross-industry knowledge spillovers and opportunities for innovation. Glaeser et al (1992) and others, however, later emphasised the importance of agglomeration externalities (also called 'localisation economies') arising from regional specialisation, whereby firms benefit from the presence of other local firms in the same industry. More recently, Frenken et al (2007) distinguish between 'localisation economies' - external economies available to all local firms within the same sector; 'urbanisation economies' - external economies available to all local firms irrespective of sector, arising from urban size and density; and 'Jacobs externalities' - external economies available to all local firms stemming from a variety of sectors. In their study of the Netherlands, covering the period 1996–2002, Frenken et al (2007) found evidence to support the view that 'Jacobs externalities' enhance employment growth,

while unrelated variety reduces growth in unemployment (hence more diversified economies have greater resilience to shocks that only affect specific sectors).

In a related vein, work by Boschma (2005) has shown that knowledge is more likely to spillover between agents when their 'cognitive distance' is neither too large nor too small. *"Accordingly, the higher the number of related industries in a region, the more opportunities exist for effective knowledge transfers between sectors. That is, related variety, rather than variety or specialisation per se, is expected to enhance regional growth (Frenken et al., 2007)."* (Boschma and Frenken, 2011, p 6).

Linked to this, the concept of 'path dependence' has been applied within evolutionary economic geography to the analysis of regional economic development trajectories - *"... a path-dependent process or system is one whose outcome evolves as a consequence of the process's or system's own history."* (Martin and Sunley, 2006, p 399). Perhaps of greater interest – to policymakers at least – is the need to understand how new regional growth paths emerge. A number of studies have shown that areas are more likely to diversify into industries that are closely related to their existing industries. The process whereby new industries (increasing variety) arise from technologically related industries in a region has been termed 'regional branching' (Frenken and Boschma 2007; Boschma and Frenken forthcoming).

Open innovation

The increasing importance of knowledge, relative to other factors of production, as a source of competitive advantage and growth has meant that much recent industrial policy and practice has focused on the process of innovation and the importance of knowledge flows within, and between, firms. Originally described by Freeman (1987), the significance of the relationship between research, innovation and economic development led to a focus on the development of national or regional systems of innovation and the 'triple helix' of university-industry-government relations (Etzkowitz and Leydesdorff, 1997).

The process of innovation has become increasingly 'open' (Chesbrough, 2003), shifting from taking place within a single firm to taking place across firm boundaries – involving other firms, universities, research institutes and end users. For individual firms, such an approach enables extension of the pool of knowledge and competencies on which they are able to draw. This is particularly relevant for industries or technologies where knowledge is widely distributed and firms cannot establish or maintain sufficient in-house capabilities. Such 'open innovation'

approaches, it is argued, have been found to raise profits, increase speed to market, enable firms to expand their markets and is desirable at times of technological change (Chesbrough and Crowther, 2006).

In the automotive industry, the innovation process has traditionally been shaped by the vehicle makers (OEMs) and has mostly been undertaken in-house (Jürgens et al, 2008). As the range of technologies that are important to success in the industry has expanded - spanning electronics, to digital, to new fuel and power technologies – it is argued that open innovation approaches have become increasingly important in the automotive industry (MacNeill and Bailey, 2010). The role of specialist suppliers of knowledge, R&D and components has become crucial for innovations of a more systemic nature (Köhler et al, 2012).

Smart specialisation

Focusing on policy approaches, the concept of ‘smart specialisation’ was developed in the context of the increasing mobility of commercial R&D facilities, in particular, the perception that Europe was losing out to other global locations. Foray and Van Ark (2007) identified two main issues facing Europe in this regard: firstly a fragmentation along national lines which was hampering the process of creating truly world class centres of expertise; and secondly the potential for wasteful competition between states or regions to attract or create leading-edge centres of scientific excellence in the same technological areas.

In industrial and regional policy terms, Foray et al (2009, p 20) describe ‘smart specialisation’ as a strategy through which, rather than spreading their investment in R&D and innovation thinly across several frontier technology research fields, countries or regions instead concentrate their investment in programmes that complement their other productive assets. Identifying an area’s relative strengths in terms of science and technology is best achieved, they suggest, through an “*entrepreneurial process of discovery*” (p 21). This collaborative learning process, involving both public and private sector actors, has parallels with Rodrik’s (2004) view of industrial policy as a ‘discovery process’.

Foray et al (2009) also link smart specialisation with the properties of general purpose technologies (GPTs) – in particular the widespread applicability of GPTs across the economy and the reciprocal nature of the complementarities between the initial invention and subsequent applications of the technology. These dynamics, they argue, can also be distributed between regions. Hence, whilst what they term

'leader regions' might invest in GPTs, 'follower regions' may be better advised to invest in the 'co-invention of applications' – *"the development of the applications of a GPT in one or several important domains of the regional economy"* (p 22). Such an approach, they argue, would enable regions to develop areas of specialisation that encourage the development and retention of 'co-specialised assets' (for example labour force skills or research programmes). Through its use of the GPT framework, this approach is distinct from a simple strategy of industrial specialisation.

Overall, Foray et al (2009) see three roles for government in (i) providing incentives for entrepreneurs and other organisations to become involved in the process of discovering the region's specialisations; (ii) evaluating and assessing the effectiveness of the promotion of particular activities (to avoid wasting money on ineffective interventions); and (iii) identifying complementary investments, for example in education and training.

The European Commission has recently (2010) called for national and regional governments to develop smart specialisation strategies, as an important component of the *Europe 2020 Strategy*. In this context, McCann and Ortega-Argilés (2011) argue that, *"if smart specialisation is to be successfully integrated into regional policy it is necessary to develop regional policies which promote technological diversification amongst the most embedded industries which have the relevant scale to generate significant local impacts, whilst at the same time promoting the connectivity of the region without inadvertently creating an adverse Krugman shadow effect."* (p 18).¹

Phoenix industries

Phoenix industries have been described as clusters of small and medium-sized businesses working with broadly similar technologies that have sprung up in former industrial areas. They benefit from the historic, relatively immobile, investments in industry knowledge and workforce skills that have taken place over a long period of time in these areas. They typically research, develop and produce sophisticated components for use in a wide range of industries and hence are sometimes described as 'enabling industries'. Christopherson (2010, p 79) describes them as benefiting from 'initial advantage' - *"... personal networks, technical skills and market*

¹ The adverse Krugman shadow effect referred to is where the increased connectivity actually promotes further outflows of knowledge or skills from the intended beneficiary region

knowledge that have developed over a long time, giving them an edge over less 'rooted' clusters in the same industry."

The notion of phoenix industries is related to wider literatures on regional economic trajectories, including the debates around specialisation, diversification and related variety; clusters; path dependence; and economic resilience. Phoenix industries can be seen as a way to escape 'negative lock-in' for old industrial regions on a declining development path - either as a source of 'escape' from an existing path or as offering a more positive, evolutionary path. Whether they are viewed as providing radical or evolutionary change varies depending on how tightly the initial definitions of a region's industrial strengths are framed. More narrow, static, definitions of existing cluster strengths make it less likely that opportunities for inter-industry evolution and growth will be identified. This has led some authors to question the validity of cluster-based approaches to regional development arguing, instead, the need for a more holistic approach (for example, Martin and Sunley (2003, 2006); Sadler (2004); and Treardo (2010)).

Actual studies of phoenix industries have been quite diverse. Christopherson and Clark (2007), for example, look at the evolution of the optics and imaging industries in Rochester, New York. They study, in particular, the relationships between the large transnational firms that came to dominate the area and the small and medium sized firms that have more recently emerged. The smaller firms tended not to compete with the larger firms in product markets but their activities were more closely related in the area of research and development. Yet Christopherson and Clark found that the small and larger firms were in direct competition for specialised labour, research and development resources, and intellectual property. Similarly, Treardo (2010) examines the transition of Pittsburgh, in the USA, from a steel making town to home to a successful steel technology cluster. Although the area lost most of its steel-making capacity, it did not lose its steel-making expertise. She identifies the technical knowledge retained in the local labour force as the key factor that enabled the area to attract and retain firms in the emerging steel technology cluster. Also of relevance for this study, Trippl and Otto (2009) undertake a comparison of cluster-based renewal processes in Styria (Austria) and the Saarland (Germany). They distinguish between 'incremental', 'diversification' and 'radical' approaches to cluster-based renewal. They conclude that local policy actors need to engage in a more or less constant search for - and support of - emerging clusters, as a way to broaden the economic base and promote related diversification in order to avoid the risk of economic overspecialisation.

3. Case study of the ‘low carbon vehicles’ sector in the UK Midlands: Background and context

The West Midlands automotive industry

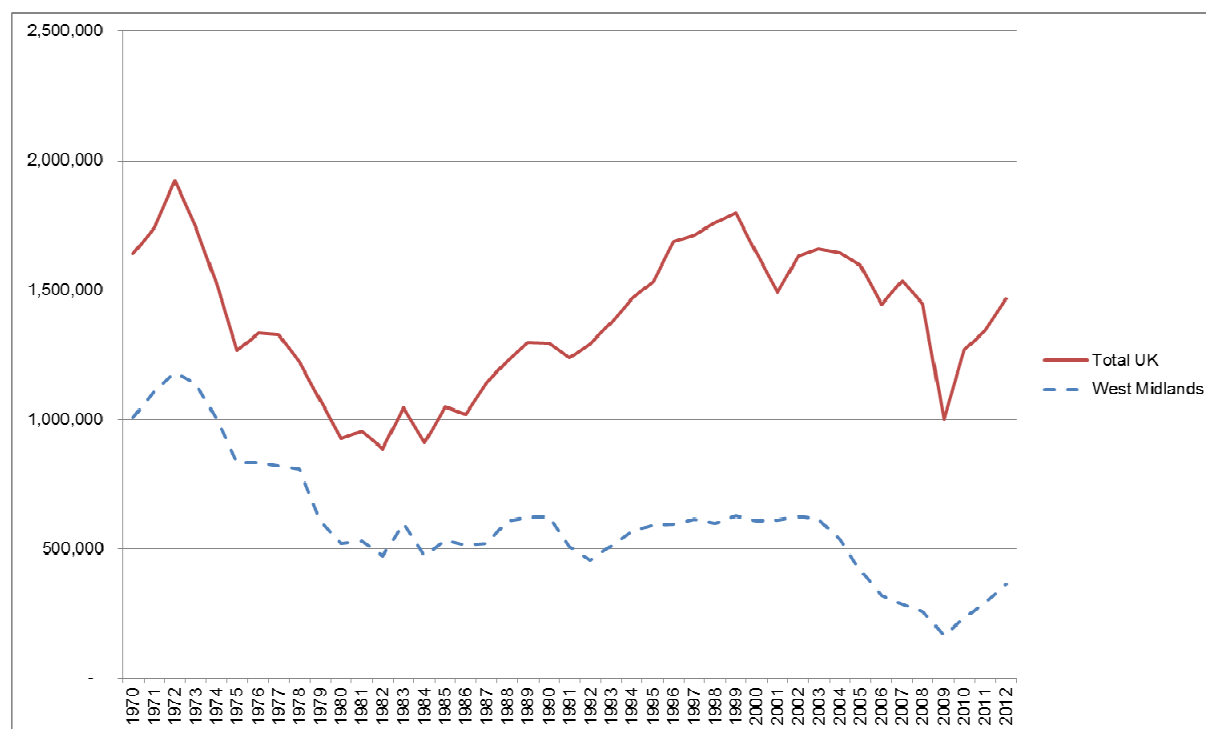
The West Midlands was the birthplace of the automotive industry in the UK. During the 1960s, the region was second only to the South East in terms of overall economic prosperity. Through the 1970s and early 1980s, however, the West Midlands declined. Failing to secure any of the major Japanese inward investments to the UK that took place during the late 1980s and 1990s, its share in total UK automotive production fell from 75% at the start of the 1970s to just 18% by 2008. There were major firm closures in the 2000s, including the final loss of volume manufacturing to the region. The West Midlands automotive sector is now largely reliant on small-scale luxury vehicle production plus a number of specialist niche firms (Donnelly et al, 2012).

The region has remained important, however, as a centre for automotive design and engineering expertise. This includes the aforementioned vehicle makers in the premium and upper premium segments; a cluster of first and second tier suppliers; a number of niche vehicle manufacturers; and a concentration of design, R&D and engineering consultancies plus university research expertise (Jarvis et al, 2012). The public policy environment has also been supportive of the industry, for example through the establishment of the Automotive Council in 2009, a joint industry-government body tasked with transforming the business environment for the industry. More recently a strategy for the sector was published (HM Government, 2013), put together on the basis of joint working between government and the industry.

The last few years have seen an upturn in the fortunes of the automotive sector in the UK. Between 2009 and 2012 car production increased by approaching 50% (SMMT, 2013). The industry in the West Midlands has also benefited with the most significant firm in the region, Jaguar Land Rover (JLR), also expanding. Indeed, over the last three years JLR has created nearly 11,000 direct new jobs with some 6,000 in the region². The impact of the associated turnaround in production volumes is illustrated in Figure 1. Around a half of the recent increase in UK auto output over 2009-2013 can be accounted for by JLR.

² <http://www.smmmt.co.uk/2013/09/major-boost-for-uk-car-manufacturing-as-jaguar-land-rover-creates-1700-solihull-jobs/>

Figure 1 – Car manufacturing output volumes in the UK and the West Midlands, 1970 - 2012



Source: Adapted from Donnelly et al (2013) and updated using data from the SMMT and Jaguar Land Rover Investor Presentation reports

Case study approach: Structured interviews with firms and other stakeholders

The remainder of this paper draws upon a case study of firms operating within the 'low carbon vehicles' sector centred on the West Midlands/Midlands³ region of the UK. The firms interviewed covered a range of activities, including vehicle design, development, manufacturing and repair; vehicle component design, development and manufacture; and engineering services providers, including providers of consultancy and/or testing facilities. All of the firms had some involvement with the development or production of 'lower carbon' vehicles - again, spanning a range of technologies including those needed for hybrid and electric vehicle development, battery and hydrogen fuel cell technologies, and the use of new materials for example to produce lightweight structures.

In total, twenty structured interviews were completed between April and August 2013. Seventeen of these were with firms involved in the sector. The remaining three interviews were with other stakeholders. Interview participants were not selected on the basis of a sampling approach, hence those interviewed cannot necessarily be considered to be representative of the sector as a whole. The firms interviewed did,

³ Some of the firms interviewed were located in neighbouring regions, hence the term 'Midlands' more appropriately describes the study area.

however, constitute a good spread by size (ranging from micro to large firms) and by activity and area of technology.

In the case of firms, the structured interviews covered the following broad areas:

1. Nature of the firm's business - Main products/services, turnover, main customers and suppliers
2. The firm's ownership and origins - Ownership status and origins, reasons for choice of location
3. Nature of the firm's workforce – Workforce size, occupational groups, industrial/technical background, commuting distances
4. The firm's external linkages - Relationships with other firms, with universities and/or with R&D centres, membership of industry networks
5. The firm's approach to learning, knowledge transfer and innovation - How the firm keeps up to date with the latest developments in technology/the industry, approach to innovation (internal, 'inbound' or 'outbound' R&D/innovation)
6. External influences on the firm and the role for public policy - Main external influences on the firm, development needs and the role for public policy.

A copy of the structured interview guide is attached as Appendix I. A summary analysis of the results from the interviews is presented in the next section. Appendix II provides a more detailed, question-by-question, analysis of the interview results.

4. Case study of the 'low carbon vehicles sector' in the UK Midlands: Summary analysis of results from the structured interviews

The results from the interviews are analysed in the following sub-sections, broken down according to the six main headings covered in the structured interviews. Emerging policy implications are identified at the end of each sub-section and these are brought together in the concluding part of this paper (section 6).

4.1 Nature of the firms' business

Firm activities and size

The firms interviewed together covered quite a broad range of activities and technologies within a fairly generally defined notion of the 'low carbon vehicles' sector. They also ranged from small enterprises, with a turnover of less than half a million pounds, to large firms turning over hundreds of millions.

Customers and markets

Many of the firms were supplying major vehicle manufacturers and/or first tier automotive suppliers. Despite its lack of a volume producer the Midlands, and the West Midlands in particular, remains an important centre for the automotive sector in the UK. A number of the firms interviewed named Jaguar Land Rover (JLR) as an important customer. Although not a volume car maker, JLR is very important regionally and nationally. It is the only large automotive firm that is headquartered, and still 'does everything', in the UK. Other global manufacturers have production facilities in the UK but they are reliant on R&D facilities around the world. The firms supplying JLR have benefited, and continue to benefit, from JLR's ongoing expansion.

A notable characteristic of many of the firms interviewed was the range of markets served beyond automotive. Indeed a number of firms were actively seeking to diversify, or diversify further, into other markets sectors. These firms were typically working with technologies that are applicable across a number of different sectors. Another noteworthy characteristic is that although nearly all of the firms interviewed were engaged in manufacturing activity, nine of these combined this with the provision of engineering or other consultancy services. This reflects the high level of research and development (R&D) activity being undertaken by these firms and embodied in their products and services.

Suppliers

A number of firms expressed a preference for using local suppliers wherever possible. This was more marked for firms producing on a smaller scale and where considerable product development was taking place, requiring frequent interaction with suppliers. For some firms this was also part of a commitment to support UK industry. The availability of local supplier firms with the right competences was also a factor. Rising production costs in competitor countries, such as China, was also cited as an increasing driver of this trend by one firm. Where cost pressures were particularly important, however, firms sourced supplies from the most competitive suppliers, wherever they were located. Equally, where it was important for a firm to obtain specialist materials, components or systems they would source these from the most appropriate supplier on a global basis.

Policy implications

In terms of emerging policy implications, there are two areas that represent potential opportunities from a local economic development perspective. First, there could be a policy role to support firms seeking to diversify - either by gaining new customers in the automotive sector or by moving into other market sectors outside automotive. This would help to build the resilience of the local economy. Second, the preference for use of local suppliers also suggests a possible role to help connect potential local customer and supplier firms.

4.2 Firm ownership and origins

Firm origins

Although there was a wide range of start dates across the firms interviewed, ten of the firms started in the period between 1999 and 2009. It is likely that the timing of a number of these new firm starts, and others that started in the 1980s or 1990s, were linked to the demise of 'old automotive cluster' firms such as Rover. Indeed, the majority of the firms interviewed had origins in the automotive sector. There is also a clear link with the motorsport sector, both in terms of the origins of the firm founders and with motorsport being an important market for some firms. Several of the interviewees suggested that firms from outside the automotive sector are also beginning to enter this market as the range of technologies has become more diverse. There was limited evidence for this among the firms interviewed, however. In fact, firms in the sector were diversifying to serve other markets beyond automotive.

One additional characteristic, worthy of note, was the longevity of several of the firms interviewed. Five of the firms were established before 1950. It would be interesting to explore what factors, such as ownership or strategy, have enabled these firms to survive and thrive through the transition from 'old' to 'new' automotive cluster firms.

Location decisions

Turning to the location decisions of firms, the historic importance of the automotive industry in the area has clearly been a very important influence on firm's location decisions. Proximity to customers; the presence of specialist skills in the local

workforce and in supplier firms; linkages with local universities; plus the reputation of the industry in the area were all mentioned as important factors. These factors can all be related to the development of the automotive industry and associated investments in the area made over many decades. Proximity to the owner or founder's home was also cited as a factor in location choice. This factor can also be linked to the historic presence of the automotive sector if the reason they originally lived in or moved to the area is because they previously worked in a local automotive firm.

When discussing their location choices few of the firms interviewed talked about the importance of the more recent investments that have been made in the area's 'automotive sector infrastructure'. Examples of the latter types of investment would be the recently announced National Automotive Innovation Campus being established at the University of Warwick, the Manufacturing Institute being created by Coventry University, in partnership with Unipart, and the Manufacturing Technology Centre recently established at Ansty, near Coventry. It could be that it will take time before these more recent investments - and those still to come - are seen as important factors in reinforcing the attractiveness of the Midlands as a location for advanced automotive technology firms.

Policy implications

From a policy perspective, the overriding message is that cluster development and evolution is a long-term process. The dominance of the automotive sector in the West Midlands was established over many decades and the sector continues to evolve. Industrial policy, whether consciously or unconsciously deployed, has been an important component in this process.

4.3 Nature of the firms' workforce

Occupational mix

The high proportion of professional and technical staff in the workforces of the firms interviewed was very much in line with their positioning at the higher value-added end of the automotive sector. Even in the more mainstream part of the sector, the car has become an increasingly sophisticated piece of engineering, more so than the aeroplane, some interviewees argued. The importance of other engineering disciplines, for example electrical and software engineering, has also grown as have

disciplines on the boundaries of engineering such as materials science. This broadening of the technologies involved in automotive production has helped to open up opportunities for new firms and new entrants to the sector as well as allowing existing firms to diversify into new markets. It has also meant that firms are finding it difficult to recruit staff with the necessary skills and experience in these new technologies.

For those firms whose business was more oriented toward making physical products, skills and experience gained on the job was very important. Some firms talked about the length of time it can take to train an employee up to the required skill level. These were also typically the firms that had developed traditions of long service in the company. Often, the way that these firms protected their intellectual property was through their knowledge of how to produce a particular product or component. Their competitors could not replicate the product without that knowledge.

Gender mix

The workforces of the firms interviewed were largely male dominated, a pattern that is presumably replicated across the sector. This may change as the importance of disciplines beyond mechanical engineering, for example software engineering, become increasingly important. That will also depend, however, on the extent to which women choose careers in those disciplines.

Policy implications

At the local level there is a role for policy to try and ensure that local education and training providers are turning out enough students in the right technological areas. However, even the firms themselves can find it difficult to predict their skills needs in specific areas very far in advance. In addition, for higher level skills firms are likely to draw on the best qualified staff not just locally but from across the UK and internationally. There may be an argument for providing short course training and development opportunities in the new technological areas for already experienced engineers and for people working in related sectors.

4.4 Firms' external linkages

Collaboration

The extent of collaboration in general and, in particular through grant-funded R&D projects, among the firms interviewed is noteworthy. Grant-funded R&D projects are clearly an important driver of collaboration activity for most of the firms. The reasons given for participating in such projects included the ability to achieve more through the sharing of resources with other firms (though with a cost in terms of the subsequent need to share the benefits from commercialisation); as a way to identify potential partner firms or other organisations; and/or as a way to identify new customers and get into supply chains.

The extent of collaborations with universities is also worthy of note, again reinforcing the importance of R&D and technological innovation in the sector. Although not specifically pursued as part of the interviews, it would be interesting to know the extent to which the collaborations with universities were driven or encouraged by the availability of public funding or if they were largely undertaken on the basis of business need, irrespective of the availability of a subsidy. Given the reliance of these firms on the development of new technology, it is probably the case that collaborations with universities would take place regardless of the availability of public funding to support the process.

One stakeholder suggested that collaborations with universities were likely to be more prevalent at lower 'technology readiness levels'⁴ (say level 3 or 4). At the higher levels (5, 6 and 7), where products/services are closer to commercialisation, firms were more likely to go for commercial research partners. Universities were also more likely to be favoured where the timescale is less important than the expertise and quality of the research.

Networks and industry bodies

Linkages with and through industry bodies and networks were also relatively important to the firms interviewed. In terms of the reasons for joining industry bodies and networks, it may be worth making a distinction between essentially firm-focused networks, such as the Niche Vehicle Network (NVN), and networks or bodies that involve both firms and government, such as the Automotive Council. The former type of networks/bodies are essentially about information sharing, best practice, keeping up to date with industry and technological developments and access to commercial

⁴ See *Automotive Technology and Manufacturing Readiness Levels: A guide to recognised stages of development within the Automotive Industry*, Automotive Council, 2011.

opportunities. The latter type are more concerned with the impact of government on the sector and the role of the sector in the economy.

One commentator spoke about the important role that the Automotive Council has played in relation to the development of the industry in the UK. A similar view was expressed by a number of the firms interviewed. All of the original equipment manufacturers (OEMs) with a base in the UK are represented on the Automotive Council's Technology Group, together with other bodies and the major energy companies. The Group has worked to inform the setting of national regulation, based on an understanding of what is possible technically and seeking to ensure that UK-based firms are not unduly disadvantaged. This has also helped the UK government to argue more effectively on regulation at EU level. The Group has also been able to exert an influence on the setting of regulation at EU level by a more circuitous route. Non UK headquartered OEMs with a base in the UK who were members of the Group were also able to make similar arguments through their own home country national structures, and up to EU level through their own national governments.

Policy implications

In terms of emerging policy implications, clearly public support for R&D and collaborative R&D projects in particular has been important to firms in this sector. Collaboration with universities has also been important although it is less clear to what extent this needs to be supported by subsidy. In any case, universities are often also partners in the collaborative R&D projects.

Industry bodies and networks are also important, both as fora for inter-firm knowledge sharing and collaboration and for collaboration between industry and government. The creation of inter-firm networks has been supported in the past by the public sector – for example the NVN was established with funding from the former Regional Development Agency, Advantage West Midlands. The establishment of an effective industry-government body, in the form of the Automotive Council, has been highlighted as being of particular recent importance to the sector.

4.5 Learning, knowledge transfer and innovation

Innovation

Analysis of the firms' responses to the questions about learning, knowledge transfer and innovation confirms their highly innovative and R&D-intensive nature. This is presumably the main reason why firms in this sector are able to exist and compete from a location such as the UK, despite the relatively high labour costs. As noted in the previous section, the results also confirm the importance of collaboration through grant-funded R&D projects and with universities.

One stakeholder observed that smaller innovative firms are often able to develop new project ideas more cheaply and flexibly than the major firms. This is particularly the case in areas outside of the traditional automotive industry areas of expertise, for example in electric motors, control electronics, high voltage batteries, electronic components and composite materials. Whereas it might take six months for a major firm even to secure the necessary internal approvals to commence a particular line of development work, a small firm with the relevant capabilities can secure small-scale R&D funding and may be able to get to prototype or demonstrator stage within the same timescale. In this respect it was observed that small firms often produced prototype or demonstrator models purely to showcase their capabilities to larger firms.

The importance of 'open innovation' in encouraging firm entry

The broader range of technologies that are now being used within the automotive sector and beyond has opened up market opportunities for a wider range of firms. Some interviewees argued that the major firms have always looked widely for potential new technologies and new supplier or collaborator firms. Proponents of this view argued that this more open approach to innovation is not a new phenomenon, although it has become more prominent recently. The major firms are always looking for the best, lowest cost, suppliers on a global basis.

It was also argued that there is more collaboration between the big vehicle manufacturers now than was the case in the past. This is a result of the constant pressure to improve product quality and reliability whilst driving down cost. Collaboration between the major vehicle manufacturers, for example, has allowed common components to be produced in very high volumes, shared across different end user manufacturers. Collaboration of this nature is more encouraged by governments than used to be the case.

Conversely, other interviewees argued that the major firms are making more use of externally sourced R&D than was the case in the past. Working with smaller, even

very small, firms gives them access to a broader range of potential innovations. The larger firms identify potential partner or supplier firms in part through working in collaborative R&D projects or by attending showcasing events. It was argued that there is now more interaction between firms at different levels in the supply chain and across technologies. Hence, it is not uncommon now to find an OEM working directly with a very small company. In the past the approach to collaboration up and down the supply chain was more hierarchical. One explanation given for this was that where the major firms are dealing with standardised products and known technologies, suppliers are selected on a lowest cost basis by the firm's procurement function. Where the products are non-standard and/or the technologies are far more uncertain, however, the identification of potential suppliers is a more complex process and tends to be led by the firm's engineering function.

Policy implications - The difficulties of bringing new products to market

Several interviewees stated that although the breadth of technologies now important in the automotive sector has opened up opportunities for a wider range of firms, the development and commercialisation of products and services based on these new technologies also represents a more risky investment. Making the step from a prototype or demonstrator to a product that can be put into volume production is an expensive process. Someone also has to bear the risk that the new product will not be commercially successful. Small firms typically, therefore, struggle to secure the necessary investment finance to make the step from innovator/demonstrator to small/medium volume producer.

One alternative for the small firm is to make this step with the support of a larger firm. Small firms can sometimes be reluctant to do this, it was argued, because they fear loss of control. In this context, one interviewee also suggested that small firms can sometimes overvalue their intellectual property, especially if backed by 'city' investors. This was perceived as being part of a more general problem in the UK whereby investors were seeking too high a return over too short a timescale. A contrast was made with Germany, where it was perceived that investors are prepared to take a more realistic, longer-term, view.

The high costs and risks associated with developing and commercialising products and services based on these new technologies was also identified as a problem, even for large firms. It was suggested that industry and government in the UK need to work together to address this. A number of interviewees took the view that there

was 'enough' support available for R&D. Rather, it was support for the 'productionisation' and commercialisation of the products and services arising from these new technologies that now needed more attention.

One final conclusion to draw from the analysis of the interview responses with regard to innovation is that patenting activity is not likely to be a particularly good measure of the level of innovation in this sector. All firms interviewed were engaged in innovation-related activity to a greater or lesser extent but only just over half of firms reported that they were using patents to protect their intellectual property. The decision on whether or not to patent depended very much on the competitive position of the firm, its business strategy and the nature of the intellectual property it was generating.

4.6 External influences and the role for public policy

External influences

Top of the list of important external influences cited by the firms interviewed were changes in regulation and standards plus the changing nature of products, markets and/or technology. The pressure to comply with emissions and other environmental regulations is exerting a major influence on the automotive industry as a whole. As discussed in earlier sections, the breadth of technologies now involved in car design, development and manufacture means that even the major firms cannot be at the leading edge in all areas - hence the need for them to draw on external sources of innovation. This factor is also driving the need for greater collaboration between firms at all levels, where multiple technologies are involved.

The recent buoyancy of the UK automotive sector in general, and the ongoing expansion of JLR in particular, has also been an important external factor driving growth in the business of a number of the firms interviewed. JLR and other manufacturers have themselves benefited from growth in markets such as China and India.

Some of the firms interviewed appeared to be benefiting from an increasing demand for more personalised or customised products, where customers were prepared to pay a high price for novel features. This was a factor, in particular, at the very high end of the market. More generally, however, many of the firms were supplying components or systems for niche or premium vehicle production. It is predominantly in these higher value added products that the demand or interest currently exists for

'low carbon' technologies. Once the technologies have been 'proven' in these - lower volume but higher margin - products they may subsequently be deployed at lower unit cost in volume production. One interviewee stated that technological advances have helped to lower tooling costs, meaning that the level of vehicle production volume needed to break even is lower than in the past.

Environmental concerns in their own right did not appear to be a particularly important direct influence on most of the firms interviewed. These concerns are, however, what lies behind the changes in regulations and standards that are driving the whole industry and would also be a factor influencing these firms customers' customer demand. It is also possible, however, that the relative importance of environmental concerns among consumers has declined during the recent recession.

Public sector support

Firms were asked about the types of public sector support or funding that they had received to date. Public funding for R&D was by far the dominant response, emphasising how important this was for many of the firms interviewed. Funding related to local economic development was the next most mentioned form of support. For the individual firms concerned, the latter type of funding was probably more important in terms of the amount of funding secured. It was far less significant, however, in terms of the number of firms benefiting. In particular, none of the 'micro' firms had benefited this form of support – though they did benefit from more general business support, the next most mentioned category of support. It's worth noting that funding related to local economic development would, of course, also be important in terms of supporting the local economies concerned.

Policy implications - Development needs and the role for the public sector

Turning to the development needs identified by firms and the role for the public sector, the ability to recruit suitably qualified staff was the most mentioned development need. This was particularly an issue in those technological areas that were relatively new to the automotive sector. As noted earlier, it is not clear how amenable this problem is to public sector intervention, given the difficulty of predicting specific skills needs very far in advance. Provision of short-course opportunities for experienced staff to gain knowledge in these new technological areas might be one way to address this.

Access to finance was highlighted as a general issue for business in the UK and particularly for manufacturing firms. The Government's recent automotive sector strategy (HM Government, 2013) has begun to address some of these issues, for example in relation to the provision of finance for tooling. In addition, through initiatives such as its 'launchpads', the Technology Strategy Board (TSB) has sought to address issues of business finance and growth alongside support for innovation.

Offering an alternate view, one interviewee argued that other sectors have been able to secure the investment necessary to modernise and grow, without the need for government intervention. The food retailing sector was cited as one such example. According to this view, a good enough idea combined with a well-constructed business case should be sufficient to secure the necessary finance for investment.

The firms interviewed were generally very positive about the funding support available for R&D projects. Differing views were expressed, however, about the extent to which the projects supported by the TSB tended to be too technologically conservative or, alternatively, were too 'left field'. Interviewees were also generally very positive about the way in which funders such as the TSB and the NVN engaged with the industry in order to inform the development of their funding programmes and as part of the project application and appraisal process. One interviewee raised an opposing view – arguing that the work of these funding bodies, government and other organisations in the sector was too dominated by the 'incumbent industry'. This was acting as a constraint and leading to incremental change, as opposed to the more radical change that is needed to address the major environmental challenges faced.

There was generally perceived to be 'enough' funding available to support early stage R&D. As noted in earlier sections, a number of interviewees suggested that where additional funding or support is needed is in moving an idea from the prototype or demonstrator stage through to volume production ('productionisation' of the technology) and bringing the product or service to market. This was perceived to be a problem not only for small firms, seeking to scale-up production, but also for large firms because of the high costs and risk associated with developing and bringing a new product or service to market.

It was argued that the UK now has a good 'institutional platform' from which to address these issues. Government Departments, such as the Department for Business, Innovation and Skills, and national agencies, such as the TSB, were perceived to be doing a better job now than had been the case in the past. The formation of the Automotive Council and other initiatives meant that interactions in

the sector between industry, government and universities were better than ever before.

There is, indeed, evidence of practical initiatives now being put in place in an effort to address a number of the issues outlined above. For example Government recently announced the establishment of *The Proving Factory*, a facility intended to help bridge the gap between small firms developing innovative low carbon vehicle technologies and the needs of the major automotive firms. More recently still, as part of the launch of a new strategy for the automotive sector (HM Government, 2013), Government announced the commitment to establish, with industry, an *Advanced Propulsion Centre* which will combine collaborative technology development with support for the industrialisation process in the field of advanced vehicle propulsion technologies.

Several other areas for public sector intervention were mentioned by interviewees. These included the criticism that regulation and standards development were sometimes acting in contradictory directions. The specific example given was of safety standards that were increasing the complexity and weight of vehicles and effectively shortening their usable life. This was contrary to emissions reduction and resource efficiency objectives. It was suggested by some that the incumbent industry might be exerting too much influence on the development of regulations and standards. Several interviewees thought that public sector procurement could be used more effectively to help drive the development of the industry. It was also suggested that this could be supported by adopting a more integrated approach to transport policy across all modes.

5. Comparisons with previous studies of phoenix industries

Previous studies of phoenix industries include work by Christopherson (2009), Christopherson and Clark (2007) and Treado (2010). A number of factors are identified in the literature as being important to the development of a phoenix industry in an old industrial area. These include the presence of: relevant skills in the local labour force and in (potential) supplier firms; technical skills and expertise in nearby colleges, universities and other training or research facilities; personal networks and market knowledge related to the industries concerned; capital for investment; and reputational factors. The following sub-sections compare the findings in the Midlands case with those of previous studies in relation to these five factors, and in terms of

the processes of firm entry and exit; and changing economic and labour market conditions.

Relevant skills in the local labour force and in (potential) supplier firms

Christopherson (2009) describes how advanced manufacturing firms can find the necessary expertise, capital and labour force skills to be able to innovate and expand in places where there have been long-term investments in industry knowledge and workforce skills. These are typically areas where there are many firms working with broadly similar technologies. The Midlands can be seen as such an area, where significant investments have been made over a long period of time related to the automotive sector. The interviews conducted with firms confirm the importance of industry expertise and workforce skills, though the role of capital is more uncertain, as is discussed further below, and may provide limits to the development of the industry in the Midlands case.

Treado (2010) examines the successful transition of Pittsburgh, in the USA, from a steel making town to home to a successful steel technology cluster. Although the area lost most of its steel-making capacity, it did not lose its steel-making expertise. She identifies the key factors in this transition as being the area's location, its industrial legacy and its labour expertise. According to Treado, the ultimate source of regional resilience in the Pittsburgh case – and in the other studies she has reviewed – is the surviving industrial expertise of the regional workforce. By comparison, in the Midlands case the results from the interviews support the view that technical skills retained in the labour force and in local supplier firms are important to firms in this sector. Along with proximity to customer firms (itself related to the historic presence of the automotive sector in the region), these were often cited as important factors influencing a firm's choice of location.

The presence of relevant skills in the labour force was not such a dominant factor across the firms interviewed, however, as Treado found in the case of Pittsburgh. In part this perhaps reflects the greater internationalisation of the labour market in the Midlands case. Many firms, for example, said they had already exhausted the local supply of specialist skills they required, and were having to recruit internationally. It is possible that the presence of specialist skills in the local labour force was more important to those firms that were more oriented towards making physical products. Firms whose workforce comprised a greater proportion of higher-level occupational roles were more likely to be recruiting on a UK or international basis for the specialist

skills they required – particularly where they were working in relatively new or emerging areas of technology.

Technical skills and expertise

Christopherson (2009, 78-9) characterises phoenix industry firms as benefiting from 'initial advantage'. This is seen as making them different from more traditionally described industry clusters. Specifically, such firms are seen as benefiting 'from personal networks, technical skills and market knowledge that have developed over a long time' (ibid). Hence, although many routine production jobs have been lost in these industries, the knowledge of how to produce and innovate has remained to some extent. This could be, for example, in the courses run by local universities and in the skills of the labour force. Similarly, Treado (2010) highlights the importance of Pittsburgh's broader tradition of expertise in materials-based industries, for example the expertise contained within the engineering departments of the region's major universities, plus the location of a number of major private sector research facilities in the region, and the fact that several important trade associations and relevant professional societies are headquartered in the region.

The West Midlands lost many routine production jobs in automotive and related industries over the period since the 1970s. In the 1960s there were more than 1 million manufacturing jobs in the region. By 2013 the number of manufacturing jobs had fallen to just over 300,000. The results from interviews support the argument that specialisms retained within local universities are important to the automotive sector in the region. Firms were questioned about the extent to which they collaborated with universities and whether they selected university partners on the basis of proximity or on grounds of excellence in relevant specialisms, irrespective of location. Even though many firms said they collaborated with universities on the basis of excellence in relevant specialisms, rather than proximity, the most frequently named universities that firms said they had collaborated with were in fact local to the area – in Coventry, Warwick, Loughborough, Oxford and Birmingham. It is also worth noting that linkages with universities appear to be more important to the firms interviewed in the Midlands case, than for example Treado found to be the case for the Pittsburgh firms. This is explored further below.

In addition to the importance of expertise retained within local universities, in the Midlands it is also the case that a number of private sector automotive firms have chosen to locate, or retain, significant research facilities within the region – for

example Jaguar Land Rover, Tata Motors European Technical Centre, MIRA (including its developing Technology Park) and Ricardo UK all have significant R&D facilities in the Midlands. In addition, there have been a number of more recent investments in public-private research facilities such as the Manufacturing Technology Centre, the High Value Manufacturing Catapult (a technology and innovation centre) and forthcoming developments such as the National Automotive Innovation Campus at Warwick University and the Manufacturing Institute being created by Coventry University in partnership with Unipart Group. Taken together, this is an impressive collection of automotive and engineering-related expertise, or 'innovation assets' as they are often described locally. In the Pittsburgh steel case, Treado noted that a number of trade associations and professional societies were headquartered in the Pittsburgh area. This is not the case for the Midlands. In the UK such bodies tend to be headquartered in London, in some cases with regional offices. This perhaps reflects the greater centralisation of activity - and the economic dominance of London and the South East – in the UK.

Personal networks and market knowledge

As noted above, Christopherson (2009) characterises phoenix industry firms as benefiting from 'initial advantage', including personal networks and market knowledge that have developed over a period of time. Of the firms interviewed in the Midlands case, a number of the owners or founders did have connections and experience rooted in the automotive sector. In some cases they had previously been employed by larger firms in the sector and it is likely that they continued to have contacts in these or successor firms. Their knowledge of market opportunities was also important. There were a number of cases in which a new firm had been established by - or with the support of - people who had previously been employed by larger firms in the sector who had identified a new market opportunity. There was also some evidence of 'forced' start-ups, for example as a result of people being made redundant from the larger firms as they down-sized or went out of business.

Availability of capital

Christopherson (2009) references the availability of capital as a factor that may contribute to the establishment of a phoenix industry. In the Midlands case it is not clear that the availability of capital has in fact been a supporting factor. If anything, a lack of access to capital appears to have been more of a drag on the sector. This is

partly as a result of the on-going effects of the 'credit crunch' but there are also longer-term and sector-specific factors at play. Domestic finance for investment in manufacturing has been a problem for British industry, stretching as far back as the late 19th Century (for example, as described by Miozzo and Walsh, 2006 (p 64-5) who cite work by Elbaum and Lazonick, 1986; Freeman, 1989; Landes, 1969; Hobsbawm 1968).

In addition, access to finance can be a particular problem for automotive sector firms in the UK. The sector has traditionally been seen as high risk by the banks. In addition, there are complicating factors associated with the complexity of supply chains, in particular with regard to finance for tooling, where the asset specificity of tools means that banks are often unwilling to accept the tools as collateral. This is exacerbated when the industry picks up and orders flow down the supply chain, given the long time-lag between the purchase of the tool and the flow of cash from final assembly, combined with the uncertainty over future volumes (The Smith Institute and SMMT, 2012). This issue was recognised in the recently produced government/industry strategy for the sector (HM Government, 2013, p 49-50).

Reputation

Treado (2010) argues that regions such as Pittsburgh, with a strong reputation in a particular industry or set of industries, may find reputation-building easier than other regions. Although globalisation has increased the range of possible locations where production may take place, it has also increased the search costs of finding the right supplier (ibid). The location of a supplier within a well-known cluster can therefore act as a signal that purchasing firms may use to help narrow their search options. There was some evidence of this effect in the case of the Midlands firms interviewed. Several firms mentioned the branding or reputational benefits of being located in the area. One firm also highlighted the importance of the growing reputation of British engineering. The latter is a relatively new phenomenon; British engineering would not have been seen as synonymous with quality of innovation during the period of decline that set in during the 1970s. It would be interesting to establish when, and for what reasons, the turnaround in reputation began to take place.

Other factors – 'presence' in local communities

One other factor that came through in the Midlands interviews was the more general presence of knowledge about the automotive sector in local communities. It was suggested that this might manifest itself, for example, through schools being more likely to arrange visits to automotive sector firms than to firms in other sectors. This could happen because teachers have greater familiarity with automotive than with other sectors. Some teachers may have previously been employed in the automotive sector, and since retrained, for example.

Firm exit and entry

Treado (2010) comments on the sometimes positive effect of the exit of formerly dominant large firms from an area. She cites work by Waluszewski (2004) on the biotech cluster in Uppsala, Sweden and Christopherson and Clark's (2007) study of the optics and imaging cluster in Rochester, New York. In both cases the existing large firms played a role in holding back the development of smaller firms because of their greater ability to secure resources such as skilled labour and access to the research infrastructure. In the Midlands case there is evidence to support that view that smaller firms find it difficult to compete with the larger firms for skilled labour. These larger firms are also typically, however, their customers or potential customers and frequently may also be partners in research projects.

The role of many small and medium sized firms in replacing their large-firm predecessors in old industrial areas was highlighted by Christopherson (2009). The new firms are characterised as typically developing and producing sophisticated components - or prototypes - for products manufactured globally. The term 'enabling industries' is sometimes used to describe such groups of firms, as they develop technologies used in many different industries. A number of the firms interviewed in the Midlands case were involved in the production of sophisticated components, or prototypes, for products manufactured by other firms either locally or on a worldwide basis. They were typically 'suppliers of innovation' to their customers, usually combining a mix of R&D, engineering services and low volume manufacturing capabilities.

In Treado's (2010) work on the Pittsburgh Steel Technology Cluster, member firms were linked by the market that they supply rather than the product they produce. All of the firms sold to the steel industry but rarely did they sell exclusively to that industry. A corresponding pattern was found in the Midlands automotive supplier firms studied. Many of the firms interviewed served industries beyond automotive.

The most often named customer industries were aerospace, defence and motorsport but firms were also involved in supplying industries such as renewable energy and medical technology. The more diversified nature of these firms' markets, particularly when compared to their large-firm predecessors, should mean that the economy of the local area is more resilient to single-industry shocks, and may be seen as a response to previous industry shocks. It also opens up possibilities for further diversification of the region's portfolio of industries, increasing related variety, which is expected to enhance regional growth (Frenken et al., 2007).

Changing economic and labour market conditions

In the West Midlands many of the large automotive sector firms have disappeared over time. The firms that remain and the new firms that have been created - including those that were interviewed in this case study - employ fewer, but generally more highly skilled workers. Around 700,000 manufacturing jobs have disappeared from the region since the 1960s. Employment in other sectors, notably in public and private service industries, has risen. This has had important implications for the region's labour market in terms of the number jobs, the opportunities at different occupational levels, the associated skill requirements and the wage levels that are available to residents.

Bailey et al (2012), for example, found that workers who lost their jobs as a result of the closure of the MG Rover factory at Longbridge in Birmingham in 2005 typically found it difficult to go back into manufacturing employment and the majority suffered significant reductions in earnings, relative to their previous roles at MG Rover. Whereas Treado writes of a mutually beneficial exchange - in which employers have access to many workers and workers have access to many job opportunities - the situation facing former automotive sector workers in the West Midlands over the last decade has been somewhat less balanced in their favour.

6. Conclusion

The story of the automotive sector in the UK Midlands, and the West Midlands in particular, stretches over more than a century. During this period the industry emerged, grew to dominate the region's economy and then began a steady decline which culminated, in 2005, with the loss of all volume production to the region. It is possible that the decline of the industry in the region is now beginning to be reversed.

Over the last three years Jaguar Land Rover (JLR), the region's most significant automotive manufacturer, has expanded production and created approaching 11,000 jobs, with some 6,000 direct jobs in the region and more in the supply chain.

This paper has sought to explore the extent to which the 'low carbon vehicles sector' in the Midlands can be understood as an example of a phoenix industry. The evidence from the interviews suggests that it can in a number of ways. The report has also considered the role that open innovation in the wider automotive industry has played in the development of the sector. Evidence from the interviews suggests that innovation and technological change have certainly been important factors driving the development of this sector. This innovation is being driven by the regulations and standards set at national and international levels concerning, for example vehicle emissions and more efficient use of resources. These regulations and standards are, in turn, driven by growing concern about the environment.

Historic, and relatively immobile, investments in the Midlands related to the automotive industry have been important influences on the location decisions of the firms interviewed. The founders or owners of these firms, in many cases, have links back to 'old automotive industry' firms such as Rover, no longer in existence. In some cases they worked for and were trained by these firms. Firms such as JLR, that have survived the transition from 'old' to the 'new' automotive industry, are also important customers for many of the firms interviewed. The presence of a thriving motorsport sector, which overlaps the region and extends to the south, has also been important.

The depth of skills and experience in the local workforce and in local supplier firms was also an important reason cited by many firms for their choice of location. Evidence from collaboration patterns show that local universities - principally Coventry, Warwick, Loughborough, Oxford and Birmingham/Birmingham City - are also important to these firms. Some 'softer' factors also seem to be important, for example the reputation of the automotive industry in the area and also the more broadly defined 'presence' of knowledge about the automotive sector in local communities. Few of the interviewees mentioned the more recent or planned investments that are now being made in the area. These investments will, however, presumably play a role in the future in continuing to re-enforce the attractiveness of the Midlands as a location for the automotive industry.

Turning to the characteristics of the firms interviewed, they were typically innovators, engaging in R&D and generally employing a relatively high proportion of professional

and technical staff. In many cases they combine the provision of R&D and engineering services and consultancy with a small-scale production capability. They were typically suppliers to larger firm customers, often working with technologies that are applicable across several sectors. Indeed most of the firms interviewed were supplying several markets beyond automotive and some were looking to diversify further. They collaborate with each other, with other similar firms in the sector, with larger firms and with universities. They compete with other similar firms in the sector but not generally with the larger firms whom they supply. They do, however, compete with these larger firms for staff resources.

Innovation and technical change have been important drivers for these firms. The range of technologies now important in the automotive sector has brought opportunities for the entry of new firms. Uncertainty about which technologies will come to dominate, combined with the range of specialism involved has encouraged larger firms to engage with a wider range of potential collaborators. This has meant that there are now more direct interactions between firms at different levels in the supply chain, between large and small firms, and between firms specialised in different technological areas.

It was argued that small firms can often innovate more quickly and more cheaply than the major auto firms, bringing new ideas to the prototype or demonstrator stage. This was seen by some as a particular characteristic of small firms in the UK. On the other hand, making the step up from prototype or demonstrator to full scale production was viewed as an area in which the UK is weak. This is compounded by the uncertainty surrounding the commercialisation possibilities for these new technologies. The necessary investment to bring a new product idea into production is harder to attract because of the associated level of risk. This was also viewed as a problem even for larger firms.

From an industrial policy perspective, the funding for (collaborative) R&D projects has been important for most of the firms interviewed. The funding has enabled more innovation to take place; encouraged greater collaboration; helped large and small firms to identify new potential partners; and helped smaller firms identify potential customers and enter new supply chains. A number of interviewees considered that there was 'enough' support available for early stage R&D. The areas where more intervention is needed, they suggested, was support for moving from the prototype or demonstrator stage to production version and from there onto full commercialisation of the new product idea.

In terms of the more traditional areas for public sector intervention, the ability to recruit suitably skilled staff was an issue for many firms. This was particularly the case in the new technology areas. Several firms stated, however, that it was difficult to predict skills needs in specific areas very far in advance. Access to finance was also identified as a constraint by a number of firms – either investment finance in order to be able to expand the business, or assistance with cash flow in the context of being able to make the up-front investments necessary when taking on new projects.

In terms of the role for industrial policy, greater and more effective collaboration between industry and government has been important to the development of the sector to date. The work of the Automotive Council was seen to have been important by a number of interviewees. This included long-term direction-setting for the industry, through the Council's technology road-mapping work; informing the setting of regulation and standards at national and international levels and the work to support the development of the supply chain in the UK. Funders such as the TSB and the NVN were also praised for their approach in drawing upon industry input in the design and execution of funding programmes. This suggests a positive role for industrial policy in terms of bringing actors together in a discovery process, and in terms of the possibilities of building smart specialisation strategies and industrial policies which are aligned with 'high-road strategies'.⁵

⁵ In fact this is largely how intelligent industrial policy design is conceived of in contemporary debates (see Rodrik, 2004; 2008), with industrial policy ideally having the quality of 'embedded autonomy', whereby it is not captured by firms and sectors, but where, as noted, it focuses on the discovery process, where firms and the state learn about underlying costs and opportunities and engage in strategic coordination.

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Appendix I

Structured interview guide used with firms

Date of interview:	
Location:	
Interviewee:	
Interviewer:	

1. Nature of the firm's business

1.1 What is the firm's name and address (is this the only site)?

1.2 What are the firm's main activities?

1.3 What products and/or services does the firm produce?

1.4 What technologies/processes does the firm use?

Turnover

(Note: If they are an operating unit of a larger firm, gather information relevant to their activities in the local area (the Midlands) if possible.)

1.5 What is the current annual turnover of the firm (please state amount or use size ranges below)?

Turnover size ranges:	Less than £50,000	£50,000 to £99,999	£100,000 to £249,999	£250,000 to £499,999	£500,000 and above
Please mark relevant box:					

Customers

1.6 Does the firm sell direct to the public or to other businesses, or both? Who are the firm's most important business customers?

Suppliers

1.7 Who are the firm's most important suppliers?

2. Ownership and origins of the firm

2.1 What is the current ownership status of the firm (please mark relevant box)?

Sole trader	Limited liability partnership	Subsidiary of UK company	Franchise
Partnership	Limited liability company	Subsidiary of foreign-owned company	Social enterprise

2.2 When was the firm established (what year)?

2.3 What are the origins of the firm?

For example:

- *Was it an existing automotive firm that has diversified or shifted entirely into low carbon technologies, serving the automotive sector and/or other sectors?*
- *Was it a firm previously working outside the automotive sector, that has identified new markets within automotive?*
- *Was it a spin-off from an existing business?*
- *Was it a spin-off from a university?*
- *Was it an entirely new start-up?*

2.4 What is the background of the firm's founders (if not already covered under the previous question)?

For example:

- *Do they come from a previous industry background in the automotive sector or in another related sector? If so, which firms?*
- *Do they come from a previous industry background in a non-automotive related sector (which might be another low carbon sector)? If so, which firms?*
- *Do they come from an academic/research background? If so, in which technical area?*
- *Were they previously Midlands based, or have they relocated to this area?*
- *Were they experienced or new to starting a business, if relevant?*

Location

2.5 Has the firm always been based at the current site, or have they moved (are there multiple sites)?

2.6 What factors were important in the choice of the firm's current location?

For example:

- *Access to customers*
- *Access to suppliers*
- *Access to partner firms/organisations/networks*
- *Access to competitors*
- *Access to research expertise (university/research centre)*
- *Access to testing/trialling facilities*
- *Availability of suitable premises*
- *Availability of skilled labour*
- *Existence of related firms/industries*

- Other reasons?

2.7 Is it likely that the firm will move location in the next, say, three years? If so, why and where would they ideally move to?

3. Nature of the firm's workforce

(Note: If they are an operating unit of a larger firm, gather information relevant to their activities in the local area (the Midlands) if possible.)

Workforce - Size

3.1 How many staff do they employ (please state amount or use size ranges below)?

Staff numbers size ranges:	Less than 5	5 - 19	20 - 49	50 - 249	250 and above
Please mark relevant box:					

Workforce - Occupational groups

3.2 Do they know the occupational and gender make-up of the workforce? If so please give details (numbers or just a rough % split across the workforce):

Occupational groups	Numbers in each group or % split:	Male/Female split? (M/F %)
Managers/Directors <i>(including production and sales managers)</i>		
Science and engineering professionals <i>(e.g. Scientists, Engineers - with a degree or equivalent plus postgraduate qualifications/experience)</i>		
Associate professional and technical <i>(e.g. Laboratory or Engineering Technicians; Sales Executives; Buyers - with a high level vocational qualification)</i>		
Administrative and secretarial <i>(e.g. good standard of general education, plus possibly vocational training)</i>		
Skilled trades <i>(e.g. Sheet Metal Workers; Welders; Vehicle Body Builders; Electricians - with a substantial period of training, often on the job)</i>		
Process, plant and machine operatives <i>(e.g. with the necessary knowledge and experience to operate plant and machinery)</i>		
Elementary occupations (e.g. Labourers) <i>(e.g. with a minimum level of general education)</i>		
Total workforce		

Workforce – Industry/Technical background

3.3 Does the workforce (or significant groups within it) come from a distinct industrial or technical background?

For example:

- *Do they have previous experience in the automotive sector?*
- *Do they have previous experience in another, related, sector?*
- *What technical disciplines do they represent – e.g. Electronics, Materials, Chemistry, Physics, Engineering, etc?*
- *Is their previous training and development largely academic or work-based?*

Workforce – Geographic spread

3.4 Is the workforce drawn predominantly from the local area, or from further afield?

4. The firm's external linkages

4.1 Does the firm have any formal or informal partnering, joint venture arrangements or linkages with other firms or organisations (including universities or research centres)? What benefits does it derive from this relationship/these relationships?

Please provide details, for example:

- *Nature of relationships with large firms?*
- *Nature of relationships with other firms of similar size?*
- *Nature of relationships with small firms?*
- *Any relationships with universities/research centres?*
- *What is the purpose of the collaboration (e.g. on technology/innovation, production, design, marketing, training, finance/funding, information sharing)?*

(Also see question 5.3 on collaboration on innovation)

4.2 Is the firm a member of any industry networks or groupings? What benefits does it derive from this membership/these memberships?

Please provide details, for example:

- *Niche Vehicle Network*
- *Low Carbon Vehicles Partnership*
- *SMMT*
- *Automotive Council UK*
- *Other?*

5. Learning, knowledge transfer and innovation

5.1 How does the firm ensure that it remains up to date with the latest developments in technology, processes, industry standards, etc?

For example:

- Staff training (where? how?)
- Attendance at conferences and seminars
- Linkages with other firms
- Membership of industry bodies and/or networks
- Technical journals/media
- Informal meetings/events/networks
- Other

5.2 What innovation-related activity has the firm undertaken recently (e.g. over the last year or since establishment, if a young firm)?

(Where - Product/service innovations are the introduction of new or significantly improved goods/services in the market; Process innovations are all new or significantly improved methods for the production or supply of goods or services. The innovation, although new to the business, does not need to be new to the industry.)

For example:

Internal

- Internal research and development (internal creative work that increases knowledge for developing new/improved products/services/processes) – How important is this, relative to the other approaches below, in meeting the firm's technology needs?
- Staff training for innovation activities
- Acquisition of machinery, equipment or software for innovation

'Inbound'

- Acquisition of external research and development (external creative work that increases knowledge for developing new/improved products/services/processes)
- Acquisition of external knowledge (purchase or licensing of patents or non-patented inventions, know-how and other types of knowledge from other businesses or organisations)
- If the above 'inbound' approaches are used, are they deployed systematically, or on an opportunistic basis? Do they relate to 'core' or 'non-core' areas of R&D?

'Outbound'

- Has the firm engaged in any 'outbound' innovation activities, such as the sale or licensing of patents or non-patented inventions, know-how and other types of knowledge to other firms/organisations or via spin-outs?
- If so, is this peripheral or central to the firm's activities?

5.3 Has the firm co-operated on innovation activity with any other organisations recently (e.g. over the last year or since establishment, if a young firm)? If so, with which types of organisations, where are they located and how did the collaboration come about? How do they protect their innovations/intellectual property?

For example, with:

- Suppliers
- Customers
- Other businesses in the industry or in a related industry
- Consultants, commercial labs, or private R&D institutes

- *Universities*
- *Government or public research institutes*

6. External influences and the role for public policy

External influences on the firm

6.1 What are the main external influences on the firm?

For example:

- *Legislation/Standards*
- *Customer demand*
- *Changes in technology*
- *Competitors (national/international)*

Public sector funding/support

6.2 Has the firm received any public sector support, including funding?

For example:

- *Grant funding/Collaborative R&D projects (e.g. from EU, TSB, BIS, LEP, former RDA, etc)*
- *Subsidised training*
- *Business advice or other support (e.g. from MAS, Business Link, etc)*
- *Was it a beneficiary of previous interventions – for example those by AWM?*

Development needs

6.3 Does the firm have any development needs, either short or longer-term? If so, in what areas?

For example:

- *Staff training and development*
- *Access to (new) markets*
- *Access to (new) technologies*
- *Access to funding/investment*

6.4 What role should the public sector (EU/National/Local) play in helping to support this firm/the low carbon vehicles sector more widely?

For example:

- *Funding/Support for R&D*
- *Legislation/Standards*
- *Subsidies to build demand for LCVs*
- *Support for development of inter-firm or firm-university linkages*
- *Public sector procurement*
- *Premises*
- *Labour force skills*

- *Management skills*
- *Access to finance*
- *Information provision (e.g. about new technologies; regulation/standards; etc)*

Appendix II

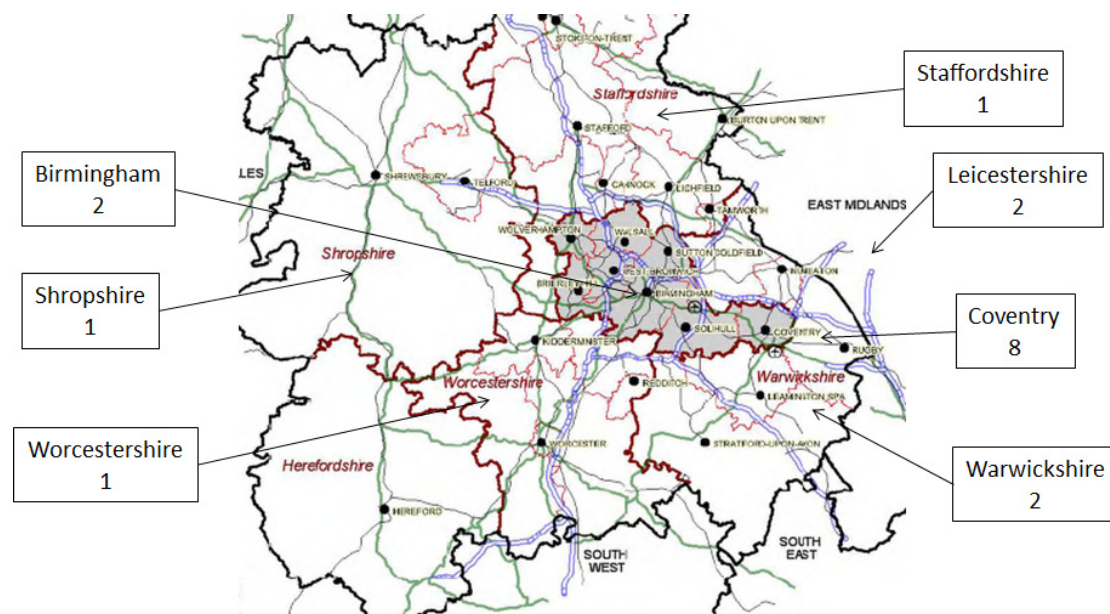
Question by question analysis of results from the structured interviews

1. Nature of the firms' business (Questions 1.1 to 1.7)

Question 1.1: Location

Figure 1, below, illustrates the physical locations of the 17 firms interviewed. More than half of the firms (10) were based in Coventry and Warwickshire. 11 out of the 17 firms operated from a single site. Of the six firms operating from multiple sites, four had overseas operations. Not surprisingly, these tended to be the larger firms.

Figure 1 – Location of the 17 firms interviewed



Questions 1.2, 1.3 and 1.4: Main activities of the firms

The definition of what constituted the 'low carbon vehicles' sector was kept relatively open when identifying firms for interview. The 17 firms interviewed covered quite a wide range of activities, including:

- Vehicle (including specifically low carbon vehicle) design, development, manufacturing, servicing, repair and retail;

- Vehicle (including low carbon vehicle) component design, development and manufacture;
- Engineering services providers (mechanical, electrical and software) including consultancy, test facilities and often with low volume manufacturing capabilities;
- Design, development and manufacture of lightweight structural components;
- Design, development and manufacture of other advanced engineering components (mechanical and electrical); and
- Design and development of fuelling infrastructure products.

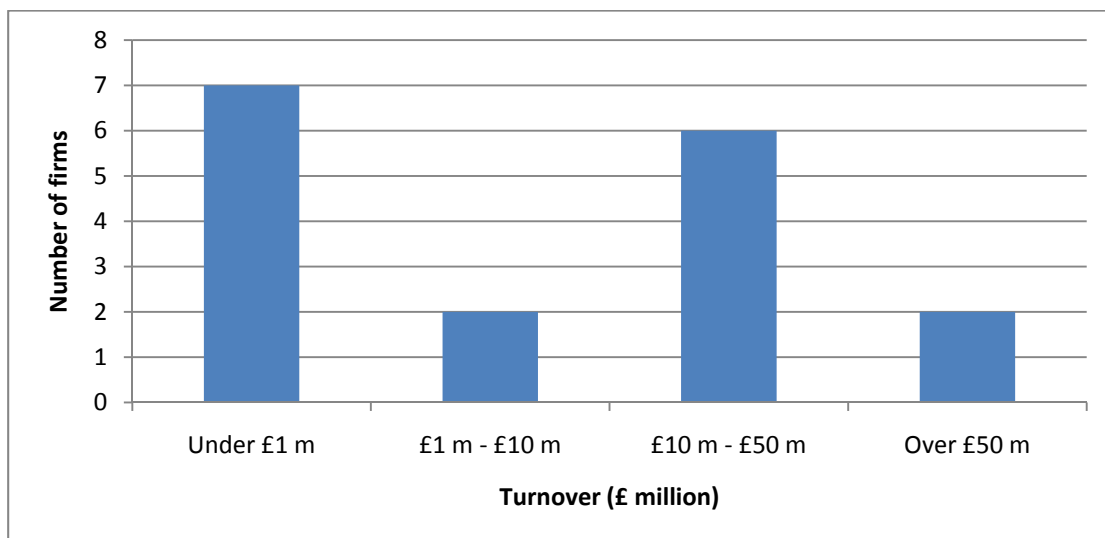
10 of the 17 firms were suppliers to vehicle manufacturers and/or to tier 1 automotive suppliers. Most of these 10 firms were in the 'small', 'medium' or 'large' categories (see the description of size categories under question 1.5, below), with just two of the 'micro' firms supplying vehicle manufacturers or Tier 1 suppliers.

14 of the firms interviewed were engaged in manufacturing activity to some degree, typically in low volumes. Nine of these combined this with the provision of engineering services or consultancy. Again, just two of these nine firms were 'micro' firms.

Question 1.5: Turnover

The firms interviewed can be clustered into 4 main groups by size of turnover (see Figure 2):

Figure 2 – Firm groups by turnover



- 'Micro' - turnover under £1 million (7 firms);
- 'Small' - turnover £1 million to £10 million (2 firms);
- 'Medium' - turnover £10 million to £50 million (6 firms); and
- 'Large' - turnover over £50 million (2 firms)

These categories are referred to at various points throughout the remainder of this analysis, where distinct patterns can be observed by firm size. For a majority of the firms, turnover was on a growing trend or was expected to grow in the future.

Question 1.6: Customers

The majority of the firms interviewed were active in other markets, beyond automotive. The top three other markets served were aerospace, defence and motorsport (see Table 1).

Table 1 – Other markets served, beyond automotive

Market served	Number of firms serving this market
Aerospace	4
Defence	4
Motorsport	4
Rail	3
Renewable energy	3
Energy infrastructure	2
Marine	2
Commercial vehicles	2
Off-Highway vehicles	2
Cycling	2
Medical technology	2
Telematics	1

Some of the firms interviewed were reluctant to identify named customers. Of those that were prepared to speak about their customers, those most frequently named included:

- Jaguar Land Rover (the most named customer);
- Mercedes Benz;
- Aston Martin;
- Bentley;
- Toyota;
- TRW; and
- “major German and Japanese automotive firms”.

Question 1.7: Suppliers

The suppliers used by firms tended to be product or project-specific. Several firms said they preferred to use local suppliers where possible, only using overseas suppliers where necessary - for example where a specialist component was needed or where they were required to use a particular supplier under a ‘directed source’ arrangement with an Original Equipment Manufacturer (OEM) that they were supplying. The ‘micro’ and ‘small’ firms tended to be more reliant on certain specialist suppliers, whether based in the UK or overseas. This may just reflect the fact that they were producing less and hence required fewer supplies than the larger firms.

In the case of those firms who said that they preferred to use local suppliers where possible, the reasons stated included that:

- the firm was only buying in low volumes and needed flexibility/a quick turnaround (as an input to their own product development);
- stability of supply chain; and/or
- trying to buy locally as a ‘policy decision’.

2. Firm ownership and origins (Questions 2.1 to 2.6)

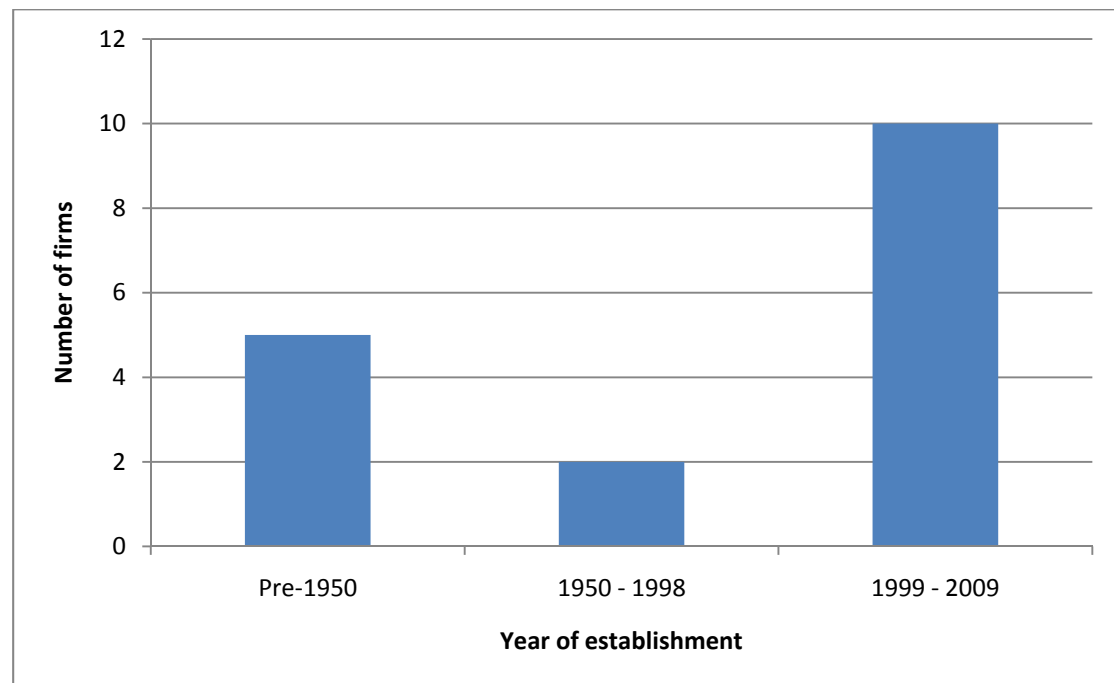
Question 2.1: Ownership status

The majority of the firms (11) were private limited companies, often with ownership still in the hands of those who started the business. Four of the firms were public limited companies.

Question 2.2: Year of establishment

There was a wide range of start dates across the firms interviewed, with the oldest firms established in the nineteenth century and the newest in 2009. The majority of the firms started in the period 1999-2009 (see Figure 3).

Figure 3 – Firm groupings by year of establishment



Questions 2.3 and 2.4: Origins of the firm

In terms of the origins of the firms and/or the firm founders, there were strong links to the automotive sector including to older automotive firms, such as Rover, no longer in existence (although the Rover brand is now owned by Jaguar Land Rover). Overall, nine firms had origins within the automotive sector, of which:

- three firms had origins with a link to Rover;
- two firms had origins in motorsport; and
- four firms had other automotive origins.

The remaining eight firms didn't have origins in the automotive sector, however these include four firms which effectively pre-date - or were formed at the same time as - the emergence of the automotive sector itself. In fact, probably only two of these

eight firms could truly be said to have origins outside, or previously unrelated, to the automotive sector.

Questions 2.5 and 2.6: Reasons for choice of, or remaining at, their current location

The most cited reasons for firms' choice of location and/or why they would remain at that location are shown in Table 2.

Table 2 – Important reasons for choice of location or for staying at current location

Reason for choice of location or for staying at current location	Number of firms who mentioned this reason
Retention of the existing workforce	5
Proximity to the owner/founder's home	5
Proximity to the firm's most important customers	4
Site or premises related factor	4
Presence of specialist skills base in the local workforce	4
Presence of local specialist supplier firms	3
Linkage with a nearby university	3
Branding or marketing benefits of being based in the UK and/or in the local area	2
Centrality of the location, which is good for logistics and ease of access to customers across the UK	1

3. Nature of the firms' workforce (Questions 3.1 to 3.4)

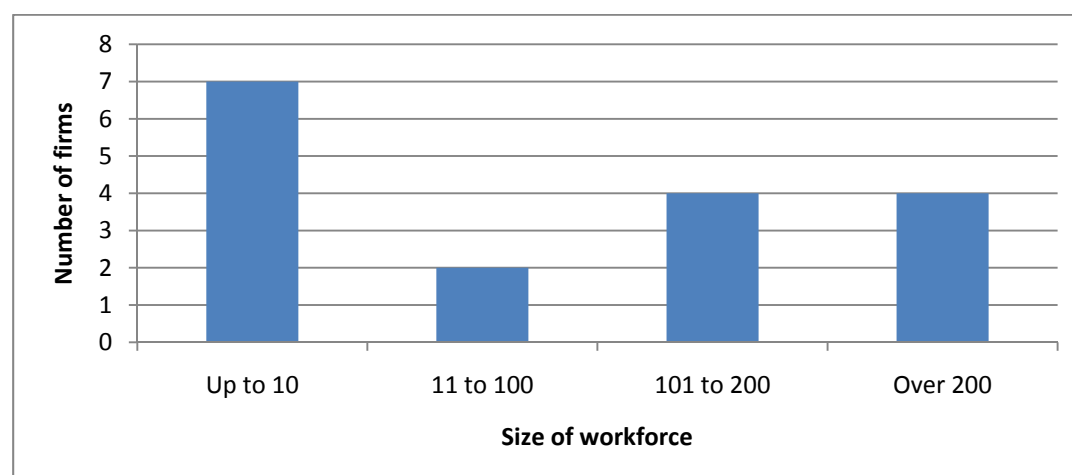
Question 3.1: Size of workforce

In terms of size of workforce, the firms again fall into 4 main groups (see Figure 4):

- 'Micro' - Up to 10 staff (7 firms);
- 'Small' - 11 to 100 staff (2 firms);
- 'Medium' - 101 to 200 staff (4 firms); and
- 'Large' - Over 200 staff (4 firms).

These are almost the same 4 groupings of firms as those that result when they are grouped by turnover, with the exception that two firms fall into the ‘large’ category by workforce size but sit within the ‘medium’ category by turnover. There are some special circumstances that explain these slight anomalies.

Figure 4 – Firm groupings by workforce size



Question 3.2: Workforce breakdown by occupational group and by gender

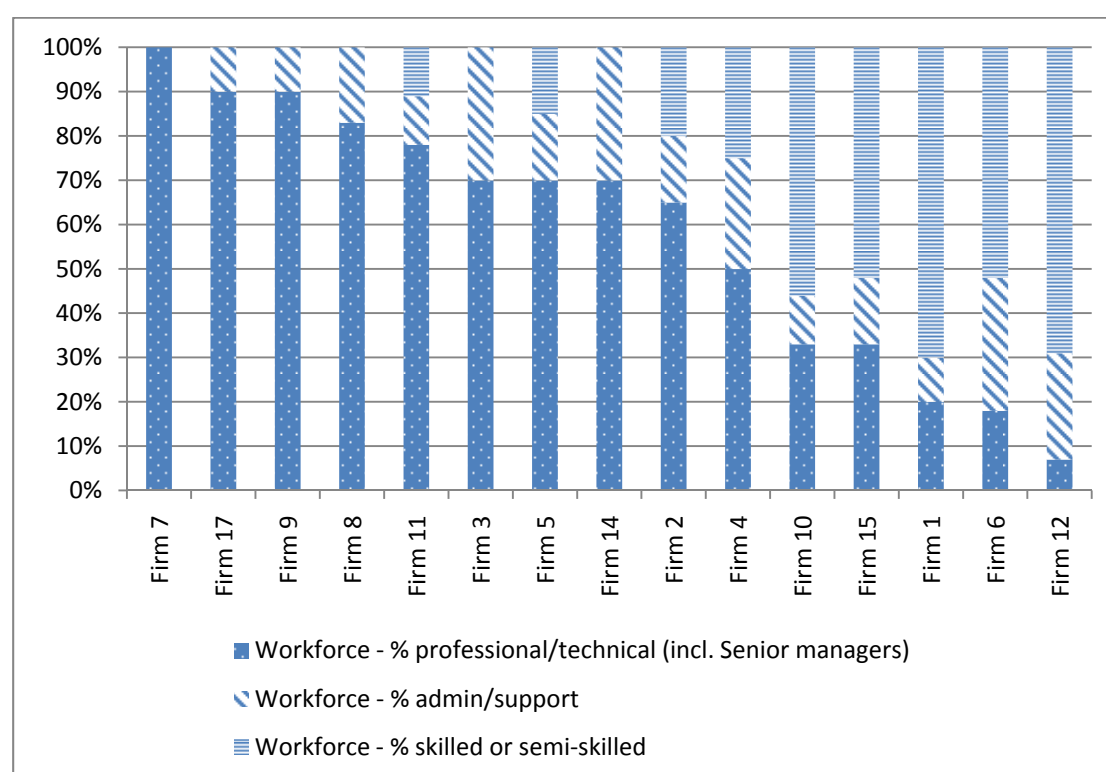
In terms of breakdown by occupational group (see Figure 5):

- the workforces of most firms were dominated by professional and technical staff (with high level vocational qualifications or qualified to degree level or above), who accounted for more than 50% of staff in 10 out of the 15 firms that were able to provide this information;
- the proportion of staff in administrative or support roles was typically between 10% and 30%; and
- the proportion of staff in skilled or semi-skilled roles ranged from 0% to 70%.

The firms with a higher proportion of skilled or semi-skilled staff tended to be those that were involved in more production-oriented activities. More of their business was about actually making things.

To some degree it was the case that ‘micro’ firms tended to have a higher proportion of their workforce in professional or technical roles but the nature of a firm’s activity was a more important determinant of the occupational composition of its workforce.

Figure 5 – Workforce breakdown by occupational group



Looking at the breakdown by gender, in most firms women accounted for less than 20% of the workforce – and for 10% or less in eight of the firms (see Figure 6). In general, female employees tended to be more represented in administrative and support roles. The main exception to this was where the firm undertook work on vehicle interior trim, where women were often employed in these skilled or semi-skilled roles.

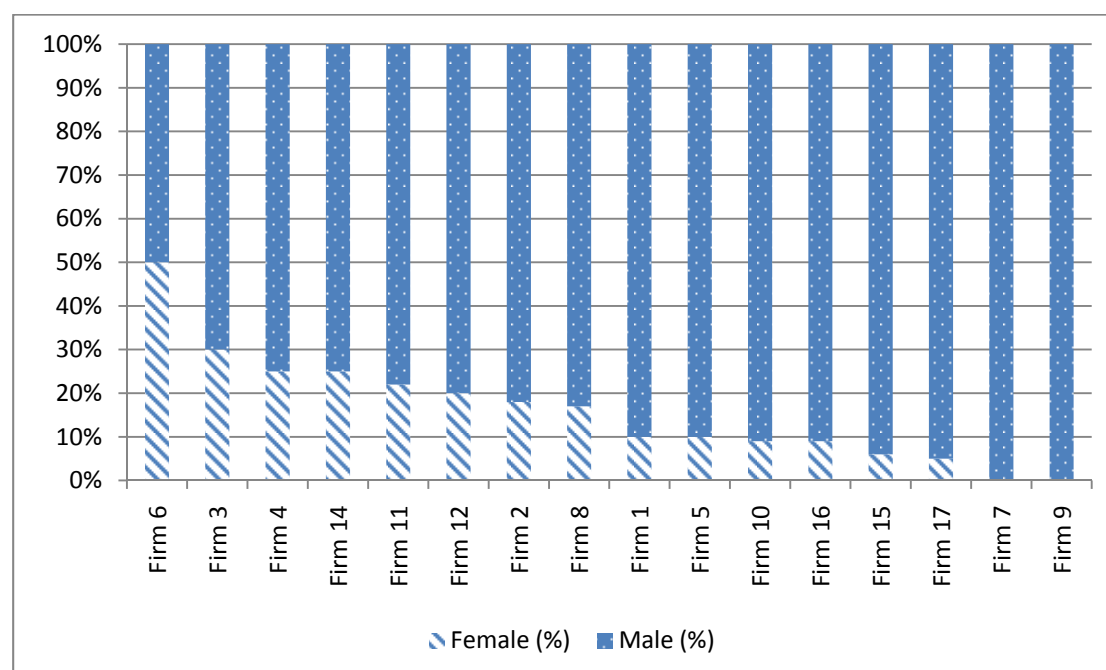
Questions 3.3 and 3.4: Workforce background and commuting patterns

Several of the older firms had traditions of long service. One firm, for example, until relatively recently had an average length of service in its workforce of around 40 years. In terms of the range of backgrounds from which firms' workforces were drawn, automotive was the predominant background but staff also typically came with experience from other sectors. This was more likely, as would be expected, if the firm served markets beyond automotive.

The workforces of most firms tended to commute relatively short distances to work. Longer commutes were generally to be found among the more senior staff. A number of firms employed some staff on a remote-working basis. Some firms also

employed certain staff on a contract/freelance basis, a practice that is common in the motorsport sector.

Figure 6 – Workforce breakdown by gender



4. Firms’ external linkages (Questions 4.1 and 4.2)

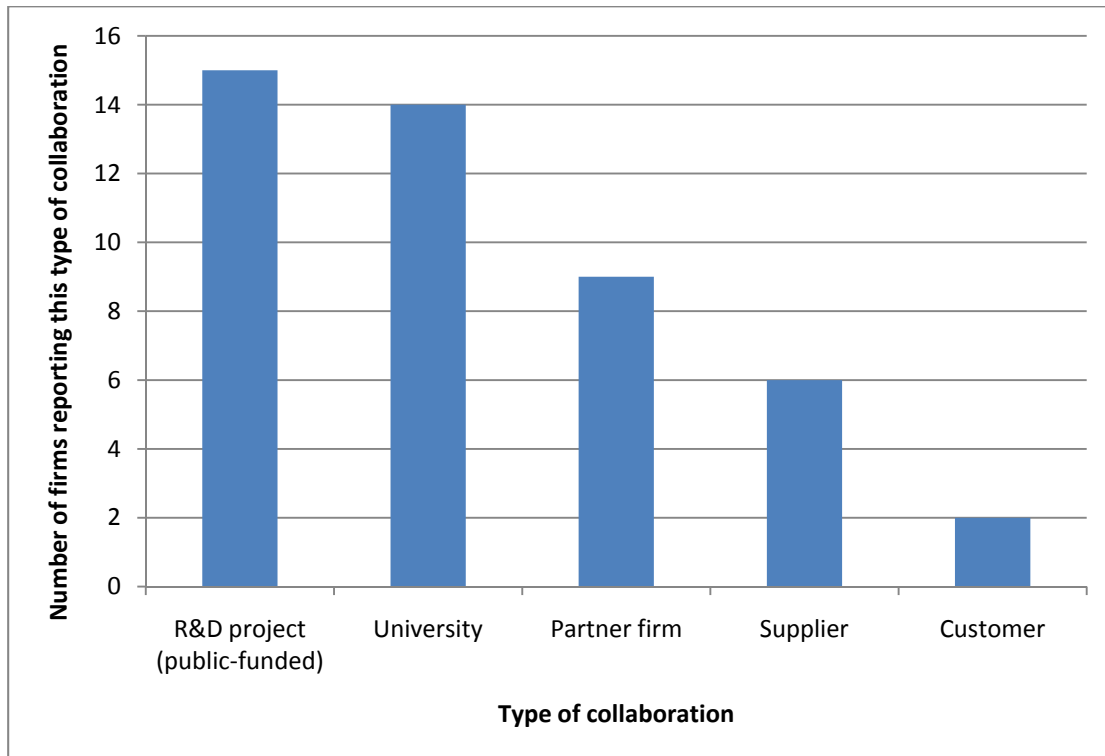
Question 4.1: Formal or informal partnering arrangements and other external linkages

All firms were involved in some form of collaboration, either with other firms or with universities. The most popular forms of collaboration (in terms of the number of firms stating that they were involved in a collaboration of this nature) were (see Figure 7):

- Collaborative R&D projects (publicly-funded) – all but two firms had participated in at least one such project;
- Collaboration with a university – all but three firms had collaborated with a university, with a split between those firms who selected collaborations predominantly on the basis of the technical specialism of the university, wherever it was located (nine firms), and those who principally looked for collaborations with local universities (five firms);
- Collaboration with other partner firms – nine firms were involved in this type of collaboration;

- Collaboration with supplier firms – six firms said they collaborated with one or more of their suppliers; and
- Collaborations with customers – two firms mentioned that they collaborated with their customers (although presumably all firms worked with their customers to some extent).

Figure 7 – Collaborations with other organisations



Firm size did not appear to be an important determinant for any of the types of collaboration listed. The nature of the firm's activity is probably the most important driver – for example if a firm requires a specialist material or component for use in production it is likely to collaborate with the supplier of that material or component.

Table 3 lists those universities that firms said they had collaborated with. This indicates that collaborations were more likely to take place with local universities, although it could be the case that universities such as Coventry, Warwick, Loughborough and Oxford also have a better match of technical specialisms to firms in this sector.

Table 3 – Universities that firms stated they have collaborated with

University	Number of firms mentioning a collaboration with this university	University	Number of firms mentioning a collaboration with this university
Coventry	9	Newcastle	2
Warwick (incl. WMG)	8	Sheffield	2
Loughborough	5	Aston	1
Oxford	5	Brighton	1
Bristol	3	Cambridge	1
Birmingham	2	De Montfort	1
Birmingham City	2	Nottingham	1
Cranfield	2	Nottingham Trent	1
Glamorgan	2	Royal College of Art	1
Imperial	2	Southampton	1
Leeds	2	Wolverhampton	1
Leicester	2	York	1

Question 4.2: Membership of industry bodies or networks

In terms of memberships of industry bodies or networks, all but one firm were involved in one or more industry-related group. The most popular group, by some distance, was the Niche Vehicle Network (NVN) (see Table 4). A number of firms were also involved in other specialist industry bodies. Several firms also participated in networks at EU level. In terms of patterns by firm size, much as would be expected, the smaller firms were more likely to be part of the NVN whilst larger firms were more likely to be involved with the Automotive Council.

Table 4 – Membership of industry bodies or networks: Most often mentioned groups

Industry body or network	Number of firms who said they were members
Niche Vehicle Network ^a	11
Automotive Council ^b	7
SMMT ^c	6
Low Carbon Vehicle Partnership ^d	4
IMechE ^e	4
IET ^f	3
London Hydrogen Partnership ^g	2

Notes to table (based on extracts from each organisation's web site):

- (a) The Niche Vehicle Network is an independent association of over 100 niche vehicle manufacturers, specialist technology companies and supply chain, established in 2005. It promotes the development and application of new technology, by bringing together independent vehicle manufacturers, system suppliers, automotive technology companies and HEIs, to collaborate on the innovative application of technologies in low-volume vehicle production.*
- (b) The Automotive Council UK was established in 2009 and is chaired jointly by the Secretary of State for Business, Innovation and Skills (BIS) and an Industry Chair. Its aims include improving the business environment for the automotive sector in the UK.*
- (c) The Society of Motor Manufacturers and Traders (SMMT) exists to support and promote the interests of the UK automotive industry at home and abroad. Working closely with member companies, SMMT acts as the voice of the motor industry, promoting its position to government, stakeholders and the media.*
- (d) The LowCVP, established in 2003, is a public-private partnership that exists to accelerate a sustainable shift to lower carbon vehicles and fuels and create opportunities for UK business. Nearly 200 organisations are engaged from diverse backgrounds.*
- (e) The Institution of Mechanical Engineers (IMechE) is a professional engineering institution.*
- (f) The Institution of Engineering and Technology (IET) is a professional organisation sharing and advancing knowledge to promote science, engineering and technology. It was formed in March 2006 by a merger of the Institution of Electrical Engineers (IEE) and the Institution of Incorporated Engineers (IIE).*
- (g) The London Hydrogen Partnership was set up in 2002 to develop a network of hydrogen fuel cell (HFC) stakeholders in the capital and help develop HFC technologies in London.*

5. Learning, knowledge transfer and innovation (Questions 5.1 to 5.3)

Question 5.1 Keeping up to date with technology/industry developments

Firms used a number of methods for keeping up to date with technological or industry-related developments. The most often used approaches were through (see Table 5):

- attendance at trade shows/exhibitions/events;
- working with suppliers;
- general market scanning/use of the internet;
- attendance at conferences;
- industry networks/membership bodies; and
- working with partner firms/universities.

Table 5 – Methods used to keep up to date with technology/industry developments

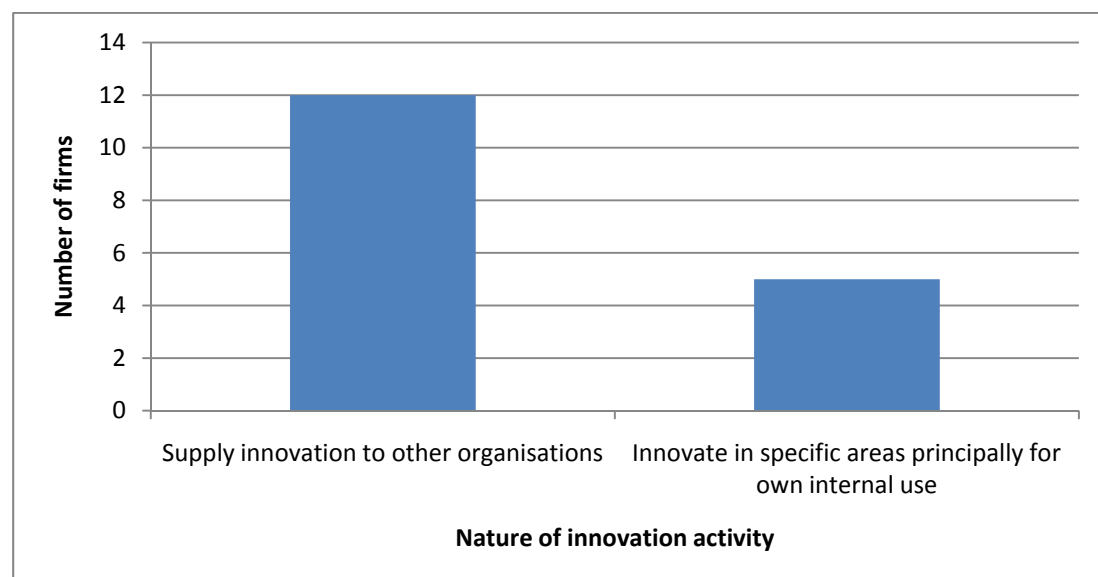
Method	Number of firms who said they used this method
Attendance at trade shows/exhibitions/events	6
Working with suppliers	6
General market scanning/use of the internet	6
Attendance at conferences	5
Through industry networks/membership bodies	4
Working with partner firms/universities	4
Staff responsible for keeping on top of specific areas	3
Participation in collaborative R&D projects	2
Through a partnering arrangement with a named firm	1
Working with customers	1
As an investor in other businesses	1
Attendance at events related to new R&D funding calls	1
Participation in industry working groups	1
Sponsorship of PhD and M.Sc. students	1

The way that firms kept up to date with developments did not appear to be influenced by firm size. It is worth noting that several of the firms interviewed regarded themselves as being at the 'leading edge' in particular technological areas, hence they would typically be presenting papers at, not just attending, conferences.

Questions 5.2 and 5.3: Innovation activity

Firms were asked about the nature of the innovation-related activity in which they engaged. In particular they were asked about the extent to which they undertook internal R&D/innovation or acquired the results of externally undertaken R&D/innovation and whether they were a supplier of the results of R&D/innovation to other firms. All firms undertook in-house R&D/innovation. The majority of firms (12) described themselves as suppliers of the results of R&D/innovation to other firms (see Figure 8).

Figure 8 – Nature of firms' R&D and innovation-related activity



Phrases such as, *“the whole company is set up to do R&D”* ... *“we need to be constantly innovating to attract the attention of customers”* ... *“the whole business is driven by technology”* ... and about R&D as the *“lifeblood of the organisation”* were used. Three firms, in particular, spoke about the drive for them to continually innovate and demonstrate new technology as a way to attract and maintain the

interest of their customer firms and potentially establish themselves in new supply chains. These were all 'micro' or 'small' firms.

The remaining 5 firms engaged in R&D/innovation in specific areas, principally for their own use. Few firms consciously regarded the acquisition of externally undertaken R&D/innovation as particularly important to them, although it must have been of some importance for those firms that were integrating a number of externally produced components or systems into their own products. This was the case for these 5 firms and for a number of the other firms.

In terms of collaboration on innovation-related activity, the most used forms of collaboration tended to be through collaborative R&D projects; with universities; and/or with supplier or partner firms (recall Figure 7).

When asked about the use of patents to protect their intellectual property, there was a roughly even split between firms that had engaged in patenting (10 firms) and those that tended not to register patents or hadn't done so to date (seven firms). Again, firm size did not appear to be associated with any particular pattern in patenting behaviour.

The main reasons given by firms who did not tend to engage in patenting were that:

- the process is too costly/time consuming;
- their competitors were developing similar products/processes so it wasn't worthwhile;
- patents are too costly to defend for a small firm;
- patents are not effective/can't be defended in China; and/or
- the approach isn't appropriate for the firm's business model.

Firms that tended not to use patents typically relied on other forms of protection, for example the fact that competitor firms find it difficult to replicate their processes; and/or that much of their intellectual property is in their software, which is harder to access and copy.

6. External influences and the role for public policy (Questions 6.1 to 6.4)

Question 6.1: Main external influences on firms

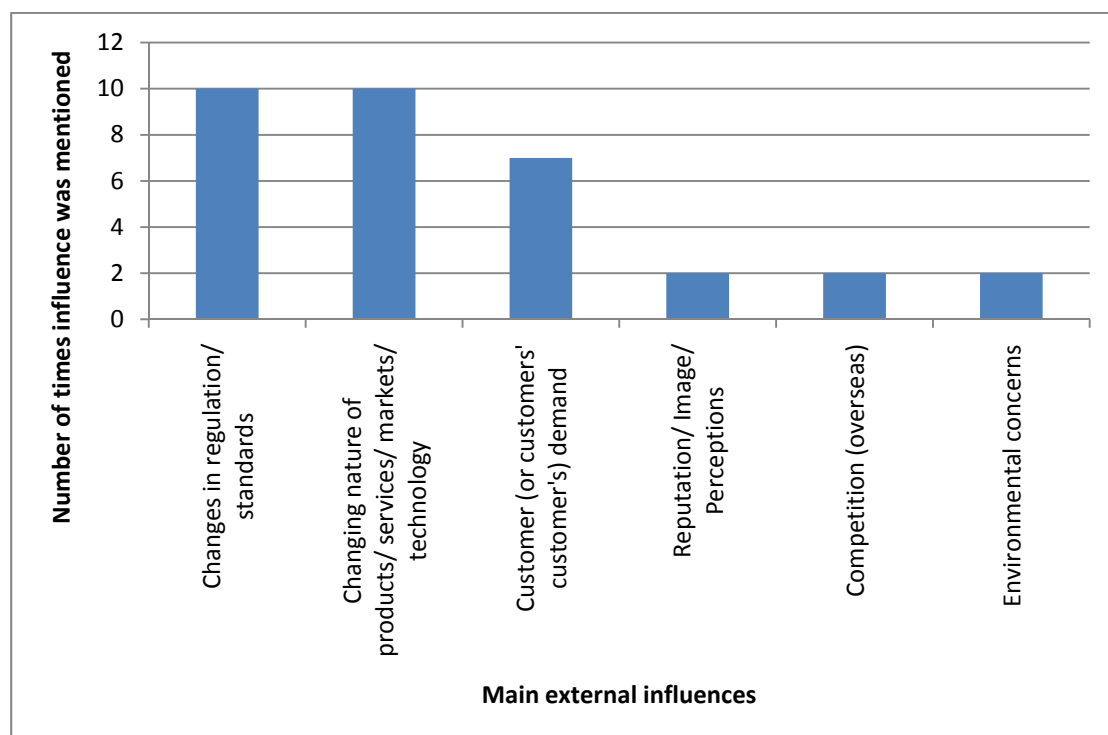
Firms were asked to name the most important external influences affecting their business. The responses have been categorised into 6 main areas:

- Changes in regulation/standards;

- Changing nature of products/services/markets/technology;
- Customer (or their customers' customers) demand;
- Reputation/Image/Perceptions;
- Competition (principally from overseas firms); and
- Environmental concerns.

Figure 9 compares the relative significance of these different areas of influence, based on the number of times they were mentioned⁶. Changes in regulation/standards and the changing nature of products/services/markets/technology were the most mentioned areas of external influence. The nature of the external influences mentioned by firms did not appear to be influenced by firm size. The specific influences that were mentioned under each of the 6 areas are summarised below.

Figure 9 – Main external influences



Changes in regulation/standards

Changes in regulations/standards were mentioned 10 times as an important external influence on a firm's business. Legislation and standards requiring reductions in vehicle CO2 emissions were most often mentioned but reference was also made to

⁶ Note that this is just a measure of how often something was mentioned, not necessarily how important or significant it was.

regulation/standards relating to safety, resource efficiency and air quality. The need to meet different vehicle standards in countries around the world was also mentioned, plus the influence of motor racing vehicle regulations for entry to specific race series.

Changing nature of products/services/markets/technology

An important external influence that related to the changing nature of products, services, markets and/or technologies was mentioned 10 times:

- 'Changing technology' in general was cited as an important influence (three firms);
- The need for the firm to be continually innovating and/or demonstrating new technology in order to maintain the interest of large firm customers (three firms);
- The changing nature of mobility - for example mobility as a service and the associated provision of new services such as mobile internet and/or the creation of new mobility products/markets (two firms); and
- Larger firms lack the necessary in-house expertise in certain specialisms and hence use other firms for support in certain areas (two firms).

Customer (or their customers' customers) demand

Customer (or their customers' customers) demand was mentioned as an important influence seven times:

- Customer (or their customers' customers) requirements (three firms);
- Changes in customer tastes/fashion (two firms);
- The buoyancy of the automotive sector over the last 2-3 years (one firm); and
- Increasing demand from overseas markets for their customers' products (principally China) (one firm).

Reputation/Image/Perceptions

A reputation or image-related factor was mentioned two times as an important external influence:

- The firm's own growing reputation as being at the leading edge in terms of use of materials/production techniques (one firm); and

- The growing international reputation of British engineering (one firm).

Competition

Competition from overseas was mentioned two times as an important external influence:

- The rising cost base for overseas competitors (principally from China), making it harder for them to compete with UK firms (one firm); and
- Competition from firms in Germany and France (one firm).

Environmental concerns

Environmental concerns were mentioned two times as an important external influence:

- The inspiration provided by environmental thinkers on the solutions that could be provided by developing more resource efficient forms of mobility (one firm); and
- Environmental concerns, originally around air quality - now CO₂, leading to public sector intervention through regulation/standards (one firm).

Question 6.2: Public sector support received to date

Firms were asked if they had received any forms of public sector support to date. The responses have been categorised into five main areas:

- Funding/Support for R&D;
- Funding related to local economic development;
- General business support;
- Funding related to knowledge transfer activity; and
- Role in vehicle trials⁷.

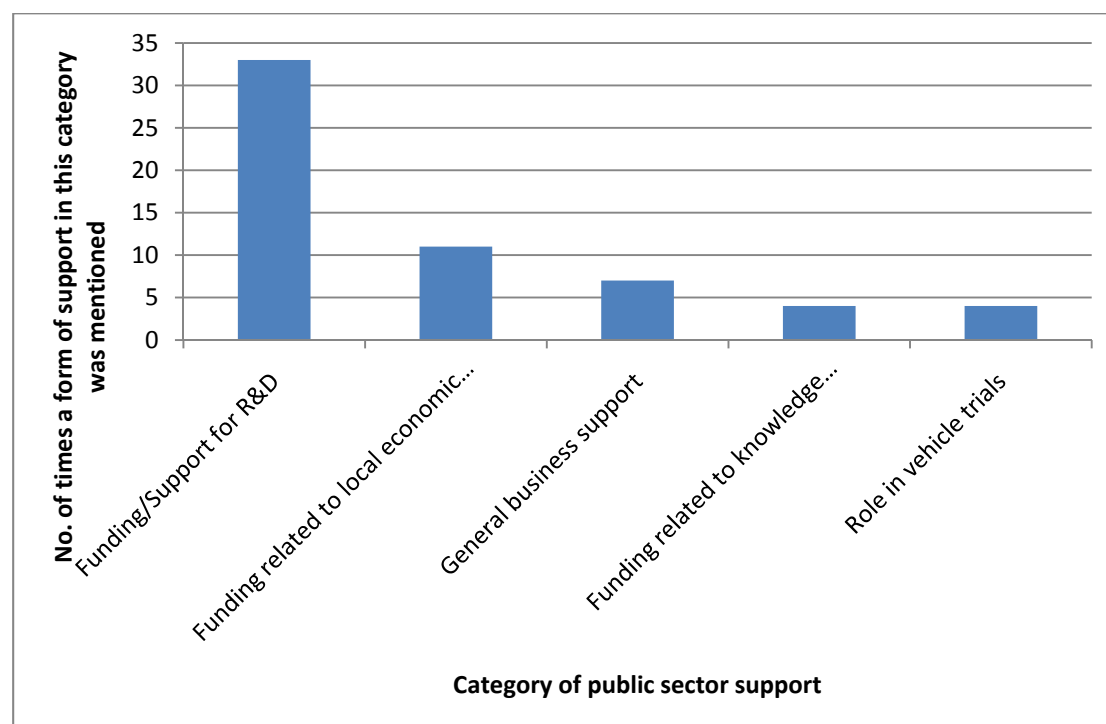
Figure 10 compares the relative significance of these different categories of public sector support, based on the number of times a type of support within each category was mentioned⁸. Funding/Support for R&D was the category from which types of

⁷ Note that a vehicle trial might also have formed part of a grant-funded collaborative R&D project.

⁸ Note that this is just a measure of how often something was mentioned, not necessarily how important or significant it was. For example, in terms of value, the funding available to an individual firm through local economic development interventions such as the 'Growing Places Fund' is far greater than what is available through grant funding for R&D.

support were most often mentioned. In terms of patterns by firm size, not surprisingly firms of all sizes had received funding or support for R&D. 'Micro' firms tended not to be recipients of funding related to local economic development. General business support was mainly used by 'micro' and 'small' firms. The specific types of support that were mentioned under each of the five areas are summarised below.

Figure 10 – Public sector support received to date



Funding/Support for R&D

A type of funding or support for R&D was mentioned 33 times:

- Technology Strategy Board (TSB) funded project (13 firms);
- Niche Vehicle Network (NVN) funded project (seven firms);
- European Union funded project (seven firms);
- R&D tax credits (three firms);
- DTI/Technology Strategy Board SMART/R&D award (two firms); and
- Department for Energy and Climate Change funding (one firm).

Funding related to local economic development

A type of funding related to local economic development activity was mentioned 11 times:

- Regional Growth Fund (five firms);
- Former Regional Development Agency funding⁹ (three firms);
- Growing Places Fund (two firms); and
- Other national grant funding (one firm).

Seven of the firms said they had some engagement with their local authority or Local Enterprise Partnership. None of these were 'micro' firms.

General business support

A type of support that fell within the category of general business support was mentioned seven times:

- United Kingdom Trade and Investment - support with exporting (four firms); and
- Manufacturing Advisory Service (three firms).

Funding related to knowledge transfer activity

Four firms mentioned involvement in some form of funded knowledge transfer activity. Three firms mentioned involvement in Knowledge Transfer Partnership (KTP) or Knowledge Exchange and Enterprise Network (KEEN) projects. One firm mentioned consultancy support from a university provided with the aid of European Regional Development Fund monies. It is likely that the level of involvement in funded knowledge transfer activity is understated as not all those interviewed may have known about – or remembered to mention – their firm's involvement in such activities. Furthermore, they were not specifically prompted to think about this type of activity during the interview.

Role in vehicle trials

Four firms mentioned an involvement in vehicle trials. In some cases it is likely that these trials may also have formed part of an R&D project funded by the Technology Strategy Board or the European Union.

⁹ The former Regional Development Agency, Advantage West Midlands, originally provided funding for the Niche Vehicle Network Programme, a number of the projects subsequently handed on to the TSB, plus funding for MAS, UKTI and the Business Link service – hence it is likely that more firms benefited from former RDA funding than actually stated that they had.

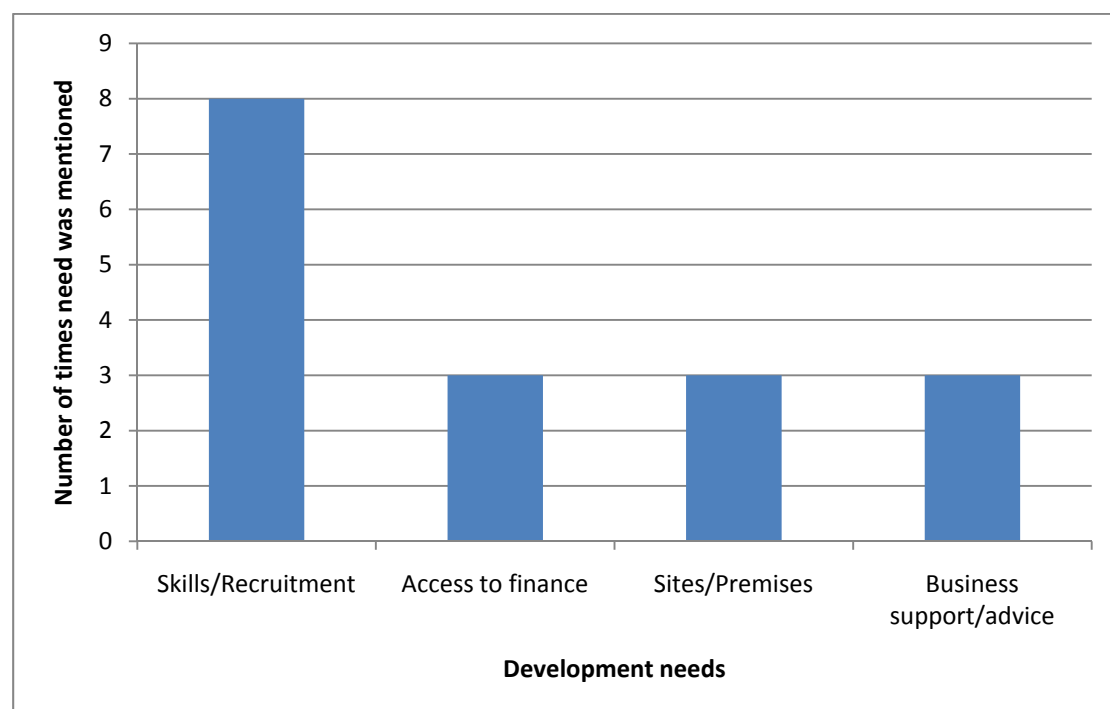
Question 6.3: Development needs

Firms were asked if they had any development needs, either in the short or longer-term. The responses have been categorised into four main areas:

- Skills/Recruitment;
- Access to finance;
- Sites and premises; and
- Business support/advice.

Figure 11 compares the relative significance of these different areas of development need, based on the number of times they were mentioned¹⁰. Skills/Recruitment was the most mentioned area of need. There were no obvious patterns in the needs raised related to firm size, other than that it was only 'micro' and 'small' firms that identified development needs related to business support and advice. The specific needs that were mentioned under each of the four areas are summarised below.

Figure 11 – Development needs



¹⁰ Note that this is just a measure of how often something was mentioned, not necessarily how important or significant it was.

Skills/Recruitment

A development need related to skills or recruitment issues was mentioned eight times:

- Difficulty of attracting suitably qualified and experienced staff - have to recruit internationally (three firms);
- Unable to match what the big firms, such as Jaguar Land Rover, pay to new graduates (although they can offer a different experience) (two firms);
- Need to recruit graduate engineers but there is a barrier as it can be 18 months before the new employee becomes 'productive' - meaning that the recruitment and training is too costly (one firm);
- Skills needs are project dependent, so it is difficult to predict in advance what skills will be required (one firm); and
- The need for specialist staff is driven by projects but the firm can't afford to carry specialist staff on a speculative basis (one firm).

Access to finance

A development need relating to access to finance was mentioned three times. For some firms this was about securing funds for expansion of the business. For others it was principally about cash flow, for example where up front expenditure was required to meet the needs of a particular project.

Sites and premises

A development need relating to sites or premises was mentioned three times. These were all related to firm expansion on or close to their existing site/premises.

Business support/advice

A development need relating to areas of business support and advice was mentioned three times:

- Support to develop business planning and sales and marketing capabilities (one firm);
- Support for sales and marketing, especially internationally (one firm); and
- Support for management development (one firm).

Question 6.4: The role for the public sector

Firms were asked what role they thought the public sector should play with regard to support for their business/for the sector more generally. The responses have been grouped into nine main areas. These nine areas are further broken down into five areas that can be considered as traditional interventions to support business, plus a further four areas that are more strategic in nature:

Traditional intervention areas to support business:

- Funding/Support for R&D;
- Access to finance;
- Skills;
- Exporting; and
- Taxation on business and 'red tape'.

Strategic intervention areas:

- Regulation/Standards (in the context of the automotive sector);
- Public sector procurement;
- Industrial policy/Sector support; and
- Transport policy.

There were no particular patterns across the responses that could be associated with firm size. The specific points that were raised under each of the nine areas are summarised below.

Funding/Support for R&D

- Not surprisingly, most firms thought that funding or other support for R&D was important;
- Some firms preferred the simpler, less bureaucratic, approach adopted under NVN-funded projects, compared to TSB-funded projects – though others noted that you would expect the level of information required to be provided by applicants to rise with the amounts of funding being applied for;
- One firm thought that TSB (and to a lesser extent, EU) funding is too focused on incremental change and too dominated by the incumbent industry – the funding should be used to support more radical change. Conversely, another firm thought that TSB funding is already directed towards too many 'left-field' projects;

- One firm commented that the time-limited nature of grant-funding means there is no natural progression to take the outcome from a project on to the next stage;
- Another firm suggested that there should be greater emphasis at the project application/appraisal stage on the expected project outcomes and subsequent plans for commercialisation of the project outputs;
- One firm said they would like to see a higher intervention rate on R&D funding support – they thought it was currently 60% on TSB projects, which is better than was previously the case;
- One firm thought that interventions such as the development of the Manufacturing Technology Centre and the new ‘proving factories’ were a big step forward in terms of helping firms to ‘productionise’ new ideas and move towards bringing them to market;
- In this latter context, several firms commented on the difficulty of moving from the prototype or demonstrator stage to full scale production – the view was expressed that there was ‘enough’ money available for early stage R&D but little or no support for firms seeking to scale up a new technology to production volumes and bring it to market. This was also seen to be an issue by the larger firms.

Access to finance

- Access to finance from the banks was highlighted by a number of firms as the principal constraint on their development;
- A number of firms commented that investors in the UK are too focused on high returning, short-term investments, contrasting this with the situation in Germany.

Skills

- Several firms noted that the younger generation of workers do not have the same practical skills as older workers;
- Views were mixed about particular skills needs, however, with some firms stating that their specialist skills needs were project-dependent and hence could not be predicted in advance and one firm suggesting a need for more automotive apprentices in specialist areas;
- One firm suggested that a short-term subsidy to offset the initial training costs to the firm would encourage them to hire new graduate engineers.

Exporting

- One firm thought that more and better support was needed for overseas marketing and sales – they felt that they were not competing on a level playing field as they thought that international competitors get better support in this regard.

Taxation on business/'Red tape'

- A couple of firms suggested the need for lower taxation on business and/or specific tax breaks to encourage manufacturing;
- These firms also thought that the amount of 'red tape' could be reduced arguing, for example, that more flexible employment laws would encourage them to hire more staff.

Regulation/Standards (in the context of the automotive sector)

- Two firms argued for the need for CO2 emissions regulation to focus on 'well-to-wheel' as opposed to just vehicle tailpipe emissions;
- One firm argued the need for the overall approach to regulation/standards to be better thought through - for example vehicle safety standards are making vehicles heavier, more complex and less sustainable and hence were in conflict with emissions reduction and resource efficiency objectives;
- One firm argued for more vigorous action on air quality control in cities.

Public sector procurement

- Two firms suggested that public sector procurement, nationally and at local authority level could be better used to prioritise energy efficiency and CO2 emissions reduction, providing a further stimulus to the industry.

Industrial policy/Sector support

- Several firms thought that more could be done to make the most of the existing capabilities of the manufacturing sector in the UK, typically contrasting the UK experience with that in Germany – some firms felt they were not competing on a

level playing field as a result of the wage subsidy in Germany and forms of 'cultural protectionism' there;

- A number of firms were positive about the role of the Automotive Council in bringing industry and government players together to undertake strategic planning for the sector (these comments were made by firms that had had some direct involvement with the Automotive Council, none of them were 'micro' firms) – some thought that the linkages that have been developed between industry, government and academia now provided the UK with a very strong platform from which to take forward further development of the sector;
- Some firms thought that a clearer strategic plan was needed for fuels such as hydrogen and compressed natural gas – though others were sceptical about the prospects for hydrogen fuelled vehicles in the short to medium term, suggesting it should not be an important focus for government;
- Looking backward, one firm was critical of the way that successive governments had allowed the progressive loss to the UK of most of its original equipment manufacturing (OEM) firms over time and the impact of this on supply chain firms;
- Although not an industrial policy or sector-specific issue, one firm commented that the current debates about the UK's continued membership of the EU was creating uncertainty for international firms considering investing in the UK.

Transport policy

- One firm suggested the need for government to adopt a more strategic approach to transport policy, looking across all modes (i.e. not treating investments in road, rail and other modes effectively as separate policy areas).



The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013 under grant agreement n 290647.

Project Information

Welfare, Wealth and Work for Europe

A European research consortium is working on the analytical foundations for a socio-ecological transition

Abstract

Europe needs change. The financial crisis has exposed long neglected deficiencies in the present growth path, most visibly in the areas of unemployment and public debt. At the same time, Europe has to cope with new challenges ranging from globalisation and demographic shifts to new technologies and ecological issues. Under the title of Welfare, Wealth and Work for Europe – WWWforEurope – a European research consortium is laying the analytical foundations for a new development strategy that enables a socio-ecological transition to high levels of employment, social inclusion, gender equity and environmental sustainability. The four year research project within the 7th Framework Programme funded by the European Commission was launched in April 2012. The consortium brings together researchers from 33 scientific institutions in 12 European countries and is coordinated by the Austrian Institute of Economic Research (WIFO). The project coordinator is Karl Aiginger, director of WIFO.

For details on WWWforEurope see: www.foreurope.eu

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