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## **Innovation in the Welsh Automotive Industry: Challenges and Strategies**

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## **Abstract**

This paper seeks to understand the status of and changes in the Welsh automotive industry in the wake of globalization and the consequent structural challenges. Hailed as a budding leader in Europe in terms of auto-component production (where Wales purportedly boasts of supportive institutions, high quality infrastructure and flexible labour conditions), its ambition to maintain or improve innovation and competitive edge in this sector appears to have been seriously thwarted in recent years by developments in the world economy. To date, few studies have attempted to model the automotive sector using a defined regional dynamics. An eclectic framework is warranted and needs to be discussed in detail by integrating aspects of systems of innovation in the light of changes in the world automotive industry and economic conditions which, by and large, permeate to regional dynamics. This paper takes stock of the ongoing structural and organisational 'revolution' in the value-added chain in the automotive industry in Wales and discusses the strengths and weaknesses of the industry from a systemic innovation point of view. Taking a systems of innovation approach which draws on basic concepts of evolutionary theory and innovation systems, we provide a descriptive analysis of the structure and boundaries of sectors for the identification of the factors affecting innovation and competitiveness of the firms, and also for the development of new public policy indications. The building blocks of the analysis consist of the following elements: the influence of regional (national) innovation system elements; technological specificities in the sector and their evolution; and market demand/ competitive conditions.

**Key words:** Wale automotive industry, systems of innovation, automotive supply chain.

**JEL classification:** O14, O33, L1, L52, L62

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## 1. Introduction

The automotive industry is so synonymous with 20th century industrial development, and so intertwined with its twin marvels - mass production and mass consumption - that it has been truly called the 'industry of industries'. The industry has traditionally been in the forefront of news, and if we go back in the recent history, we observe that there have been dramatic structural developments. On the one hand, there is the global re-evaluation of production locations due to significant differences in factor costs; on the other hand, there are unmistakable growth limits in the primary markets.<sup>1</sup> The result has been a free-for-all battle over market share. The automotive industry thus has to bear the double burden of market and production site competition. The battle for markets and clients in the sector has reached an unprecedented ferocity. The consequences are far-reaching structural and regional reorganization along the whole added value chain. For manufacturers, and particularly automobile suppliers, the focus is increasingly on 'stay or leave' decisions with regard to present markets and traditional production locations. The latter in particular is hitting the UK and Wales.

In the course of its history the automotive industry has on several occasions set the paradigms for analyzing industrial organization, including mass production (Ford), and 'lean production' (Toyota). In the last three to four decades, further radical changes have affected the entire value chain, from manufacturers and suppliers to service providers and dealers (Chanaron, 2004; MacNeill and Chanaron, 2005; Womack et al, 1990). The main drivers of these fundamental changes are the combined pressures of cost recovery and intense competition which have driven scale economies, the outsourcing of 'non-core' activities and the gradual inclusion of a range of high value electrical, electronic and communications components where cost recovery is more readily attained. In addition, increasing regulatory pressures and growing consumer awareness – for example on the environmental front - have led to the development of new technological developments such as the search for more efficient power trains as well as a drive for efficient alternative propulsion.

The battle for markets and customers in the sector has reached an all time high leading to far-reaching structural and regional re-organisation along the whole supply-chain of the automotive industry. In contrast with expected 'life cycle' models of industry development, the 'crisis of cost recovery' has intensified over time (Bailey et al., 2008). As a result, large scale production over different models and brands using a platform sharing approach has

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<sup>1</sup> The saturation of the auto industry's primary markets (which basically refer to the triad - US, Europe and Japan) is well established in literature.

been adopted to generate the cash for future model development. Simultaneously, major manufacturers are developing assembly operations in low cost locations such as Central and Eastern Europe, or the southern states of the US. The industry is now confronted with further major and profound challenges (Maxton and Wormald, 2005). The financial crisis has exposed the business model and financial position of most companies as fundamentally weak; profit margins are low and the need for scale efficiency has led to over-investment in production capacity (Bailey et al, 2008) now exacerbated by the global recession. This is true of most of the industrialised nations, but more so in the UK, which in recent years has seen a series of plant closures as well as the failure of the last distinctively British volume car manufacturer, MG-Rover. This definitely hints at a deep structural change and a long term trend which has been widely observed and discussed in industry and academia alike.

Having led the UK industrial revolution<sup>2</sup>, Wales continues to be a major part of the manufacturing landscape in the UK in general and the automotive industry in particular<sup>3</sup>. The automotive sector in Wales, which is the mainstay of its manufacturing, is what has remained (or rather was resurrected) during the lengthy period of restructuring that the region has experienced. Supportive government policy during the post-war years boosted the engineering and other manufacturing firms, giving rise to the thriving automotive cluster that can boast of being the most active sector in the region in recent years. Be it in innovation or encouraging foreign investment, this sector has always been in the forefront.

Innovation is one of the main ways to increase competitiveness and profitability in any industry, and especially in a highly competitive sector such as the automotive industry. The automotive sector is already highly mechanised and is one of the most highly regulated industrial sectors. Given the ongoing structural changes in the industry, which have only deepened due to the recent financial crisis, there is strong market pressure to step up productivity and become even more innovative. The automotive industry in Wales faces both market and production site competition not only from countries in the European Union, but also the newly industrialising countries. So the key questions are: what happens in and to an oligopolistically structured industry when its underlying foundation is being shaken by the emergence of new competitors in the global market? Does the Wales auto industry and its component suppliers have a chance in the long run?

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<sup>2</sup> From the 1780's to the mid-1980's Wales was the main supplier of agricultural and heavy industrial inputs, especially coal and steel (Cooke, 1998).

<sup>3</sup> For instance, between 1983 and 1993, Wales, with 5 per cent of the UK's population and GDP, consistently attracted between 15 per cent and 20 per cent of inward investment in the UK (Cooke, 1995).

Any attempt to understand the dynamics of modern industrial growth and competitiveness requires us to study the evolution of the core of the process, especially the speed at which micro agents are becoming interdependent and increasingly integrated into the broader system. Adopting this strategy in the paper, my objective is to first understand the present state of the Welsh automotive industry, and its evolutionary path over the past decades and second, to examine whether and how this sector can become adept in adjusting to the competitive conditions. The idea is to provide a (synoptic) reflective overview of the state of innovation or rather the system of innovation in Wales' automotive sector. The main strands of the analysis will focus on the boundaries and depths of the automotive sector, drawing out both its strengths and attractions, but also its weaknesses and limitations, so as to provide an incisive and theoretically informed assessment of the industry. By doing so, we should be better able to judge the significance of the industry for regional development, regional innovation and competitiveness.

Building on recent theoretical and empirical research into innovation systems (Lundvall, 1992; Nelson, 1993 etc.) the current paper sets out to assess the expected connection between innovation and firm performance in the automotive industry in Wales. In the innovation system perspective the assumption that "innovation" is key to sustaining economic competitiveness and is directly connected to firms' operational and business performance. The paper is organised as follows. In section 2, the evolutionary characteristics of the Welsh automotive industry are discussed and recent trends analyzed. In section 3, the systems of innovation approach is used to describe the model for innovation and growth in the Welsh automotive sector. The strengths and weaknesses of the sector's innovation system are then elaborated using a re-christened version of systems of innovation. Section 4 is a discussion of prospects and strategies for overcoming the challenges faced by the Welsh automotive sector. It concludes with some policy implications for overcoming the challenges.

## **2. The Wales automotive industry: whither the trend?**

### **2.1 Significance of the Automotive industry in the UK and Wales**

The competitiveness of the automotive sector depends on the sector's flexibility, the responsiveness of its innovation ecosystem to emerging opportunities and its adaptability to new challenges. The acceleration in Wales' manufacturing economic performance was triggered by a positive attitudinal shift in the government approach to business. It is true that

the global landscape of automotive manufacturing is rather unfavourable to the old and mature industrial economies like the UK, but it is also driven by incremental innovations which could give a comparative advantage to firms in the mature industries. The strength of the automotive industry lies in promoting innovation and strengthening it qualitatively by concentrating on the high-value added segments. Therefore, a strongly performing locally grounded (indigenously controlled) manufacturing sector is critical to improving regional growth prospects for Wales, and hence reducing the persistent GDP per capita gap between Wales and the UK.

The automobile industry in the UK, as in many other nations, has a coveted place in its manufacturing sector due to its potential to propel national economic growth and foster the development of technological capabilities through its powerful backward and forward linkages, and the localization of high value added manufacturing processes (Humphrey, 2000). The industry is still one of the largest in the UK, employing about 800,000 people in vehicle manufacturing and related automotive activities. For instance, in 2007 there were more than 3000 businesses, a total manufacturing workforce of 180,000 and overall GVA in excess of €11,000m (BERR, 2009). A further 552,000 people were recorded as employed in related trades such as retailing and fuel. The sector generates revenue of nearly £50 billion contributing to 3 percent of the GDP. In terms of international trade, the automotive industry, including engines, generates £25 billion – accounting for some 10% of UK exports. The automobile and parts sector was the fourth largest contributor to R&D in the UK top 850 companies and the top global 1,400 companies in 2007.

The automotive industry continues to be an important part of the UK economy. The industry trends of globalization and consolidation are well illustrated by the UK experience where the open nature of the economy has enabled and encouraged these trends more than in other European countries. Government policies, and flexible labour laws, have encouraged inward investment by Toyota, Nissan, Honda and BMW. The UK has also become a major engine producer with investments by Ford (Wales, Dagenham), Toyota (NW England) and BMW (West Midlands). Although overseas ownership makes the UK industry vulnerable to global decisions on cost cutting and the re-location of production, given the innovative capacity there are a number of advantages. It has brought major investment and the innovative capacity of UK engineering is still strong. There have been new investments in the UK automotive sector in recent years, mostly in the engine segment. From an investment of £1300 million in 2002, the investments in the sector increased to £1400 million in 2006. In addition, the UK has a major concentration of high value automotive design and engineering businesses. It is also the centre of the world Formula 1 industry with most of the major teams

being located in 'Motor Sport Valley' (Pinch and Hendry, 1999). The UK motorsport sector is believed to account for some 80 per cent of the global motorsport market (NAIGT, 2007). The UK motorsport industry has an estimated annual turnover of £4.6 billion and directly employs 38,000 people, of whom 25,000 are engineering and technical staff.

Having been a cradle of the industrial revolution of UK, Wales continues to be a major part of the manufacturing landscape of the UK in general. The Principality of Wales is on the western side of central southern Great Britain and covers an area of about 20,779 km<sup>2</sup>. It is bordered by England to the east and by sea in all other directions. The region has around 3 million inhabitants, two-thirds of whom live in south Wales, mainly in and around the cities of Cardiff, Swansea and Newport and surrounding areas, with another significant population in the north-east around Wrexham, which is also a major industrial area.

Over the last two centuries, Wales has been transformed from a predominantly agricultural country to an industrial, and now a post-industrial economy. From the middle of the 19th century until the post-war era, the mining and export of coal was a dominant industry. From the mid 1970s, the Welsh economy faced massive restructuring with large numbers of jobs in traditional heavy industry disappearing and being replaced eventually by new ones in light industry and in services. In the late 1970s and early 1980s, Wales was successful in attracting an above average share of foreign direct investment in the UK. However, much of the new industry was essentially of a "branch plant" type.

Significant restructuring in recent years has reduced the number of people working in manufacturing but manufacturing still accounts for a large proportion (27 per cent) of the region's GVA, even greater than the UK average (ONS, 2010). Approximately 1.18 million people work in the region – of whom 161,500 are engaged in manufacturing (Statwales, 2009).<sup>4</sup> Total Gross Value Added (GVA) in Wales in 2009 was £44.5 billion, 74.3 per cent of the UK average. Table 1 presents a description of some structural characteristics of the Wales economy and particularly of the manufacturing sector.

Wales currently has one of the lowest workforce employment rates, and a relatively low per capita income (Table 1). This has led to regional policies focused on promoting inward investment in high-tech sectors, strengthening the skills base and encouraging innovation

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<sup>4</sup><http://www.statswales.wales.gov.uk/TableViewer/document.aspx?ReportId=10579#peopleworkemployment>



and enterprise (Cooke et al., 1995; Cooke, 2004).<sup>5</sup> In Wales, inward investment has been most significant, attracted by an intensive regional support regime, which has contributed to a shift in the industrial sector from a traditional concentration in metals manufacturing and processing and other heavy industries towards electronics and white goods production (Cooke et al., 1995; Cooke, 2004). Although the effectiveness of this policy strategy has been questioned (see, for example, Fuller and Phelps, 2006) it is clear that inward investment has been a major factor in reshaping the Welsh manufacturing sector over recent years. Manufacturing inward investment to the region has been concentrated in two main sectors (electronic and electrical engineering and automotive components) although there have also been large-scale investments in other transport sectors (e.g. aeronautical engineering).

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<sup>5</sup> Wales is one of the 'devolved' territories of the UK with considerable discretion over most aspects of social and economic policy.

**Table 1: Structural characteristics of Wales and UK**

	<b>Wales</b>	<b>United Kingdom</b>
<b>A. Land Area and Population</b>		
Land area (1000*km <sup>2</sup> )	20.78	1,728
Population (x million, 2007)	3	60.9
Population density (per km <sup>2</sup> , 2007)	142	246
<b>B. Labour Market and Per Capita income</b>		
Working age employment rate (% , 2010)	67.1	70.6
Unemployment rate (% , 2010)	8.1	7.9
GDP Per capita income (£, 2008)	15,237	20,520
<b>C. GVA, Manufacturing Share, Employment</b>		
Agriculture (% of GVA, 2007)	0.5	0.8
Industry (% of GVA, 2007)	27.1	21.4
Services (% of GVA, 2007)	72.4	77.8
GVA in manufacturing (£ million at basic prices, 2007)	7,841	154,881
GVA in auto industry (SIC 2007 Division : 29) (£ million, 2008)	*	38,886
Total Employment Costs (£ million, 2008)	479	5,699
<b>D. Expenditure on R&amp;D (2008, in £ million)</b>		
Businesses	244	15,631
Government	45	2,290
Higher education institutions	254	6,519
Total	543	24,440
<b>E. Allocation of EU Structural Funds (Objective 1, 2 and 3; £ million at 2004 prices)</b>		
2000	219	1500
2001	214	1751
2002	209	1631
2003	203	1608
2004	200	1585
2005	211	1575
2006	209	1526

\* - Not available

**Sources:** National Statistics, <http://www.statistics.gov.uk>.

The automotive sector in Wales, which is the mainstay of its manufacturing, is what has remained (or rather was resurrected) during the lengthy period of restructuring that the region has experienced. The industry in Wales has been subjected to several changes during the past decades. These processes are manifested in several waves of plant closures, relocation (to lower cost locations) and downsizing in the automotive and

supporting sectors. While the Welsh Assembly Government (WAG) has encouraged and mapped out a stimulus plan to re-vitalize the growth of the automotive sector, the recent global meltdown and the growing number of low-cost destinations among emerging economies is creating additional challenges to faster growth. It is therefore necessary to examine the evolutionary trend of the industry and examine the extent to which these factors contributed, at least partially, to the recent trend of laggard growth.<sup>6</sup>

## **2.2 Wales' Automotive industry: Imperfect past and volatile present**

### **(i) Early years (1780 till Mid-1980)**

Wales' centrality in the industrial and economic development of the UK recently came into prominence once again, due to the heavy foreign investment and leadership in cutting-edge technology in manufacturing. But from the 1780s until the mid-1980s, Wales' share in overall (manufacturing) income in UK was limited to heavy industrial inputs, especially steel and coal while agricultural supply predominated in overall income generation. In the 20<sup>th</sup> century Wales experienced a lengthy period of restructuring from the early post-war years until the effective ending of major coal production following the defeat of the miners in the 1984-85 strike. From 1985 until now, in about a quarter century of development, Wales once again took a significant lead in manufacturing production in UK and led the race among other regions in terms of attracting foreign direct investment.

The lengthy restructuring of Wales's economy during the post-war years stood it in good stead. During this time government policy encouraged the relocation of engineering and other manufacturing firms to South and North Wales. This encouraged the establishment of companies, such as Ford, Ferodo, GEC, Hoover, Hotpoint, Borg-Warner etc., many of which underlined the importance of American investment in a UK economy. But between 1945 and 75, there was no obvious pattern to the incoming foreign investments except for the fact that they were classical branch-plants. The scenario changed however, after the establishment of the Welsh Development Agency (WDA) in 1976, which for the first time took a leading role in promoting strategic economic development. Although an economic plan did not come about until 1992, the WDA nevertheless tacitly developed and followed a sectoral strategy to intensify the level of investment, both domestic and foreign, in automotive and electronic

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<sup>6</sup> Munday et al (2000) raised concerns about the stability of foreign companies producing standardized products at the mature phases of life cycles. With ongoing globalization, opening up of new markets and greater mobility of capital and resources, low cost assembly work has already been shifted to countries with a greater competitive advantage in terms of production cost.

engineering. Given that the period of intense job loss in the heavy industries was in the 1980s, the strategy of promoting investment paid off really well during the period.

## **(ii) Recent developments (1985 to date)**

Between 1983 and 1993, Wales consistently attracted between 15 per cent and 20 per cent inward investment in the UK (Cooke, 1995). Much of this investment in engineering industries came from Japanese, American and European (especially German) firms. Ford opened its new high range engine plant at Bridgend, South Wales in 1978 and this was followed by acquisitions or new, greenfield investments by several companies viz., Calsonic, Valeo, Robert Bosch, Trico, Gillet, etc. In 1992, Toyota began production of 200,000 engines a year to supply to their assembly plant in Derby to export back to Japan. With the Ford engine plant producing 500,000 Zeta engines as well as Jaguar's new AJ26 V8 engine, Wales became one of the key centres of high quality, high-skilled automotive engine components production in Europe. These prestigious and indigenously developed supplier companies started to build a customer base that included all the UK and major European manufacturers in the automotive industry.

By early 2000, there were over 250 automotive companies in Wales – around 40 of the top 100 global leaders - woven into a diverse established supply chain. In addition the sector manufactured a high proportion of the engines made by both Ford and Toyota in Europe. The experience in engine manufacture placed Wales in a leading position in the production of drive train technology globally. Companies like TRW, Visteon, Meritor and Magna have been competing with global leaders since 1995 and have a customer base that spans the whole of the UK and major European manufacturers in the sector (Rhys, 2002). These firms have much deeper supply-chain links with UK-based, domestic and foreign-owned assemblers such as Rover, Ford, Toyota, Honda, GM and Peugeot, and more recently with Tata (who took over Land Rover and Jaguar). Welsh suppliers have over sixty direct supply contracts with these firms and some 130 indirect supply contracts (i.e., through another firms in the supply chain). However, it has also been noted (see Rhys, 2002), that per capita gross value added is about 7 per cent less than the UK average and capital expenditure is lower by 20 per cent. Thus, although it is increasingly capital intensive, the industry lags in productivity.

The burgeoning growth trajectory of the Welsh manufacturing sector in general and the automotive supply chain in particular has declined significantly in the more recent period. In contrast to the growth trajectory between 1991 and 1998 most of the large and medium

sized firms have reduced their workforce.<sup>7</sup> Official statistics at UK level show large firms (>250 employees) accounted for 228,000 of the UK's 348,000 manufacturing job losses between 1998 and 2001. This was approximately two-thirds and the trend in Wales was no different (Office of National Statistics, 2003). Wales slipped from fourth to sixth in the regional manufacturing employment share in approximately one year. Wales was now closer to the profile of the 'post-industrial' regions like the South East and South West in its modest share of manufacturing employment rather than to manufacturing regions such as the Midlands where the trajectory was positive up to 1998 (Cooke, 2002). The speed of the change, and the manner in which inward investment firms and the linked remnants of the Welsh steel heritage contracted, impacted heavily on the innovation potential of the region and its engineering industries including the automotive sector.

## **2.3 Current economic and structural trends in the industry**

### **2.3.1 Regional and industrial policy guiding Wales' automotive industry**

The regional institutions in Wales and their policies have clearly had a big impact on the auto industry. At the European level, the industry is affected by three major types of policy. The first is the macroeconomics of free trade inside and outside the EU. The second involves common standards (regulation) on emissions (EURO IV, EURO V late 2009 and EURO VI, 2014) and safety (EURO NCAP tests) which are compulsory in all member states. Another important area is re-cycling and the End of Life Vehicle (ELV) Directive which came into force at the beginning of 2007. This requires member states to legislate to increase re-use, recycling and other forms of recovery of ELVs and components.

At UK national level policies have been, for the most part, non-interventionist and concentrated on improving the business environment (Bailey and Driffield, 2007). For example, labour laws have remained 'flexible' in order to attract and retain inward investment. Thus, while the indigenous companies have declined, new overseas investments, either through FDI or acquisition, foreign owned transnational firms have maintained 'an automotive industry in the UK' (as opposed to a UK automotive industry). The non-interventionist approach has been shelved for the present with the Automotive Assistance Package (AAP) and the promise of support to Vauxhall (Opel) and the introduction of a scrappage scheme in common with other member states. In manufacturing national policy has shifted away from sector-specific support to general support for all manufacturing sectors (i.e. from vertical to horizontal industrial policy measures). The same

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<sup>7</sup> The cascade effect is said to have been started by Corus, the Anglo-Dutch joint venture that absorbed British Steel which cut a significant employment (Cooke, 2002).

change is apparent in respect of skills and training with the creation of the National Skills Academy for Manufacturing which has superseded the former more specialized Automotive Academy.

Research funding has, however, remained largely sector-based although there is support for research in horizontal or 'platform' technologies. Much of the automotive specific effort has been directed through the Foresight Vehicle Programme which has sought to fund collaboration amongst companies and research organizations in order to address forecasts for 'future vehicle capabilities' as outlined on a technology road map. Reduction of life cycle emissions (LCE) has been a major policy imperative. One example is the CENEX initiative to promote UK market development and competitiveness in low carbon and fuel cell technologies for transport applications. CENEX, which was established with support from the Department for Business, Enterprise and Regulatory Reform (BERR) seeks to stimulate market transformation and networking amongst providers and end users including the Low Carbon Vehicle Procurement Programme and the Low Carbon and Fuel Cell Technology Knowledge Transfer Network.

Much of this has been prompted by recognition of the environmental challenge. The King (2008) report, for example, concludes that considerable reductions in CO<sub>2</sub> emissions (up to 30%) could be achieved in the short term by enhancements to conventional vehicle systems whereas in the medium term advances in hybrid and battery technologies could bring a 50 per cent reduction in CO<sub>2</sub> emissions per kilometer by 2030. A second report, that will guide future UK policy, is the Automotive Industry Growth Team Report (BERR, 2009). This report makes a number of recommendations to improve the business environment, to stimulate further inward investment, to improve the market conditions for low carbon vehicles, to coordinate R&D efforts and to set up small scale demonstrator fleets as well as to continue the policy of improving supply chain efficiency.

At the regional level, policy is implemented by the Welsh Assembly Government through the Department of Economy and Transport. WAG's strategy is aligned with the national strategy to support low carbon vehicles and intelligent traffic systems. Since its inception in its various programmes, WAG has developed an action and implementation plan to map the actions for the development and delivery of businesses across Wales. The Entrepreneurship Action Plan in 2000 was a Welsh Development Agency milestone and the subsequent policy documents of WAG viz., WAVE (Wales: A Vibrant Economy) and more recently WAG's Economic Renewal Plan, promote manufacturing productivity as a key objective. In addition, policy has supported technology development through funding to local universities and

building technological capability by promoting centres of excellence in the region in order to facilitate synergies between the private and public sector.

### **2.3.2 Automotive demography: key characteristics**

In this section, we provide an overview of the existing aggregate indicators to provide a picture of the current growth of this industry and its position in the UK automotive sector. Given the paucity of consistent data for indicators such as R&D, entry-exit characteristics, and innovation structure (product or process innovation) for the Welsh automotive industry we present only the broad sectoral trends in the industry, comparing it with the UK trend, wherever possible.

The automotive sector is vital for Wales' economy. It accounts for over one fifth of its manufacturing turnover and it is critical in bringing FDI into the region. Automotive manufacturing is one of the largest sectors in Wales, generating over £3 billion annually. The 250 companies in the automotive sector in Wales, employ over 20,000 people. Wales is home to a few big vehicle manufacturers (Ford, Toyota) and a number of world class supplier firms. The sector manufactures a high proportion of the engines made by both Ford and Toyota in Europe. Major global companies such as Bosch, Toyota, TRB, TRW, Visteon and more recently SPX Contech have their manufacturing footprint in Wales. There have been some recent investments by Connaught, Takao Europe Manufacturing Limited and Stevens Vehicles in the automotive sector. The established base of tier 1 and 2 automotive suppliers together with the wide range of test facilities is proving crucial to niche vehicle companies choosing to locate in Wales.

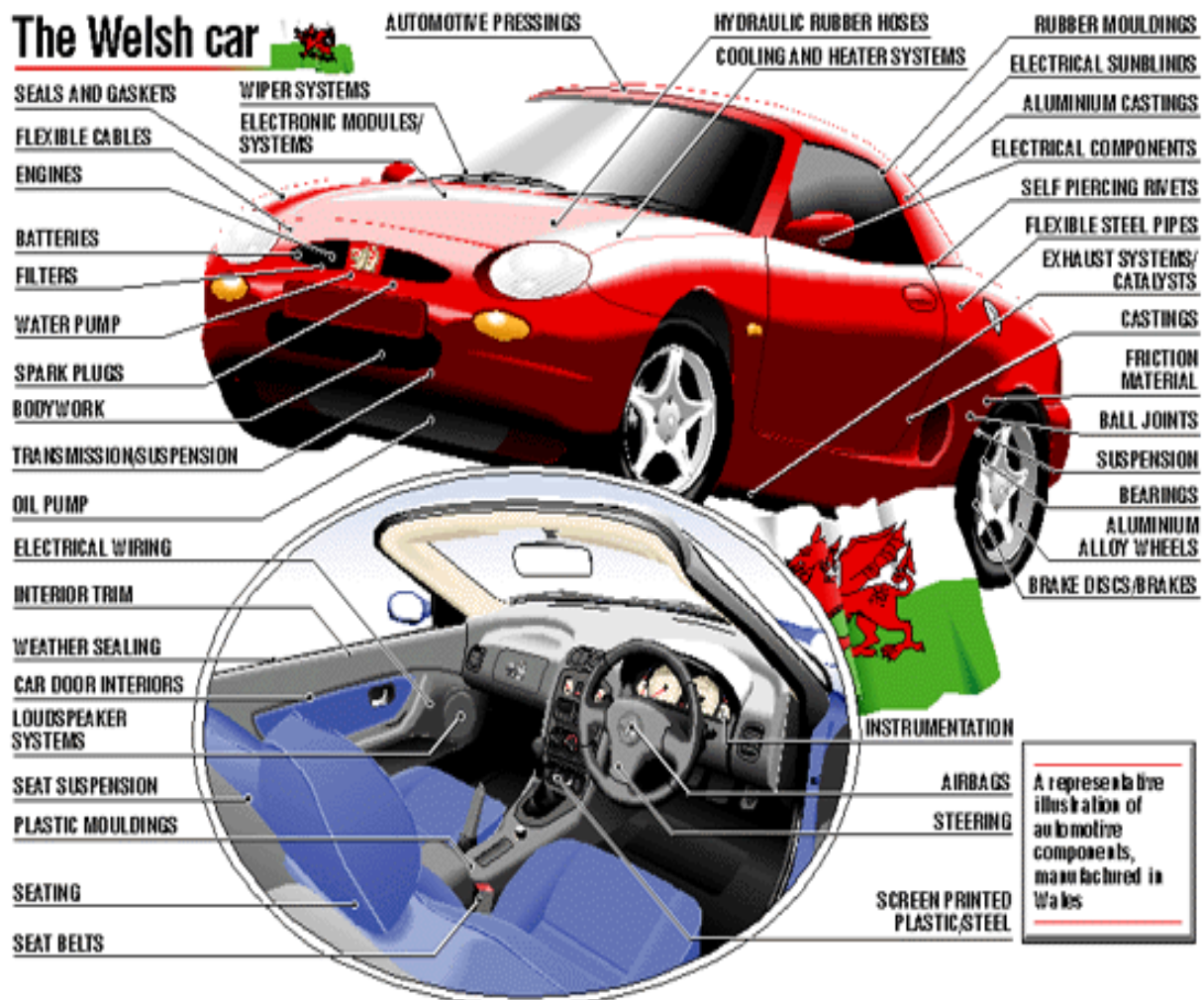
The Wales automotive industry is quite diverse in terms of its product range (Chart 1 provides a picture of the diversity in the industry's product range). The industry possesses some technology-intensive and innovative electro-mechanical components and system manufacturers, viz., Mollertech, Bosch, Schaeffler, TRW, Visteon, Tata.<sup>8</sup> These are additional to firms like Ford and Toyota which produce core technology products such as engines.

Wales has several mechanisms for stimulating innovation and rapid company incubation as well as an extensive network of business support with a high degree of regional penetration. The automotive sector is supported by several Centres of Excellence in research and innovation in power electronics, electric motors, energy storage systems and combustion expertise. For instance, the University of Glamorgan's Fuel Cell Technology Centre

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<sup>8</sup> Electro-mechanical includes brake, steering, ignition and engine management systems etc.

(developing vehicles of the future utilizing hybrids of fuel cells, batteries, ultra capacitors and advanced internal combustion engines in various configurations), Swansea University's electronic systems design group (worked with Toyota to further develop hybrid vehicle technology), Cardiff University's Centre of Research in Energy, Waste and the Environment (working with Ricardo to research GDI engine fuel injection) are some of the major Centres of Excellence in automotive research in Wales.



Source: [www.autoline.org](http://www.autoline.org)

In spite of having some well-established centres of excellence, the industry has been mainly composed of relatively low value, low technology generic and bulky non-mechanical component manufacturers.<sup>9</sup> This resonates with the status of manufacturing in the region. Generally, the manufacturing sector in Wales is set against the background of low levels of new firm creation (Keeble and Walker, 1994), combined with factors likely to hinder enterprise growth including low levels of capital availability, high levels of external control,

<sup>9</sup> Generic components include fasteners and stampings, and bulky non-mechanical components include glass, forgings, castings, seats etc.



and a poorly diversified industry and occupational structure. The current skill structure also continues to show a poor occupational mix - low-skilled occupations are over-represented whilst professional, scientific and technical workers are under-represented (IMI, 2009).

The IMI report notes that skilled trade occupations, including technical skills, are relatively important and also says that the industry shows the volume of managers and customer service and sales staff is high compared to other occupations. Thus the industry is still characterized by low-skilled workers which partly corroborates the conclusion that there is a legacy problem inherited from the heavy industries. The recent recession does not appear to have affected the occupational mix.

Wales is the second most successful UK region in securing automotive foreign direct investment (Ernst and Young, 2006). In fact, the economic restructuring of manufacturing in Wales can be said to have been propelled by the FDI driven growth initiative pursued by the Welsh Government. The automotive sector in particular has been mostly FDI led, so multinationals have a key role in the sector's competitiveness. Unfortunately, there is not much evidence to prove that these foreign firms are contributing to innovation in the industry. On the contrary, there is increasing evidence that although many of these foreign firms are global leaders in their own right, the types of activities they are undertaking in Wales are mostly assembly operations rather than innovative. The situation has worsened in recent years due to the relocation of some of the large automotive OEMs and the financial crisis. This has resulted in a lack of 'critical mass'.

#### **2.4 Upshot of the structural and economic trends in Wales' automotive industry**

The automotive sector is beset with low levels of new firm creation in the region, together with the presence of other weakening factors, viz., a poorly diversified industry and occupational structure, low levels of capital availability, and high levels of external control. In general, the firms have more ability to adapt and redesign products than to really push the technology frontier. Instances of technological upgrading are conspicuously few in number except for take pockets of excellence such as the European Technical Centre of Calsonic Llanelli Radiators.

This could be linked to the branch-plant syndrome and low R&D profits of inward investment. This has been confirmed by studies which show that the initial operations of the multinational firms were merely assembling rather than generating technological capability in the region

(Munday et al, 2000). Several micro-level studies have shown that many of the firms have low decision making discretion with respect to investment in plant and equipment as well as sales and marketing of products, though they have considerable decision making power over the output levels and work force expansion or contraction.

Thus, even though several years have passed since devolution, the state of innovation in Wales has remained largely hierarchical and dependent on public policy.<sup>10</sup> The manufacturing sector in general and the automotive industry in particular is no exception. In fact, the industry has been heavily shaped by the strategic goals of the public sector agencies (such as WAG which absorbed the erstwhile WDA). Though some of the goals and objectives of the regional government are also shared by industry, the innovation system in Wales has a structure resembling a pyramid, with a large proportion of innovation under-achievers dominating the manufacturing activity at the bottom while the top comes to a point with a very small number of 'star' players. The automotive sector in particular has been mostly FDI led, so multinationals have a key role in the sector's competitiveness. Unfortunately, there is not much evidence to prove that these foreign firms are contributing to the innovation in the industry. On the contrary there is increasing evidence that although many of these foreign firms are global leaders in their own right, the activities they are undertaking in Wales are mostly assembly operations rather than developing innovative products or processes. The situation has worsened lately due to the relocation of some of the large automotive OEMs as well as the more recent financial crisis.

All these may be symptomatic of a weakening '*system of innovation*' in the Wales automotive sector. In fact, since the 'emerging' system of innovation was focussed around the engineering sectors and these sectors were particularly hard hit (when the large firms contracted), it started to have a cascade effect on the automotive supply chain. With the withdrawal of some large players or thinning of their businesses in Wales, the sector started losing the 'regional 'interlocutors' who were the kingpins of its strength and performance. This also led to the breakdown of the embryonic relationships between universities, government and business which were just starting to take off, thus resulting in a hollowing out of the automotive manufacturing base in Wales.<sup>11</sup> In order to tease out the systemic

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<sup>10</sup> Although the current policies are not WDA-animanted as they were in the nineties, there is still heavy public intervention.

<sup>11</sup> The closing down or thinning of businesses also meant suspension of research grants to universities and/ or closing down of the regional R&D laboratories (e.g., Corus shut down its 200-person materials research laboratory in 2001). This led to the dying out of the links that connected the main pillars of the innovation ecosystem (businesses, government and universities).

dimensions of the problem, we look in the following section at the strengths and weaknesses of the Wales automotive industry using a systems of innovation approach.

### **3. Assessing Wales' automotive innovation performance through a 'systemic innovation system' lens**

#### **3.1 Motivating innovation trends**

It is often held that innovation occurs in a supportive environment. It has become almost a cliché to argue that the innovation by firms can only be understood fully by examining them in relation to the system in which they are embedded. Assuming that a firm's innovation is characterized within a system implies that learning, adaptive and absorptive capabilities of the firm are localized. This is because innovation involves the transformation of an idea into a marketable product or service, a new or improved manufacturing or distribution process, or even a new method of providing a social service. This transformation involves an adaptive network of institutions that encompass a variety of informal and formal rules and procedures — an *innovation ecosystem* — that shapes how individuals and corporate entities create knowledge and collaborate successfully to bring new products and services to market.

Innovation processes, like any process, evolve over time and are influenced by many factors during the course of their evolution. Because of the complex nature of the process requiring several complementary dimensions of technology, knowledge, skills, and uncertainty about the outcome and success of the outcomes vis-à-vis the costs incurred, firms almost never innovate in isolation. Rather they interact with each other and with other organisations to gain, develop or exchange knowledge, information and other resources. In fact, a firm, being an integral part of the broad system, cannot function as an island entirely on its own. Rather its activities (including technological activities) are likely to involve other firms or organisations operating in the same system. The behaviour of firms is as much affected (constrained or furthered) by other firms and institutions as it influences them, thus enforcing a two way process of interaction.<sup>12</sup> Following from this simple notion, innovation is therefore widely perceived to result from a coalescence of inputs and ideas from a multitude of sources within and outside firms. These sources which serve other firms (suppliers, customers, and competitors) and institutions (universities, research institutes, financial institutions, government regulators etc) fortify their innovative activities.

Put differently, it can be assumed that 'innovations in firms are both the cause and the consequence of interactions.' This implies that we cannot regard a firm as an individual

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<sup>12</sup> The institutions, as used here can be laws, social rules, cultural norms, and technical standards etc.

decision-making unit isolated from the rest of the system. We must consider all the important factors shaping and influencing innovations to deliver a comprehensive understanding or explanation of the process.

This notion of innovation as a systemic process, based on a series of networked interactions and institutional learning, stems from the writings of authors such as Lundvall (1992), Nelson (1993), and Nelson and Rosenberg (1993). Innovation systems could be characterized at national (Lundvall, 1992) level and regional level (Cooke, 1992), and even sectoral level (Carlsson and Stankiewicz, 1995; Breschi and Malerba, 1997).<sup>13</sup> Subsequent writings have defined the concept more closely (see Cooke, 1998). The theoretical roots of this systemic notion lie in 'interactive learning theories' and 'evolutionary theories' (Edquist, 1997). According to this perspective of innovation, interaction among firms and specificities concerning the patterns of interaction constitute the breeding ground for the creation, application and diffusion of knowledge. The interactions, often sustained rather than arms-length, lead to synergetic creation of knowledge, and learning which is so crucial for innovation.

Indeed, the very essence of the systems of innovation approach is its emphasis on the importance of innovating firms working together with other firms and with a range of other organisations. Here, the firm is seen as working within a context composed of a broader scientific and technological community, influenced by relationships with suppliers, customers, regulators and research and training organisations. This is the systemic perspective.

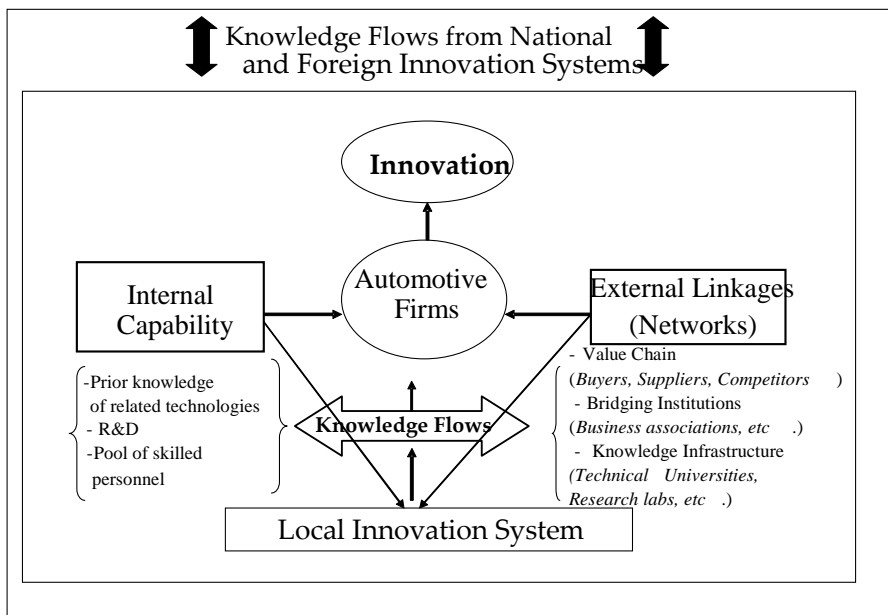
Chart 2 is a graphical illustration of innovation dynamics from a systemic viewpoint. Observe that every firm operates in an environment which is partly given by the economic and physical infrastructure of the industry, influenced by government policies. The major actors which influence the firm are the firms in its value chain (customers/ suppliers), the government, educational institutions, research bodies and the industry associations. The environment of the firm can be thought of as an immediate or primary environment and a remote or distant one. The major actors which influence the firm in its primary environment can be thought as firms or organisations having day-to-day interactions through the value

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<sup>13</sup> Systemic notions are commonly found in the literature. Some of the important concepts include industrial networks (Hakansson, 1989); production complexes (Scott and Storper, 1992), value chains (Porter, 1990), industry clusters (Porter, 1990), development blocks (Dahmen, 1989); industrial systems (Saxenian, 1994), innovation systems (Lundvall, 1992; Nelson, 1993) etc.

chain.<sup>14</sup> The firm - together with these other actors - can be said to form a local system of innovation. Also note that the macro environment is given by the existing physical, socio-economic and technological infrastructure available in the region or country. Moreover, there are also feedbacks from other systems of innovations.<sup>15</sup>

**Chart 2: A Modified Framework for Wales Automotive Industry**



**Source:** Adapted from Parhi (2006)

### 3.2 The innovation system in the automotive industry

In the automotive industry, production is dominated by the vehicle makers, or Original Equipment Manufacturers (OEMs), with the top 10 of these accounting for about 75 per cent of total output. These OEMs form the core of a matrix of upstream supply and downstream distribution and sales, controlling in consequence the industry's innovation model which for the most part is 'top down' – i.e. hierarchical - and proprietary with closed interfaces and few open areas where independents can easily plug in (Jürgens, Blöcker and MacNeill, 2008). Given that the industry is mature and is dominated by large companies, the sector is not at the cutting edge in terms of the knowledge economy and technology (Cooke et al., 2005). On the contrary, innovation in the industry is mostly incremental and process oriented. Given the socio-economic maturity of the market, companies are generally risk averse. Firms also

<sup>14</sup> Others, while still important in furthering or constraining innovation, may be hard to quantify in practice.

<sup>15</sup> Trade or knowledge exchanges across regions/countries may be understood to contribute to these dynamics.

face the so-called 'QCD' (quality cost delivery) challenge as they need to extract maximum returns from production under the 'lean model' (Womack, et al 1990) of continuous improvement, squeezing resources and cost cutting. As a result, the industry has tended to be conservative in its approach. Nevertheless the need for cost recovery has driven a great deal of technological change such as the inclusion of electronic control devices which have made vehicles more fuel efficient, safer and more reliable. At the same time, the rise in oil prices, concern about global warming and, more recently, the financial crisis have all led governments and consumers to seek fuel economies and vehicles with lower emissions and higher levels of environmental sustainability, thereby presenting major challenges to the industry.<sup>16</sup>

Innovation systems related to the automotive industry can be divided between those closely connected to company headquarters where new knowledge is produced and innovation is developed, and those in 'branch plant' countries or regions that are primarily users, rather than producers, of knowledge and therefore innovation followers (MacNeill and Bailey, 2009). In the latter, the innovation system is geared to incremental process improvement with networks aimed at cost reduction. New, radical, change is controlled by gatekeepers outside the region or the country in question. Relationships between the players tend to be old fashioned and adversarial and based on asymmetries of power and knowledge (Taylor, 1995). Innovation systems tend to be reactive and reflect a production system being for the most part closed, proprietary and dominated by a small number of large transnational companies. In contrast, more proactive innovation systems are characterized by high levels of trust and reciprocity. Cooke (1998) distinguishes three types of innovation system: 'dirigiste', where external control is exerted by industries or governance organizations, those that are 'networked' amongst different levels of governance and funding sources, and those that function from the 'bottom up' or 'grassroots' level. Given the nature of divisions in the automotive sector described above, we may expect to see the differences between innovation systems reinforced with the more radical developments taking place in those areas where the major firms have their headquarters and only incremental developments occurring in the follower regions.

The changes described above not only affect the vehicle paradigms, they also open markets to new players with particular expertise in these new technologies. Two examples (amongst

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<sup>16</sup> A number of technological routes to emissions reduction are currently being explored by the OEMs (large and small), major suppliers and R&D organizations. The different possibilities are explored in the UK Report on Low Carbon Vehicles (King, 2008), which distinguishes between short and long term changes to both fuels and vehicle technologies.

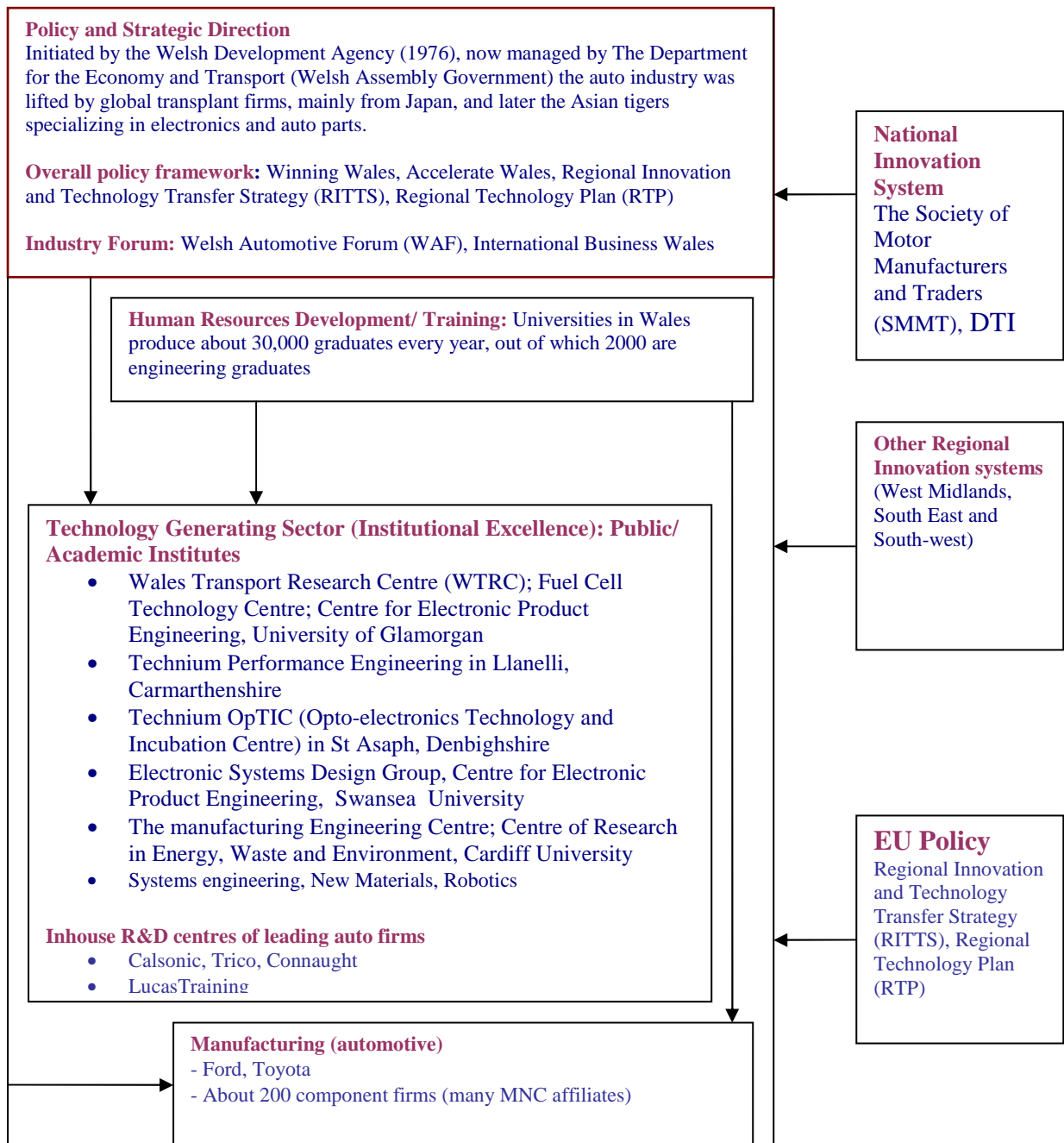
many) are Tesla Motors of Silicon Valley, California and the US-Indian electric car manufacturer Reva whose G-Wiz electric car is marketed in Europe, the USA and Japan. The former has signed an agreement with Lotus for manufacturing in the UK and recently Daimler purchased a 10 per cent stake in the company in order to integrate Tesla's Li-ion battery technology into the electric SMART that has a drive developed, manufactured and fitted by the UK firm Zytec. These examples show how new players can develop innovations but may need to collaborate or network with established assemblers to bring them to the wider loop of the market. Such collaborations might also change the territorial organization of the industry. The new players, as shown in the example may well be located outside 'traditional' areas, but they need to be allied to the 'knowledge network' of the major players and link to their networks of upstream supply and downstream logistics and marketing. In these kinds of situation, knowledge networks may extend over long distances.

As the industry changes to deal with the political and economic constraints of the 'post-crisis' period, there is a challenge for policy to be geared to the transition. In a later work Cooke (2005) distinguishes between what he terms the 'industrial paradigm' of policy based upon sectors (or clusters), closed innovation, closed sources and disciplinary science and a new 'knowledge-based paradigm' of networks, open sources and inter-disciplinary science. Policy in the former circumstances has tended to be geared towards support for efficiency savings through business support mechanisms such as subsidized management consultancy or training. Such policy measures have often followed the expressed 'needs' of the major OEMs and suppliers in their quest to reduce costs. These companies have been adept at playing countries, regions and plants against each other within their own 'internal bidding' procedures (Bailey and Cowling, 2006).

### **3.3 Characterizing Wales' automotive innovation system**

In the following, we provide a detailed mapping out of the system of innovation in the automotive sector in Wales and identify the principal elements in the system. A system consists of (i) institutions (ii) actors, relationships and networks, and (iii) knowledge, technological domain, and boundaries. The following scheme (Chart 3) maps out the system of innovation in the automotive industry in Wales. From the discussion above, one can identify four essential elements to the system. Broadly, they are: policy and strategic direction, human resource development or the supply of technical skills, technology generating sectors and the manufacturing sector.

**Chart 3: Systemic elements of Wales' automotive industry**





As has been mentioned in the previous discussion, the automotive industry has been a favoured candidate of the policy makers in Wales receiving strong support from the regional government. But in recent years it has not prevented the withdrawal of large firms from the region and a consequent lack of 'critical mass'. The elements of the automotive industry in Wales as identified in Chart 3 and the accompanying discussion of the essential facts about the state of Wales' automotive industry (section 2.3) shows several weaknesses in the system of innovation. As might be expected for a region with significant level of overseas ownership in the automotive sector, strategic decision making is quite limited as far as the industry in Wales is concerned. Most of the decision making is carried out elsewhere, generally limited to the headquarters of these companies. Thus high level technical knowledge inputs to the larger businesses come from outside the region. Even those companies most embedded in the region, such as the top tier suppliers TRW, have transferred much of their advanced R&D work to Germany in order to be closer to major OEMs and the centre of gravity of automotive technologies. It is therefore clear that the region has missed a generation of investment in many modern technologies. As a result, local knowledge networks are mostly concerned with manufacturing and with incremental innovation. The innovation system therefore fits Cooke's dirigiste model dominated by outside interests combined with little in the way of unique or 'sticky' knowledge (Malmberg and Maskell, 1997).

However, for the knowledge intensive business and niche sector (such as power train technology), the knowledge balance is rather different. Here the Wales region is clearly a producer of knowledge since the companies are either knowledge producers per se or are able to control their own knowledge flows by virtue of local ownership. Amongst these niche and specialist companies, one significant group is the 'Niche Vehicle Network'. For instance, Narrow Car Company, Abercynon is developing the Naro car series which is a range of 'free leaning' vehicles that improves mobility and addresses the key issues of efficiency and emissions. Similarly, the Connaught Motor company, Llanelli produces petrol/electric hybrid sports cars through innovative engineering, including the world's first performance hybrid sports coupé, while Stevens Vehicles Cwmbran have designed and developed a small electric zero emissions vehicle and have set up in Wales to manufacture and develop the range. Thus, a good installed manufacturing capacity is in place for tool making, fabricating, injection moulding, die casting and special purpose machine building. Similarly, Calsonic Kansei leads an international line-up covering power train, steering and braking systems, interior trim and seating, and power electronics. Most of these examples are in high-technology parts production. The participants are developing particular technologies but are too small to be able to market these in whole vehicles for general sale. Inevitably these will

be prototyped and sold or licensed to major companies which are mostly outside the region or which will be controlled at least by companies outside the region. Hence, there is a need for more flexible, responsive governance in order to push these private sector firms to build a sustainable system of innovation in the automotive sector.

#### **4. Policy challenges and some reflections**

The traditional base of low to medium technology manufacturing in the Wales region has seen the development of an innovation system dominated by external influences and geared to incremental process innovation. The positive impetus induced by the public sector in the 1980s did pay off to create a positive growth effect in the manufacturing sector although the trends started to reverse by the end of the century due to the rapid structural changes in the industry. The 'take-off' phase of the manufacturing sector in general and the automotive sector in particular was therefore only transitory in nature. Whether Wales can remain a long term location for automotive production depends substantially on whether the OEMs can hold their sway as the central core of the automotive clusters in this economic region. It will only become critical for Wales if the actual core of automotive production – assembly and development disappears. If the OEMs were to successively thin out their Wales plants and in the end shut them down completely, this would then automatically force the suppliers to migrate. As long as the OEMs remain in their Wales locations with essential real world functions in production and development so will a considerable part of the supply industry also stay and prosper in Wales.

It is true that the global landscape of automotive manufacturing has been transformed in a way which is less than favourable to the old and mature industrial economies like the UK. But the industry is also driven by incremental innovations which give a comparative advantage to the mature industry and the firms within it. So the strength of the industry lies in promoting innovation and strengthening it qualitatively by concentrating on the high value-added segments. Some of the examples above illustrate how new players can develop innovations but they may need to enter into ventures with established assemblers to bring them to the wider market. And in many cases, these new players can be located outside 'traditional areas'. Wales has a clear advantage in the niche sectors such as power train technology. The players in this sector have a real potential to upset the balance that has weakened the automotive base. However, given that the knowledge base of these companies is outside the 'traditional' areas, they need to be allied to the traditional knowledge of the major companies and linked to their networks in order to create the required impact in the market.

The acceleration in Wales' manufacturing economic performance was triggered by an attitudinal shift of the government toward a pro business approach. But until very recently, regional policy towards the automotive sector was motivated by the prevalent top-down lean manufacturing paradigm and the short term needs of a small number of large companies (Bailey, Kobayashi and MacNeill, 2008). However, the policy for the sector needs to adapt to the changing regional circumstances of the industry and the demise of volume car production. There is a need for more flexible, responsive governance and a more receptive private sector to build a synergetic innovation cycle in the automotive sector. The traditional public centralized funding and governance of innovation should be replaced by more market-oriented innovation system support to address the pressing competitive challenges that the sector is facing due to the changing nature and form of innovation.

## References

- Bailey, D., Kobayashi, S., and MacNeill, S. (2008), "Rover and Out". Globalisation: The West Midlands Auto Cluster and the end of MG-Rover., *Policy Studies*, 29, 3, 267-280.
- Bailey, D., and Cowling, K. (2006), 'Industrial Policy and Vulnerable Capitalism', Institute for Economic Development Policy Discussion Paper Series, University of Birmingham
- Bailey, D. and Driffield, N. (2007), Industrial Policy, FDI and Employment: Still 'Missing a Strategy', *Journal of Industry, Competition and Trade*, Vol.7, Iss.2, 189-211.
- BERR, (2009), An Independent Report on the Future of the Automotive Industry in the UK New Automotive Innovation and Growth Team (NAIGT), available at <http://www.bis.gov.uk/files/file51139.pdf>.
- Breschi S. and Malerba F. (1997), Sectoral systems of innovation: technological regimes, Schumpeterian dynamics and spatial boundaries in Edquist C. (ed), *Systems of innovation*, F Pinter, London
- Carlsson, B. and Stankiewicz, R. (1995): "On the nature, function and composition of technological systems". In: Carlsson, B. (ed.): *Technological Systems and Economic Performance: The Case of Factory Automation*. Kluwer Academic Publishers. Dordrecht, 21-56.
- Chanaron, J. (2004), Relationships between the core and the periphery of the European automotive system, *International Journal of Automotive Technology and Management*. Vol 4, 2/3, 198-222
- Cooke, P. (1992), Regional innovation Systems: Competitive Regulation in the New Europe. *Geoform*, 33, 365-382.
- Cooke P. (1995), 'Innovative Regional Clusters: The Automotive and Electronics Industries in Wales', *Regional Industrial Research Reports*, CASS, Cardiff.
- Cooke P. (1998), Regional innovation Systems: Introduction. In H-J Braczyk, P Cooke and M Heidenreich (Eds.) *Regional innovation Systems*. UCL press, London
- Cooke, P. (2002), 'Industrial Innovation and Learning Systems: Sector Strategies for Value Chain Linkage in Less Favoured Regional Economies', *Regional Industrial Research Reports*, CASS, Cardiff.
- Cooke, P. (2004), 'The regional innovation system in Wales', in *Regional Innovation Systems. The Role of Governances in a Globalized World*. Routledge, London.
- Cooke, P. (2005), Regionally asymmetric knowledge capabilities and open innovation: Exploring 'Globalisation 2'- A new model of industry organisation, *Research Policy*, Vol.34, Issue 8, 1128-1149.
- Cooke, P., Morgan, K. and Price, A. (1995), 'Regulating regional economies: Wales and Baden-Wurtemberg in transition', in RHODES, M (Ed.) *The Regions and the New Europe: Patterns in Core and Periphery Development*, 106-135. Manchester University Press, Manchester.

Dahmen, E. (1989), "Development blocks in industrial economics", in B. Carlsson (Ed.), *Industrial Dynamics: Technological, Organisational and Structural changes in Industries and Firms*, Kluwer, Boston.

Edquist C. (ed) (1997), *Systems of innovation*, F Pinter, London.

Ernst and Young, (2006), *European Investment Monitor (EIM)*, Ernst and Young, France.

Fuller, C. and Phelps, N. A. (2006), 'Multinational enterprises, repeat investment and the role of aftercare services in Wales and Ireland', *Regional Studies*, 38, 7, 783-801.

Hakansson, H. (1989), *Corporate Technological Behaviour- Co-operation and Networks*, London: Routledge.

Humphrey, J. (2000), 'Assembler-supplier relations in the auto industry: globalization and national development', *Competition and Change*, 4: 245-271.

IMI (2009), 'Skills priorities for the Automotive Retail Sector – Wales', Final Report, IMI Research Department, The Institute of the Motor Academy, UK.

Jürgens, U, Blöcker, A and MacNeill, S (2008), *The Automotive Sector: Knowledge Stocks and Flows*.EURODITE Working Paper. Available at:  
[http://www.eurodite.bham.ac.uk/partners/WorkPapers/WP3/WP3i/Automotive\\_final.pdf](http://www.eurodite.bham.ac.uk/partners/WorkPapers/WP3/WP3i/Automotive_final.pdf)

Keeble D., and Walker, S., (1994), 'New firms, small firms and dead firms: spatial patterns and determinants in the United Kingdom', *Regional Studies*, Vol.28, 411-427.

King, J. (2008), *The King Review of Low Carbon Cars*. HM Treasury, London.

Lundvall, B-A. (Ed) (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter, London.

MacNeill, S. and Chanaron, J. (2005) *Trends and Drivers of Change in the European Automotive Industry: Mapping the current situation*, *International Journal of Automotive Technology and Management*, Vol. 5, 1, 83-106.

MacNeill, S. and Bailey, D. (2009), *Changing Policies for the Automotive Industry in the UK West Midlands: An Open Innovation Model*. By Stewart., *Applied Research Working Paper Series*, Coventry University, United Kingdom.

Malmberg, A and Maskell, P. (1997), *Towards an explanation of regional specialisation and industry agglomeration*. *Europe. Planning Studies*, 5, 1, 25-43

Maxton, G., and Wormald, J. (2005), *Time for a Model Change. Re-Engineering the Global Automotive Industry*. Cambridge: Cambridge University Press.

Munday. M. (2000), 'Foreign Direct Investment in Wales: Lifeline of leash?', In Bryan J and C. Jones (Eds), *Wales in the 21st Century: An Economic Future*, Basingstoke: MacMillan Business.

NAIGT (2007), *An Independent Report on the Future of the Automotive Industry in the UK*, available at <http://www.berr.gov.uk/files/file51139.pdf>.

Nelson, R. (Ed.) (1993), *National Innovation Systems: A Comparative Study*, Oxford: Oxford University Press.

Nelson, R., Rosenberg N. (1993), 'Technical Innovation and National Systems', in Nelson, R. (ed.) National Systems of Innovation: A Comparative Study, Oxford: Oxford University Press.

Office of National Statistics (2003b), Small Business Statistics, London, ONS.

Parhi, M. (2006), Dynamics of New Technology Diffusion: A Study of the Indian Automotive Industry". Doctoral Dissertation, University Press Maastricht, Maastricht.

Pinch, S., and Hendry, N. (1999), 'Discursive aspects of technological innovation: the case of the British motor sport industry', Environment and Planning A, 31(4), 665-682.

Porter, M. (1990), The Competitive Advantage of Nations, New York: Free Press.

Rhys, G. (2002), The Automotive Sector in Wales: Still Alive and Well, Report to Third Autoconference, London, November (<http://www.autoconference.co.uk>)

Saxenian, A. (1994), Regional Advantage: Culture and competition in Silicon Valley and Route 128, Cambridge MA: Harvard University Press.

Scott, A., and Storper, M. (1992), 'Regional development reconsidered', In Regional development and contemporary industrial response, ed. H. Ernst and V. Meier, 3-24. London: Belhaven.

Taylor, M. (1995), 'The business enterprise, power and patterns of geographical industrialisation', in S Conti, E J Malecki, P Oinas (eds) The Industrial Enterprise and its Environment: Spatial Perspectives, Ashgate, Aldershot, Hants, 99-122.

WAG (2002), Wales for Innovation: the Welsh Assembly Government's Action Plan for Innovation, Cardiff WAG (2003) Business & Environment Action Plan for Wales, Cardiff

WAG (2005) Wales, A Vibrant Economy, the Welsh Assembly Government's Strategic Framework for Economic Development, Cardiff.

Womack, J., Jones, D., and Roos, D. (1990), The Machine that Changed the World, New York: Rawson Associates.