CURDS Centre for Urban & Regional Development Studies

Newcastle University

Foresight Future of Manufacturing Project

How does manufacturing contribute to UK resilience?

Prepared for

Government Office for Science

October 2012

Andy Pike, Stuart Dawley and John Tomaney

RR2013/04

Government Office for Science

Foresight

Foresight Future of Manufacturing Project

How does manufacturing contribute to UK resilience?

Foresight Future of Manufacturing Project

Foresight Driver Review – DR 3.4

Contents

How does manufacturing contribute to UK resilience?

Professor Andy Pike

Centre for Urban and Regional Development Studies (CURDS)
University of Newcastle

Dr Stuart Dawley

CURDS

Professor John Tomaney

CURDS

October 2012

This review has been commissioned as part of the UK Government's Foresight project, Future of Manufacturing. The views expressed do not represent policy of any government or organisation

Executive Summary

This review and think-piece outlines how manufacturing contributes to UK resilience currently and identifies aspects of its future role, reflecting its economic, social, cultural, technological and environmental value and importance in the UK. Section 2 outlines the different definitions of resilience and utilises the following in the report: the ability of an entity to ride out or withstand and/or bounce-back or rebound to recover its form and position from disruptive change such as financial crises, recessions, technological shifts, hazardous climate changes and other (internal and external) shocks and events. This section identifies some of the potential determinants of economic resilience at the micro-level (firms, workers), meso-level (sectors, industries) and macro-level (national economy and institutions). It also addresses different types of shock, slow burn processes and tipping points as well as anticipation, pre-emption and preparedness in avoiding and mitigating the impacts of disruptive change. This section identifies ways of measuring resilience including variation indicators, sensitivity ratios, changes in scale and scope measures, qualitative measures, vulnerability and adaptability indices and social and ecological metrics.

Section three identifies the characteristics of the UK central to its resilience including: historically industrialised and advanced, mature economy, society and polity; coping with long-run de-industrialisation; productivity, competitiveness and wealth generation; unbalanced sectoral and spatial development; open and internationalised economy and society; market-oriented, liberalised and lightly regulated political economy; and, physical geography as an island on the western periphery of Europe. It emphasises the importance of the geographical dimensions of resilience because of the spatially differentiated ways in which places are vulnerable and able to demonstrate adaptive capacity in response to disruptive change.

Section 4 identifies the importance of manufacturing in output, employment, productivity, innovation and R&D, trade, supply chains, manufacturing-service linkages, training and skills development and tax revenue. It also identifies its contributions to resilience in recovering lost output, employment and productivity, generating new and replacement employment, innovating for growth, motor of recovery especially in export-led sectors, upgrading the workforce, and focus of sectoral rebalancing. Potential costs and problems generated by manufacturing for resilience are also outlined including cyclical sensitivity and recovery, employment loss, reliance upon external export markets and government procurement contraction. The geographical dimensions of manufacturing's contribution to resilience are also emphasised in its geographies across the UK and the differential role of manufacturing as both a positive and negative element of the resilience of places in the context of disruptive change.

Section 5 identifies gaps important to the contribution of manufacturing to resilience in the UK including 'smart' industrial strategy, geography, ownership, global production networks and broken supply chains, 'manu-services', productive security and adaptive capacity. Section 6 discussed international perspectives on the role and development of manufacturing for resilience from Germany, the USA and China.

Section 7 concludes the report. It argues that manufacturing has the potential to make a positive contribution to enhancing the resilience of the UK. While recognising the problems of a sensitivity to economic downturns, struggles to recover output following demand shocks and continued employment losses, the potential benefits and contributions as well as the 4

international experience outlined in the report mean manufacturing is a strategic and valuable sector for resilience that cannot be ignored or neglected. Now and into the future manufacturing has considerable value to the UK. The contribution of manufacturing to resilience can benefit from consideration of the geographical dimension of spatial differentiation in the vulnerability and adaptive capacities of places where manufacturing is concentrated and the tailoring of appropriate policy responses; a recognition that singular reliance upon market mechanisms is insufficient and forms of 'smart' industrial strategy and policy are being pursued by the UK's manufacturing competitors internationally; and, building longer term adaptive capacity to pre-empt, mitigate and adapt to disruptive change is the critical future challenge.

1. Introduction

This review and think-piece outlines how manufacturing contributes to UK resilience currently and to outline its expected future role, reflecting its economic, political, social, cultural, technological and environmental value and importance in the UK. Section 2 addresses the definition and measurement of resilience. Section 3 discusses the characteristics of the UK salient to its resilience and emphasises the importance of the geographical dimensions of resilience in the spatially differentiated vulnerability and adaptive capacity of places across the UK. Section 4 focuses on the specific role of manufacturing in UK resilience to identify why and how it matters and the geographical dimensions of manufacturing and their contribution to resilience. Section 5 identifies gaps in the contribution of manufacturing to UK resilience relating to 'smart' industrial strategy, geography, ownership, global production networks and broken supply chains, 'manu-services', productive security and adaptive capacity. Section 6 discusses international perspectives from Germany, USA and China that demonstrate the value and importance of manufacturing in their resilience. Section 7 summarises the findings and concludes. The method for the review and think-piece is twofold. First, it reviews key elements and case examples from the relevant literature from three key sources: academic (e.g. journals, books), government (e.g. reports, reviews) and grey (e.g. think-tanks, trade organisations). Second, it identifies and reflects upon the relevance of the key elements and international experiences for the role of manufacturing in UK resilience. The temporal focus is the current situation and future issues to 2020-50.

II. Definition and measurement

Multiple definitions of resilience are evident in different disciplinary approaches to the issue and these have configured a variety of ways of measuring its specific dimensions.

2.1 Defining resilience

Resilience has emerged as a notion seeking to capture the differential and uneven ability of an entity to pre-empt, react, respond and cope with uncertain, disruptive, volatile and rapid change. Resilience has gained attention in countries and regions responding to an ever more diverse array of external shocks and transitions. These include financial crises, dangerous climate change, food shortages and price spikes, energy disruptions, utility network breakdowns, technological shifts, terror campaigns, natural hazards and extreme weather events. The potential vulnerabilities of places to such risks are seen as heightened due to the increased interconnection and interdependence between places in the context of globalisation. Similarly, places disconnected and marginalised in processes of globalisation can find their resilience corroded and threatened too. As an emergent rubric in this changing context, resilience is attracting burgeoning academic and policy attention in both the US (Foster 2007a; Pendall *et al.* 2007), Europe (CLES 2008; Colbourne 2008; Edwards 2009; Folke *et al.* 2002) and elsewhere (Cork, 2009).

Table 1: Definitions of resilience

Type of resilience	Main focus of interest
Engineering Resilience (found in physical sciences)	Ability of a system to return to, or resume, its assumed stable equilibrium state or configuration following a shock or disturbance. Focus is on resistance to shocks and stability near equilibrium
Ecological Resilience (found in ecological sciences)	The scale of shock or disturbance a system can absorb before it is de-stabilized and moved to another stable state or configuration. Focus is on 'far from equilibrium' behaviour of system
Adaptive resilience (found in complex adaptive systems theory)	The ability of a system to undergo anticipatory or reactionary reorganization of form and/or function so as to minimize impact of a destabilizing shock. Focus is on adaptive capability of system

Source: Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32.

Existing literature on resilience spans several disciplines and is fragmented across different starting points and foci ranging from the individual to the spatial. Psychology and psychiatry focus upon the individual and their resilience during life course transitions and events (Kaplan 1999). In ecological systems, resilience is related to system functioning rather than the stability or otherwise of its component populations and maintenance or loss of steady states (Adger 2000). For Adger (2000: 347), social resilience is "the ability of communities to withstand external shocks to their social infrastructure". Work connecting ecological and social resilience has noted its multiple definitions and temporal dimensions, drawing upon eco-system notions to interpret resilience as "the buffer capacity or the ability of a system to absorb perturbations, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behaviour" (Adger 2000: 347). Such approaches recognise that while resilience is "widely used in ecology...its meaning and measurement are contested" (Adger 2000: 347).

Economic analysis has focused upon the national level and the ability of nation states to avoid disturbance of their equilibrium position through avoiding, withstanding or dampening the effects of shocks by diversification and/or macro-economic stability (Duval *et al.* 2007). Engineering resilience focuses upon the vulnerability of people and places to hazardous environments and natural disasters, forecasting the likelihood of catastrophic events and systemic breakdowns and their social and economic implications (Vale and Campanella 2005). Recent research has focused specifically upon the resilience of places, often regions, and

defines resilience as "the ability of a region to anticipate, prepare for, respond to, and recover from a disturbance" (Foster 2007a: 14) or "the ability of a region...to recover successfully from shocks to its economy that either throw it off its growth path or have the potential to throw it off its growth path" (Hill et al. 2008: 4).

Conceptions from across the disciplines give resilience particular and different meanings (Table 1). Systems theory is commonly utilised to understand the relationships and interactions between component elements that underlie the presence or absence of resilience in relation to external (exogenous) as well as internal (endogenous) perturbations. Emphasis is typically placed upon the return or displacement to single or multiple equilibria and upon internal and external factors that either strengthen or threaten systems, either contributing to or weakening their resilience.

Distilling the meaning from the various conceptions, resilience is defined in this report as the ability of an entity to ride out or withstand and/or bounce-back or rebound to recover its form and position from disruptive change. Such change includes financial crises, recessions, technological shifts, hazardous climate changes and other (internal and external) shocks and events. The focus of the report is on the contribution of manufacturing to the UK as the resilient entity – that is, how manufacturing helps or hinders the UK's ability to ride out or withstand and/or bounce-back or rebound to recover its form and position from disruptive change. The focus on the resilience of the UK is – as discussed below – closely inter-connected with the resilience of the manufacturing sector within the UK. A resilient manufacturing sector affords the potential for a greater contribution to the UK's resilience overall.

Focusing on the definition of economic resilience in this report, it is useful to consider what some of its potential determinants might be at three key levels:

I. **Micro-economic**: At the level of firms, resilience can be determined by whether specific business units are able to withstand and respond to disruptive changes such as demand shocks, technological shifts and financial crises. For example, resilient firms are those with the capacity to diversify, manage a portfolio of economic specialisms to counter cyclical market shifts, undertake R&D and maintain an appropriate capital base. At the level of individual workers, resilience is shaped by whether specific people can cope with disruptive changes such as redundancy, skills obsolescence and technological shifts. A resilient worker might then be considered one with the capacity and willingness to retrain and acquire or update skills and even to exercise mobility to move geographically to new employment opportunities.

II. **Meso-economic**: At the level of industries and sectors, resilience is determined by the capacity of the aggregate of firms to ride-out and adapt to disruptive changes including recessions, cyclical downturns and radical innovations. Resilient industries and sectors, for example, are those able to sustain demand by diversification through different sectors and/or geographical markets and to shape and pre-empt technological developments.

III. **Macro-economic**: At the macro-level, the resilience of national economies and institutions are determined by their ability to withstand or rebound – or even to pre-empt – disruptive changes such as demand shocks, currency collapse and sovereign debt crises. For example, resilient national economies and institutions are able to shape and manage aggregate demand and pursue policy mixes that maintain credibility in financial markets.

An important and meaningful aspect of resilience is its temporal nature. This is especially significant in addressing the longer run issues of resilience up to 2050. A distinction can usefully be drawn between 'shocks' and 'slow burn' disturbances:

System shocks include disasters (e.g. Hurricane Katrina, California earthquakes, the Philadelphia yellow fever epidemic) and, to a lesser extent, plant closings in cities that are heavily dependent upon those plants. Shocks, can, of course, recur, even every year, as when Florida experiences repeated hurricanes or southern California bursts into flame in the late summer. Shocks can also be of the positive variety, such as when a region wins a bid for the Olympic Games or learns of success in luring a major new economic investment to the community. Examples of 'slow burns' (or 'slow moving challenges') include deindustrialization, urban sprawl (which usually occurs 'below the radar'), prolonged population growth, and global climate change (Pendall *et al.* 2007: 13).

'Slow burn' disruptions can also include cumulative pressures for change such as mounting competition from other economies internationally and ongoing technological advances. Such changes can be incremental and apparently small scale when considered in isolation. However, they can reach critical junctures or 'tipping points' and become manifest as specific shocks. For example, when ongoing and intensifying competition eventually undermines the financial viability of a major employer in a local economy and rationalisation results.

Further important distinctions include the extent to which the disturbance is anticipated or not and whether it is a high probability-low risk or low probability-high risk occurrence. Another recognition is the magnitude and scale of perturbations and their subsequent resonance to capture potential 'after-shocks' and second, third and so on order effects. Again this medium and long-term outlook is important in addressing future resilience issues. Indeed, 'shocks' (exogenous and/or endogenous) are often closely intertwined with the unfolding of broader, longer run and 'slow burn' processes of change and appear as accelerated episodes of disruptive change. Different circumstances in places shape whether, when and how such slow burn processes may reach tipping points to generate shocks. For example plant closures in the context of deindustrialization, gridlock levels of congestion as part of urban sprawl, acute pressure on public service provision such as education and health as part of prolonged population growth, and volatile and hazardous weather events in the context of global climate change.

Although a vitally important area, to date there has been limited research on the ideas of anticipation and pre-emption in relation to economic resilience. For example, identifying the ways in which disruptive change can actually be in some way foreseen and avoided. Adaptive capacity – discussed below – is one area that has begun the process of thinking through ideas about preparedness and promoting the capacity of especially places more actively to anticipate and pre-empt potentially disruptive change or at least to attempt to minimise and manage its most damaging consequences (Pike *et al.* 2012).

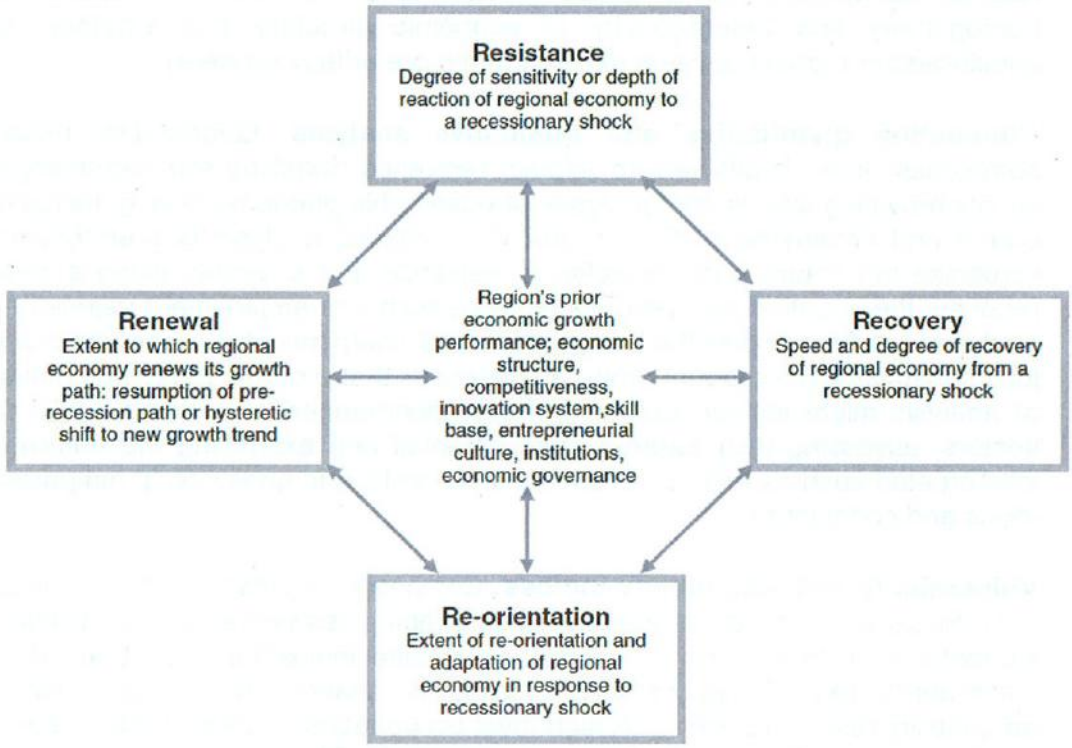
2.2 Measuring resilience

Resilience is conventionally measured in terms of the rate or speed with which an entity recovers its previous position, for example an economy regaining its level of output or employment following a shock such as a recession. This approach is used in accounts that interpret resilience as "the ability of a regional economy to maintain a pre-existing state (typically assumed to be an equilibrium state) in the presence of some type of exogenous shock" and the "extent to which a regional or national economy that has experienced an external shock is able to return to its previous level and/or growth rate of output,

employment or population" (Hill *et al.* 2008: 3). Resilience here is understood as whether or not and to what degree and in what time frame a spatial unit such as a national economy, region or city can return to its pre-shock position and level of output or employment.

Martin (2012) has sought analytically to clarify dimensions of economic resilience in relation to recessionary shocks (Resistance, Recovery, Renewal, Re-orientation) and to identify measures to capture each dimension (Figure 1). This framework focuses attention upon 4 dimensions, their potential influences and ways of tracking their change over time.

Figure 1: Dimensions of regional economic resilience in relation to recessionary shocks



Source: Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32.

Building upon these recent conceptual developments, work on economic resilience in particular is exploring a range of measurement approaches and indicators with wider value for capturing other dimensions of resilience, including:

- **Variation measures**: Breaking the same episode of disruptive change into different phases – for example preceding, during and after – the level of variation (e.g. % change) of a specific indicator (e.g. output, employment) relative to the national benchmark can be examined. Negative variations would imply less resilience than the national level and positive variations would suggest more (little or no variations would indicate similar levels).

- **Sensitivity ratios**: This measure can explore relative changes in an indicator in a place compared to national benchmarks (e.g. % increase or decrease in output or employment in region/% increase or decrease in output or employment nationally) to identify

whether there has been low (relative) resilience (high sensitivity) to change or high (relative) resilience (low sensitivity) (Martin 2012).

- **Scale and scope of changes in economic structure**: Measures to capture the extent and nature of shifts in economic structure include measures of relative specialisation and diversification (e.g. absolute and relative changes in output, employment and occupations) and changing location quotients (e.g. using a ratio to compare the – typically regional or local – incidence of particular activities to a reference – often national – to identify specialisations) revealing the changing geographies of economic activities. Measures from ecology such as the Shannon diversity index can quantify the changing diversity of different types of sectors or firms in the region and their shifting relative abundances as a means to examine the role in resilience of relative homogeneity and heterogeneity in economic structure (i.e. whether being more specialised or more diversified makes them more or less resilient).

- **Connecting quantitative and qualitative analysis**: Quantitative measures may sometimes prove insufficient to explain resilience, masking the underlying causes by simply providing counts and analyses of observable phenomena (e.g. indicators such as output and employment). Connection to qualitative analysis is therefore important to scrutinise the nature and character of resilience. For example, when a local economy recovers the quantitative level of its previous output or employment trajectory, qualitative analysis can focus upon the composition and character of the economic activities and jobs constituting the rebound and the processes that produce *these* outcomes. This form of analysis might include exploring the preponderance of growing, static or declining sectors, assessing their future growth potential and examining the nature of the new jobs created such as their occupational level, skills and quality (e.g. temporary, full-time, terms and conditions).

- **Vulnerability and adaptability indices**: Composite indices have been constructed that seek to capture the key causal elements shaping resilience for a particular entity. For example, in local economic analysis, composite indicators have been developed for vulnerability (e.g. % public sector jobs, % change in unemployment rate) and adaptability (e.g. % residents in high level occupations, % jobs in high value-added and growing sectors) (Cambridge Econometrics 2010). The resilience of local economies is then assessed and ranked in terms of their relative levels of vulnerability and adaptability on these measures.

- **Social and ecological resilience**: Broadening the focus beyond economic indicators requires measures to capture the social and ecological dimensions of resilience and their relationships to quality of life and sustainability (Pike *et al.* 2007). Emergent measures of subjective wellbeing, ecological footprints, CO2 emissions, energy use and waste management for example have been used to enable exploration of the sustainability dimensions of resilience. For example, this approach can examine whether places may be adapting to disruptive change along a trajectory of quantitatively lower level economic growth but of qualitatively more sustainable character.

III. UK resilience

As a state with a particular economic, social, political and cultural history, the UK has a number of distinctive characteristics that shape and contribute to its particular issues in relation to resilience. The emergent nature of the concept of resilience and its multiple dimensions and means of measurement mean there is no single study which captures the changing extent of the resilience of the UK in the round and compares it to experience internationally. Several of the key issues and their relevance to resilience include:

- **Historically industrialised and advanced, mature economy, society and polity**: The UK pioneered industrialisation and is well established as a high-income, advanced and mature economy and society. While early manufacturing leadership enabled the UK to capture first mover advantages in propelling economic growth and prosperity as the 'workshop of the world' in the late 19th Century, later industrialising countries have been able to catch up over much shorter time frames and present competitiveness challenges for manufacturing in the UK (Storper *et al.* 2007). This historical experience reinforces rather than reduces the importance of manufacturing in maintaining the competitive lead and wealth creation potential in the UK. This history provides the UK with substantial resources and capacities for addressing resilience challenges as well as some issues and risks. Longstanding and enduring institutions, for example, provide continuity and stability but also raise questions about their capacity for adaptability and evolution.

- **Coping with long-run de-industrialisation**: Pioneering industrialisation has meant the UK was also first to experience de-industrialisation – a decline in the absolute and relative weight of manufacturing in economic output and employment (Pike 2011). The UK and its manufacturing sector are now having to compete with later industrialising countries such as the Asian Tigers and China (Rowthorn and Ramaswamy 1997). This economic transition generates issues of adaptation and adaptability which have been acute for particular geographical concentrations of particular industries in the UK, for example in steel and heavy engineering in the historically industrialised centres of the North East, South Wales and West Central Scotland (Rowthorn and Martin 1986).

- **Productivity, competitiveness and wealth generation**: As a former Imperial power and early industrialising country, the UK's productivity, relative competitiveness and ability to pay its way in the world through economic activity and trade have been recurrent concerns for wealth generation and prosperity (Coates 1994). While the UK has developed world-leading specialisations in particular economic sectors – such as aerospace, creative industries, financial services and pharmaceuticals – these tend to be in high value-added activities within highly internationalised markets with global inputs and outputs that require high skill levels. This raises questions about their connection and contribution to resilience within the UK, for example in generating multipliers through demand for goods and services within the UK and the creation of a wide variety of employment and skills development opportunities within the labour market.

- **Unbalanced sectoral and spatial development**: The UK has evolved a heavy reliance upon services, especially financial, and particularly the global centre of the City of London (Froud *et al.* 2011a). This sectoral imbalance has underpinned a spatial imbalance in the geographical concentration of economic activity and growth in

London and the Greater South East (Chapman 2011). The global financial crisis and its broader implications demonstrated the resilience issues for the UK of being overly dependent upon the highly inter-dependent, volatile and uncertain international financial system and the global hub of the City of London. Concerns have been recurrent too about the relationships between the financial activities in the City of London and the provision of finance in the 'real' economy to manufacturing firms and SMEs in particular (Coates 1994).

- **Open and internationalised economy and society**: The UK is a very open and internationalised economy and society, shaped by its history of development and especially the Empire. This pattern of development has meant the UK is highly interconnected and interdependent in a global context. It is therefore especially open, exposed and vulnerable to the transmission of external shocks, instabilities and disruptions from elsewhere. Recent experiences demonstrate this lack of resilience, for example the financial sector's exposure to the sub-prime housing mortgage crisis in the US and the manufacturing sector's exposure to recession, instability and the sovereign debt crisis in its major export markets in the Eurozone.

- **Market-oriented, liberalised and lightly regulated political economy**: The UK is a liberal-market economy with a market-oriented and lightly regulated political economy. This characteristic integrates the UK closely with market dynamics across a range of economic, social and institutional dimensions, shaping its vulnerability to external shocks (e.g. collapses in demand for particular goods and services) and its adaptive capacity in responding to such shocks (e.g. the capacity and resources of the private sector and the state and its institutions).

- **Physical geography as an island on the western periphery of Europe**: The physical geography of the UK shapes its resilience challenges through emphasising the importance of its pattern of natural resource endowments (e.g. climate for agriculture and food production, potential and actual energy resources) and its spatial proximity to its trading partners (e.g. enabling pipelines and shipping routes for energy and food supplies). With the growing emphasis upon renewable energy resources, for example, the UK's geography is becoming more important for its resilience in its potential offshore wind and tidal generation capacity.

3.1 The geographical dimensions of resilience

In attempting to understand resilience at the national level in the UK it is vital to examine its geographical dimensions at the sub-national level. This spatial perspective is important in understanding the inherent geographical differentiation of resilience in the context of the definition used here. Spatial differences are inherent in the ability of entities to ride out or withstand and/or bounce-back or rebound to recover their form and position following disruptive change. Challenges such as financial crises, recessions, technological shifts, hazardous climate changes and other (internal and external) shocks and events impact different places in different ways. Places differ too in relation to the type of shock, for example it is important to distinguish between locally-specific idiosyncratic and particular shocks (e.g. a closure or relocation of a plant) and the local impact of system-wide and more generalised shocks (e.g. an oil-price hike, a recession, shifts in national policy). Specifically, places vary in relation to:

- **Vulnerability**: Different places exhibit different types and degrees of vulnerability to disruptive change. Major urban centres, for example, are more likely to be targets for malicious attacks on infrastructure due to the scale and visibility of disturbance and impact that can be caused (Coaffee *et al.* 2008). Resource endowments vary spatially and shape the access, availability and security of places in securing continuous and reliable supplies of water, energy and food. Climate change is complicating and changing this pattern of resources. Geographical proximity to natural hazards such as seismic activity zones generating earthquakes, tsunamis and volcanoes or severe weather and flooding is spatially variable, shaping the differential exposure to risk and negative outcomes in particular places.

- **Adaptive capacity**: the ability of places to ride out or withstand and/or bounce-back or rebound to recover their form and position following disruptive change is highly geographically differentiated. Some places demonstrate the capacity to remain unaffected or to adapt and snap back from such challenges while others end up weaker, vulnerable and adversely affected. The highly spatially uneven implications of the global economic downturn from 2007 have demonstrated this geographical differentiation (Davies 2011). Emerging research suggests that places better able to prepare for and cope with disruptive economic change exhibit a number of connected characteristics: related variety in their economic structures to enable innovation and entrepreneurship for economic renewal, adaptive institutional arrangements able to interpret and reconfigure in response to changing conditions and contexts, and an ability to maintain advantageous positions and relationships in wider economic and governance systems to access knowledge and resources across geographical scales (Pike et al. 2012).

IV. The role of manufacturing in UK resilience

Manufacturing plays an integral and important role in resilience in the UK and its geographical dimensions are especially significant in understanding the potential benefits and costs of its contribution.

4.1 Manufacturing matters for resilience

Manufacturing retains a distinctively valuable and important role for the UK in economic, political, cultural, technological and cultural terms (BIS 2010). Contrary to some views predicting its demise as a set of 'smokestack' or 'rustbelt' economic activities left behind as contemporary economies become dominated by modern service sector activities, manufacturing still matters. Crucially, this is because manufacturing has changed in significant ways, public statistics are unhelpful in capturing the scale and scope of the changes, and policy makers have either ignored and/or exercised benign neglect of manufacturing in the context of market-led approaches and the broader 'tertiarisation' of the economy in the shift to services. However, the more robust and resilient economies internationally retain strong manufacturing sectors (Roos 2011). A central concern for manufacturing in the UK is its productivity, relative competitiveness and growth potential into the future to 2020-50. Given the periodic rationalisations and contractions during its history, for example in the late 1970s and early 1980s, a key question concerns the benefits and costs of its potential contributions in the wake of de-industrialisation and how this relates to its contribution to the resilience of the UK.

As the 'flywheel of growth' (Kaldor 1972), manufacturing is a generator of considerable benefits and multipliers:

- **Output**: Producing gross domestic product (GDP)
- **Employment**: Creating direct and indirect employment and incomes
- **Productivity**: Producing value-added and providing the highest potential for productivity growth
- **Innovation, research and development**: High levels of expenditure on applied research and innovation generating wider diffusion and spill-over effects to the broader economy
- **Trade**: Generating export earnings from overseas sales and maintaining positive trade balances
- **Supply chains**: Purchasing goods and services generating direct and indirect multipliers for investment, growth and employment within the wider economy
- **Manufacturing-service linkages**: Creating demand for high value-added and specialised services such as accountancy, advertising, legal, marketing and research

- **Training and skills development**: Developing a highly skilled workforce and creating training opportunities for new labour market entrants

- **Tax revenue**: As a sizeable and productive economic activity producing output and employing people, manufacturing is a substantial contributor to national tax revenue.

As a result of its pivotal role as a vibrant sector of economic activity, manufacturing makes the following vital contributions to resilience:

- **Recovering lost output, employment and productivity**: In the wake of disruptive change, manufacturing can contribute to generating GDP, jobs and value-added as part of regaining previous growth trajectories both directly and indirectly through its wider supply chains for goods and services

- **Generating new and replacement employment**: Manufacturing can create new kinds of job opportunities in new and growing activities to replace those lost, for example in recession and economic downturn

- **Innovating for growth**: Periods of disruptive change can stimulate what Joseph Schumpeter called 'creative destruction' with manufacturing demonstrating high innovation potential for product and process advances

- **Motor of recovery especially in export-led sectors**: As UK economic growth has stuttered and fallen into a double-dip recession, the export orientation of manufacturing has meant it has outperformed the national economy in making a positive contribution to economic recovery (Sissons 2011)

- **Upgrading the workforce**: The role and position of manufacturing in training and skills development is vital in upgrading the existing workforce for example in learning new skills as well as producing portable transferable skills of use in different activities, enhancing the flexibility of the labour market in response to shocks

- **Focus of sectoral rebalancing**: As part of the UK government's policy of 'rebalancing' the sectoral and spatial structure of the UK economy it aims to grow manufacturing rather than reduce the size and contribution of the services sector, especially financial services. This policy suggests a future role for manufacturing and its contribution to UK resilience.

The importance and role of manufacturing in resilience has been renewed in the wake of the global financial crisis from 2008. The countries that are demonstrating the most rapid levels of recovery, including Germany, are benefitting from the contribution of high value-added export-oriented manufacturing (Roos 2011). Moreover, the strong performance and relative resilience of the BRICS[1] during the early period of the downturn has also been attributed to manufacturing-led export growth too, especially in Brazil and China (Beattie 2010).

Manufacturing is not an unqualified benefit to UK resilience in all cases. There are costs and problems that manufacturing generates including:

[1] Recently the acronym BRIICS has been developed by commentators to incorporate the emerging economies of both Indonesia and South Africa (OECD 2009).

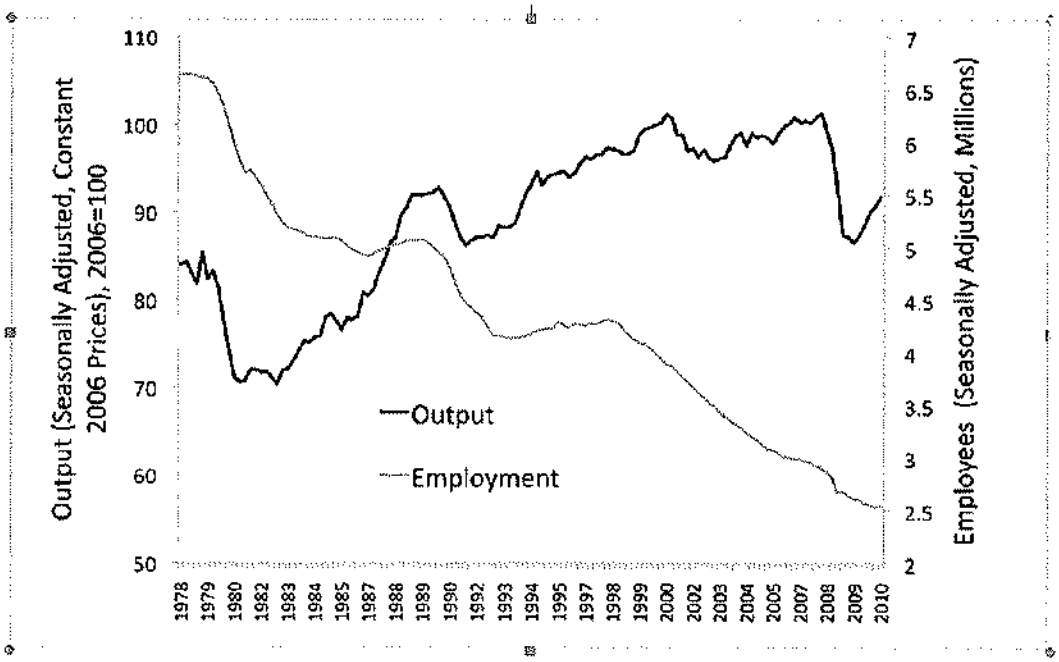
- **Cyclical sensitivity and recovery**: In terms of output, manufacturing displays variation in cyclical sensitivity and recovery times which raise questions about its contribution to resilience. Manufacturing output varies from recession to recession, and recovery to pre-shock levels of output typically takes much longer than the fall in output associated with the shock (Figure 2). In addition, the trend in manufacturing output growth seems to have slowed down markedly from the mid-1990s onwards.

- **Employment loss**: As an indicator of de-industrialisation, manufacturing employment has declined dramatically since the late 1970s and early 1980s recession reflecting productivity growth and structural transitions within the sector. In terms of the labour market, manufacturing employment has not proved resilient in being able to rebound to pre-recession levels following cyclical downturns within the broader economy.

- **Reliance upon external export markets**: As a tradeable sector, manufacturing can demonstrate a reliance upon external markets. This can be a positive contributor to growth and resilience but can also expose it to cyclical changes and instabilities that are beyond the influence of particular national governments. For example, the sovereign debt crisis and instability in the Eurozone is reducing demand for manufacturing exports from the UK and is the focus of efforts at resolution amongst the supranational institutions in the European Union and Eurozone Member States.

- **Government procurement contraction**: Austerity and state retrenchment in the wake of the global financial crisis have meant reductions in state expenditure and changes in the procurement of manufactures from producers in the UK. This has meant for example the cancellation of projects as well as tendering processes emphasising on cost efficiency and value for money that has involved competition from manufacturers with operations outside the UK. Where demand contracts then this can negatively affect the prospects and resilience of manufacturers in the UK more reliant upon government procurement for example in defence and transport equipment.

Figure 2: Real Output and Total Employment in UK Manufacturing, 1978(2)-2010(4)



Source of Data: http://www.statistics.gov.uk/statbase/TSDSeries1.asp

Given the combinations of potential and actual benefits and costs under specific conditions, the resilience of manufacturing in the UK has been a constant source of concern. Historically, taking a national level view, manufacturing tends to be deeply impacted during periods of recession. Table 2 illustrates the differential impact of recent recessions in production activities, demonstrating severe reductions in output and employment relative to services and the overall total. The definition of production activities here is broad and includes manufacturing, water, energy and construction – several of which activities are especially susceptible to cyclical change and involve varying relationships to manufacturing. Similarly, more recently, while the financial services sector received much attention as the cause and centre of the economic downturn from late 2008-, the manufacturing sector was equally affected in terms of job loss in the early stages of the initial recessionary period (Figure 3). Both economic activities lost around 250,000 workforce jobs in absolute terms but this constituted double the relative loss for manufacturing (8%) compared to financial and business services (4%). In the context of disruptive change, then, manufacturing in the UK seems not to cope especially well, often contracting and rationalising while finding it difficult to regain its size, weight and momentum in recovery. This adverse and apparently damaging reaction to shocks raises questions about the resilience of the manufacturing sector in the UK – its ability to withstand and bounce back from disruptive change – and its broader contribution to the UK's resilience. It raises concerns too about what is particular about the UK context that makes manufacturing struggle to recover in ways that are demonstrated by other more robust and resilient manufacturing sectors elsewhere for example Germany. The experience in Germany is considered in Section 6 below.

Table 2: A tale of three recessionary shocks: output and employment contractions in the UK economy

	1979-1983 recession		1990-1993 recession		2008-2010 recession	
	Output	Employment	Output	Employment	Output	Employment
Production	-14.6	-18.2	-6.7	-14.1	-14.7	-9.8
Services	- 2.4	- 1.9	-1.1	- 2.7	- 4.6	-1.4

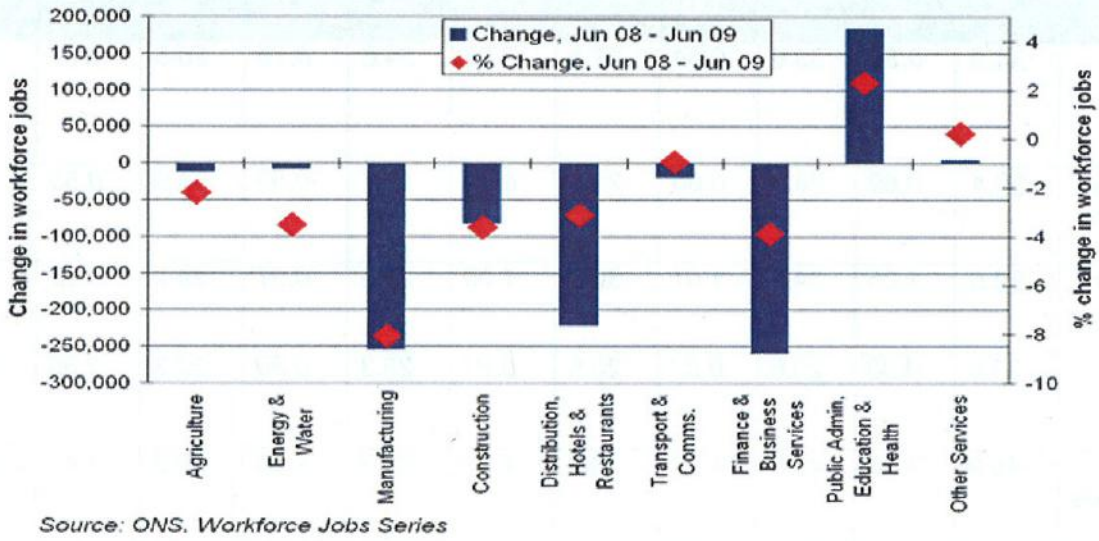
Notes: Contractions are measured in percentage terms from peak to trough in output and employment, respectively; output is GVA in 2006 prices; quarterly data in each case. The troughs in output typically occur sooner than those in employment, and the latter also takes longer to recover. Calculated from data available at http://www.statistics.gov.uk/statbase/. Production industries include: manufacturing, mining, energy, water and construction.

Source: Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32.

4.2 The geographical dimensions of manufacturing in resilience

Manufacturing in the UK has a particular geography. It has been shaped by the history of industrialisation and its subsequent evolution, shaped by deindustrialisation and the economically, socially and spatially uneven transition to a service-dominated economy. Table 3 illustrates the geographically differentiated dependence upon production industries across the regions in the UK and their evolution over time. In line with the national experience of a decrease from 39.9% to 17.6% of employment between 1971 and 2008, all regions have experienced substantial reductions – often more than half – in absolute levels of employment in production activities as a result of de-industrialisation and productivity improvements. The pattern becomes even more differentiated when the experience of specific regions is considered. The South East has experienced substantial absolute declines in levels of employment, falling from 34.3% to 15.6% between 1971 and 2008, and reductions in the spatial concentration of production activities, decreasing the location quotient from 0.86 to 0.66 over the same period. The manufacturing heartland in the UK – the West Midlands – has seen its proportion of employment fall from the highest level nationally of 50.4% in 1971 to 20.9% in 2008 while its location quotient has fallen from 1.56 to 1.34 over the same period. Indeed, the South West, East Midlands, North West, North East, Wales and Northern Ireland have all experienced declines in proportions of employment but *increases* in their relative geographical concentration in production activities, demonstrating their relative specialisations in production activities and degree of resilience in retaining at least some levels of manufacturing employment. Indeed, the promotion of agglomeration economies through the geographical concentration or 'clustering' of economic activities has generated evidence suggesting it may contribute to the competitiveness, sustainability and resilience of economic activities but remains the subject of debate (Martin and Sunley 2003). Manufacturing change in the regions, then, is geographically differentiated and the different manufacturing activities in each region are different in their abilities to respond and contribute to resilience challenges.

Figure 3: Change in workforce employment by sector, 2008-09



Source: Walne, D. (2009) Understanding the Impact of the Economic Downturn on Places, Paper for the Regional Studies Association Conference, November, London

The geography of manufacturing directly influences its contribution to resilience. How manufacturing contributes to resilience and how places cope with disruptive change is highly geographically uneven. In some places manufacturing plays an integral role in their capacity to remain unaffected or to adapt and bounce back from such challenges. For example, in a region with a strong export orientation, manufacturing businesses can export their way to recovery, generating a degree of resilience for the regional economy. While in other regions manufacturing can contribute to making them weaker, vulnerable and adversely affected. For example, in some regions highly reliant upon domestic consumer demand for their goods and services can be adversely affected by recession and the collapse in consumer confidence. Similarly, in periods of state retrenchment and austerity, manufacturing businesses reliant upon public procurement and government contracts can suffer from a negative demand shock.

In existing work, classification and typology of the resilience of places has been deployed. Chapple and Lester (2007) focus on start and end status for below (stagnant, faltering) and above (transformative, thriving) average performance for cities and counties across an array of economic and social indicators. Hill *et al.* (2008: 5) identify three kinds of responses to negative economic shocks: economically resilient regions returning or exceeding their growth path within relatively short time periods; shock-resistant regions not disturbed from their growth paths; and, non-resilient regions "unable to rebound and return to or exceed their previous path".

Table 3: Regional dependence on production industries, selected years (% of total numbers employed and location quotient)

	1971		1979		1983		1990		1992		2008	
	%	LQ	%	LQ	%	LQ	%	LQ	%	LQ	%	LQ
South East	34.3	*0.86*	30.6	*0.84*	27.1	*0.83*	24.8	*0.75*	20.5	*0.77*	15.6	*0.66*
Greater London	30.1	*0.69*	24.3	*0.66*	21.5	*0.64*	17.7	*0.53*	14.9	*0.55*	10.3	*0.47*
Eastern	39.0	*1.05*	34.9	*1.01*	30.7	*1.00*	27.5	*0.91*	24.2	*0.98*	18.9	*1.00*
South West	33.5	*0.80*	29.6	*0.83*	26.5	*0.81*	25.3	*0.80*	22.3	*0.86*	17.4	*1.01*
East Midlands	48.9	*1.30*	43.3	*1.27*	38.2	*1.24*	34.3	*1.26*	30.2	*1.40*	23.0	*1.43*
West Midlands	50.4	*1.56*	44.6	*1.41*	38.1	*1.34*	33.9	*1.32*	29.6	*1.41*	20.9	*1.34*
Yorks-Humber	46.5	*1.21*	40.9	*1.16*	34.4	*1.05*	30.7	*1.08*	27.4	*1.16*	20.8	*1.15*
North West	44.1	*1.10*	38.1	*1.15*	*31.9*	*1.09*	*29.5*	*1.08*	*25.6*	*1.15*	*18.7*	*1.14*
North East	45.1	*1.16*	40.7	*1.09*	*33.7*	*1.06*	*30.5*	*1.04*	*25.9*	*1.12*	*20.0*	*1.17*
Wales	41.0	*1.17*	36.3	*1.15*	*31.3*	*0.86*	*28.1*	*0.97*	*26.2*	*1.13*	*20.4*	*1.20*
Scotland	39.6	*0.93*	34.5	*0.92*	*29.4*	*0.86*	*26.6*	*0.85*	*23.5*	*0.91*	*17.6*	*0.88*
Northern Ireland	39.7	*0.89*	33.0	*0.91*	*26.8*	*0.82*	*26.2*	*0.86*	*24.1*	*0.99*	*19.9*	*1.09*
UK	39.9	*1.00*	34.9	*1.00*	30.9	*1.00*	27.0	*1.00*	23.6	*1.00*	17.6	*1.00*

Note: Production industries include: manufacturing, mining, energy, water and construction. Calculated from data supplied by Cambridge Econometrics. The data are mid-year estimates.

Source: Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32.

Experience of previous recessions in the UK demonstrates how London and the Greater South East with their combination of manufacturing and services have typically recovered much faster and more robustly than other regions (Martin 2012). Table 4 demonstrates how employment is lost much more readily in production activities across the regions in recessionary shocks. Wales, for example, lost over a quarter of its employment in production during the 1979-83 recession. This negative employment effect was much reduced in the more services-oriented recessionary shock in 1990-93. Services demonstrate lower levels of employment reductions or even manage to increase employment during recessions, for example services in the South West during the 1979-83 shock. Although, crucially, the picture is highly geographically differentiated by region with the North East losing more than 5% of its services employment in the early 1980s recession. Manufacturing in the UK regions, then, appears more vulnerable and less resilient to recessionary shocks in terms of employment change and this is geographically differentiated across regions.

Table 4: Regional responses to two major recessionary shocks: employment change in production and services (%)

	1979-1983 recession		1990-1993 recession	
	Production	Services	Production	Services
South East	-12.1	4.7	-24.6	-3.1
Greater London	-17.9	-3.5	-25.5	-8.2
Eastern	-11.9	7.8	-18.6	-3.0
South West	-9.6	4.8	-15.9	-0.5
East Midlands	-15.7	4.4	-16.5	0.7
West Midlands	-21.9	1.5	-21.0	-3.2
Yorks-Humber	-23.1	1.7	-16.3	1.1
North West	-25.0	-4.1	-19.2	0.1
North East	-26.3	-5.5	-19.1	1.0
Wales	-26.7	-2.2	-10.8	-1.3
Scotland	-22.3	-1.5	-12.9	2.5
Northern Ireland	-22.7	2.4	-8.3	3.7
UK	-19.4	0.6	-18.8	-2.3

Note: Production industries include: manufacturing, mining, energy, water and construction. Calculated from data supplied by Cambridge Econometrics: these data are yearly rather than quarterly, so the recessions are defined in terms of peak and trough years (as measured by national employment).

Source: Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32

The emerging analysis of the recent global financial crisis and recession is revealing similar patterns of geographically differentiated change in manufacturing. Manufacturing places have been hardest hit (Industrial Communities Alliance 2009) but, significantly, are recovering more strongly in some parts of Europe (Davies 2011). Importantly, in the wake of the global financial crisis, national government policy is seeking a 'rebalancing' of the UK economy sectorally towards manufacturing as well as spatially away from reliance upon London and the Greater South East. This aim is being translated into the need to grow manufacturing in absolute and relative terms within the UK.

V. Gaps in the contribution of manufacturing to UK resilience

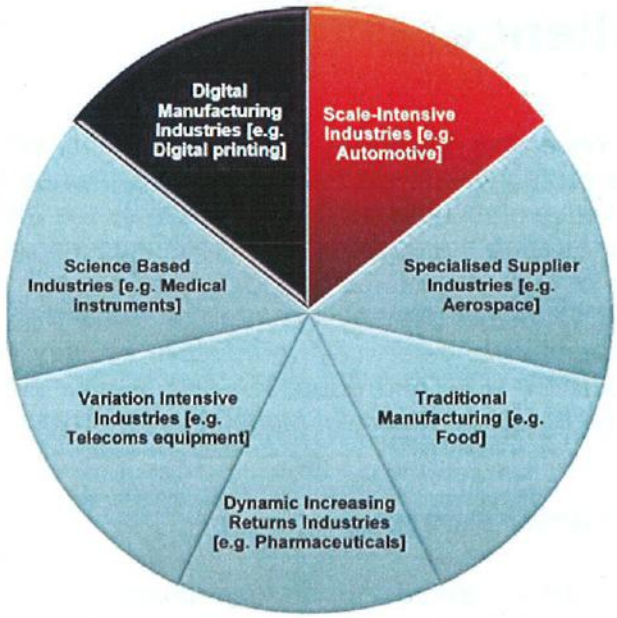
Having defined resilience and examined its measurement, established the importance of manufacturing and its contribution to UK resilience and explained the geographical dimensions of the differential resilience of manufacturing places across the UK, this section identifies some of the key gaps in considering the contribution of manufacturing to UK resilience. Issues were selected on the basis of their importance and longer term relevance. Issues addressed in this section include 'smart' industrial strategy, geography, ownership, global production networks and broken supply chains, 'manu-services', productive security and adaptive capacity. Other issues including innovation, skills and education and finance are relevant but the subject of other reviews within the Foresight *Future of Manufacturing* project.

5.1 'Smart' industrial strategy

Recent research has demonstrated the entrepreneurial role of the state as an industrial strategy and policy actor, proactively creating, shaping and nurturing private sector activity rather than leaving its development to purely market-led outcomes (Mazzucato 2011). In this work, new and smarter forms of industrial policy are distinguished from traditional approaches typically derided as 'picking winners', 'subsidising lame ducks' and seeking artificially to stimulate demand. Smart industrial strategy involves states being proactive and entrepreneurial, taking risks to harness the best of the private sector and working in a catalytic way to initiate reactions that lead to the wider diffusion of innovation.

Central to 'smart' industrial strategy is the recognition of the diversity and variety of manufacturing activities (Figure 3). Each kind of activity has different roles, needs for policy support and potential contribution to broader resilience. While the US is often cited as the exemplar market-led economy, Mazzucato (2011) demonstrates how it has proactively pursued 'hidden' industrial strategy by shaping and encouraging bottom-up initiative in a distributed and decentralised way in activities identified as strategic with wider positive implications such as nano-technology. In contrast to horizontal, non-sectoral and supply-side forms of policy, 'smart' industrial strategy approaches recognise the sectoral specificity of particular forms of manufacturing. Going beyond the overly broad categories of high, medium and low technology, smart approaches seek more tailored and targeted forms of support. These attempt to respond to the very different requirements and geographies, for example, between traditional manufacturing such as food processing and science-based industries such as medical instruments.

Figure 3: Types of manufacturing business



Source: Roos, R. (2011) What does the future hold for manufacturing in South Australia?, Public Lecture, Adelaide Town Hall, September.

International experience is revealing the limitations of purely market-led approaches to manufacturing and its role in resilience whereby manufacturing is typically left to cope with cyclical fluctuations and demand shocks. Smarter approaches are beginning to frame the need for clearer understanding and specification of the role of government and the potential and pitfalls of modern and smarter industrial strategy and policy. The suspicion is that the ways in which manufacturing in the UK regions is more acutely affected by economic downturn and recession (see Section 4) may be because of an over reliance upon market-oriented adjustment when other countries are taking a more strategic and supportive view to adaptation in manufacturing. New approaches more closely examine which parts of the manufacturing system or sectors are and could be most significant in contributing to resilience. They identify and prioritise the key areas of manufacturing and their regional concentrations where long-term advantages are being constructed which may yield commercial and wider benefits for resilience and adaptive capacity. For the UK, this involves asking specific questions about what are the different roles and needs of key strategic manufacturing activities in the UK including aerospace, automotive, bio-sciences, environmental technologies, high-specification engineering, new materials and pharmaceuticals. In terms of future development to 2050, the issue of 'smart' industrial strategy raises a number of questions:

- Can the UK Government's market-led view accommodate a more proactive approach to 'smart' industrial strategy and policy?
- Will the market-led approach disadvantage manufacturing in the UK relative to its competitors given the strategic priority and support they receive from their respective governments?
- Can a market-led approach alone deliver the kind and degree of sectoral and geographical rebalancing envisaged by Government policy?
- Will a market-led approach enable and deliver the long-term investments in innovation

capacity and potential for the future success and resilience of manufacturing in the UK?

5.2 Geography

As demonstrated above, manufacturing activities in the UK have a distinct geography and this matters for their contribution to resilience at the sub-national and national levels. The pattern of change in manufacturing activity across the UK is reinforcing the specialisation of specific regions, especially those beyond London and the Greater South East – although it is important to recognise the absolute importance of manufacturing within these regions even though its relative size is less than services. Therefore, the geographical dimensions of manufacturing and its contributions to resilience are important. In the context of 'smart' industrial strategy, where manufacturing is located and concentrated can influence its relative performance, for example where significant agglomerations enhance innovation performance and skills upgrading in local labour markets (see, for example, DTI 2001). This geographical dimension was recognised in recent government initiatives such as 'New Industries, New Jobs' under the previous administration. 'Smart' industrial strategy and policy, then, can fruitfully incorporate this geographical dimension rather than taking a spatially-blind or neutral national outlook.

Significantly for future development to 2050, in the context of the UK government's aim of sectoral and spatial 'rebalancing', for some key sectors the emergent manufacturing activities with growth potential are predominantly located in peripheral locations within the UK. Offshore wind energy, for example, is an area of growth potential and the footprint of its potential generation area and manufacturing growth highlight the importance of especially the northern and eastern regions of the UK (Case example 1). Connecting future development trajectories to renewable sources of energy and the manufacture and servicing of its infrastructure hold possibilities for maximising the contribution of manufacturing to UK resilience and rebalancing through a focus upon particular areas.

Case example 1: Offshore wind energy

Having installed its first demonstration sites in 2000, the UK has accelerated into the world's largest market for offshore wind. In the longer term, projections estimate a market worth £19billion per annum and the creation of 250,000 jobs by 2050 (Carbon Trust 2010). Given the size and scale of the undertaking, over 6,000 turbines are forecast to be installed by 2030 (Carbon Trust 2012), significant manufacturing activity is already taking place to meet growing demand in various coastal localities proximate to the key market of the UK North Sea. In particular, the North East of England pioneered the development of offshore wind in the UK through the installation of various national demonstration projects including the Blyth Offshore Wind Farm in 2000. One North East (ONE), the recently abolished Regional Development Agency, subsequently identified offshore wind as a key industry for the region's future which could build upon and convert historical assets such as the skills, shipyards and engineering infrastructures developed previously in shipbuilding and oil and gas fabrication. The strategic activities of ONE helped develop a world leading R&D asset base (National Renewables Energy Centre - NaREC) and support the diversification of existing firms in related industries into the new and emerging market. By 2010, over £300m of offshore wind contracts had been delivered by North East firms and over 250 firms have been identified as either already operating in this field or having strong potential to do so (NELEP 2011). Whilst the North East offers a competitive advantage in terms of diversification, other northern localities are also seeing significant manufacturing investment, for example Siemens' decision to build a new £80m turbine factory in Hull, creating 700 direct jobs.

Building a geographical sensitivity into considerations of manufacturing and its contribution to resilience provides a way of focusing attention and mobilising institutional actors. A regional or local dimension to manufacturing growth can enable examination of its potential contribution to resilience, for example through local supply chain development and skills upgrading. In terms of future development to 2050, the issue of the geography of manufacturing raises a number of questions:

- How can a geographical dimension be built into considerations of national industrial strategy and policy for manufacturing?
- In what ways can a geographical focus enable the maximisation of the contribution of manufacturing to resilience at the regional and local levels and for the national level of the UK?
- Can a market-led approach deliver the kind and degree of sectoral and especially *spatial* rebalancing envisaged by Government policy?

5.3 Ownership

The question of who owns manufacturing activities in the UK is longstanding. The UK's historically open and international political economy has meant the UK has a liberal market for corporate control and the City of London performs a pivotal role as an international financial centre servicing mergers and acquisitions activities. The prevailing view is that foreign ownership of UK manufacturing activities does not matter. Especially in the context of globalisation, the national domicile of ownership is seen as less important than the creation of output and employment within the UK national territory. Yet periodic concerns emerge when well known 'British' brands are bought and sold in merger and acquisition activity and capacity in R&D, production and assembly is rationalised or outsourced internationally, leading to economic costs and losses to the UK (Kay 2004). The market-led approach risks creating a less resilient manufacturing sector. The liberal regulatory context can be contrasted with the more interventionist strategy and regulation elsewhere especially continental Europe where ownership is seen to matter more and – even in the shared legal frame of EU competition law – questions of strategic economic development and the public interest form part of decision-making and takeover regulation.

Foreign ownership of manufacturing reflects longstanding concerns about external control and the evolution of the 'branch plant economy' in manufacturing in the UK and especially its production-oriented regions and nations (Firn 1975). Table 5 illustrates the characteristics of the branch plant across a range of dimensions. Important for the discussion here are the potential downsides to the contribution of manufacturing branch plants to resilience in the UK and the view that manufacturing activity in the regions has been adversely affected in economic downturns as a consequence of its external ownership and control (see Section 4). Branch plants, for example, tend to be the first to be rationalised during economic downturns and their lack of strategic functions and autonomy limits their potential for upgrading. Some have related the evolution of the 'branch plant economy' to the lightly regulated economy and labour market in the UK in which it is easier and cheaper to close plants and both hire and fire labour – especially for foreign-owned firms (Ashcroft and Love 1993). This is in contrast to the more regulated co-ordinated market economies in continental Europe where it is more costly and onerous to close capacity and reduce employment (Pike and Dawley 1999). With the cost-cutting, 'race to the bottom' route effectively closed off by regulation, manufacturing in

Germany, for example, has focused upon innovation and upgrading to higher value-added activities for its competitiveness (Streeck 1991). The regulatory and institutional context, then, is integral to shaping and supporting the contribution of manufacturing to resilience.

Table 5: Branch plants and performance/networked plants

Branch Plant	Performance/networked Plant
Role and autonomy • External ownership and control; structured position and constrained autonomy; • Truncated and narrow functional structure involved in part- process production and/or assembly; • Cloned capacity and vertically inte- grated with limited nodes capable of external local linkage (for example, suppliers, technology); • State-policy subsidised establishment via automatic grants to broadly designated areas	*Role and autonomy* • External ownership and control but possible enhanced strategic and operating autonomy as well as responsibility for performance increased within a flattened hierarchical structure; • Wider functional structure involved in full process production tilted toward manufacturing rather than solely assembly; • Sole capacity with product (range), division or market mandate at the expense of rationalisation elsewhere; • Increased nodes capable of linkage (for example, R&D with technology support, human resources with training); • State-policy support for establishment on selective and regulated basis (for example, job creation, local content)
Labour process • Labour-intensive, semiskilled and unskilled work; • Routinised and specific tasks within refined technical division of labour; • High-volume production of low to medium technology products; • Standardised process technology; short-term, task-specific, on- the-job training integrated with production	*Labour process* • Capital and technology intensive, semiskilled and skilled work with increased need for diagnostic and cognitive skills; • Recombined job tasks and individual/team responsibility for performance; • Low to high technology and low to high volume production flexibility; • Flexible and reprogrammable process technology; • Longer term, co-ordinated with investment, on-the-job and off-the-job training

Labour-market strategies • Employees considered interchangeable, replaceable, and in need of constant super- vision; • Limited screening and high labour turnover and absenteeism; reliance on external labour market	*Labour-market strategies* • Rigorous scrutiny and increased selectivity in recruitment; employees as human resources needing investment; • Teamworking to reduce labour turnover and identify employee with the goals of the company; • Development of core internal labour market and peripheral (part-time, temporary) segments
Supplier linkages • Limited since integration with broader corporate structures of production and supply chains; • Intra-firm linkages substituted for local ties; • Limited local supply-chain knowledge and greater awareness of potential suppliers in headquarters region	*Supplier linkages* • Outsourcing increase with just-in-time (JIT) and synchronous suppliers; • Increased potential for local procurement and supplier agglomeration; • First and second tier supply chain management; • Increased global sourcing and partnership relations; • Growth in dependence in the local supply network; • Geographically distributed production networks and JIT operated over (inter)national distances
Local economic development implications • Externally owned and controlled plants with limited decision making powers locally ('dependent development', 'branch-plant economy') • Vulnerable to closure or relocation ('footloose', 'runaway industries', 'hypermobile capital'); • Limited growth rates in employment and output; • Low technology and skills ('screwdriver plants'); • Few local linkages ('enclave development', 'dual economy', 'industrialisation without growth', 'cathedrals in the desert'); • Diversified industries not building upon or modern-ising existing	*Local economic development implications* • New concepts of externally owned and controlled plant with increased decision making autonomy for strategic and operational issues, more rooted and anchored in the local economy ('embedded firm'), higher levels of technology and skills, higher innovative potential, more local linkages and increased technology transfer through research and technological development functions; • Supplier links upgrading process technology improvement and partnership development with suppliers; • Potential for the plant to be a

regional industrial strengths; • Limited innovation potential and technology	'propulsive local growth pole', 'vehicle/catalyst for local economic development' and capable of setting in train 'sustainable transfer from dedicated production processes development and suppliers

Source: Pike, A. (1998) "Making performance plants from branch plants? In-situ restructuring in the automobile industry in UK Region", Environment and Planning A 30: 881–900

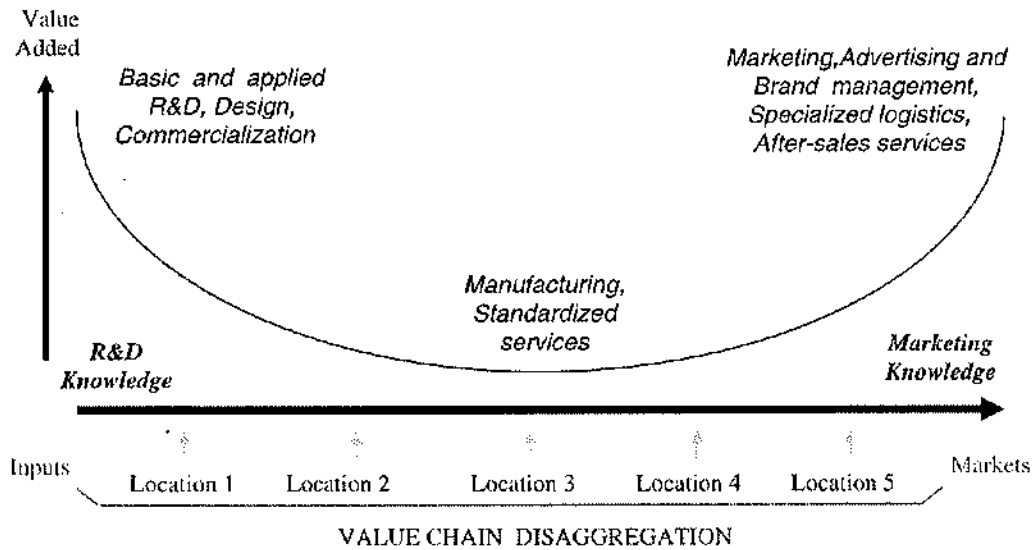
Research has explored whether and to what extent new 'performance plants' are evident in manufacturing in the UK and beyond. Performance plants may offer potentially greater contributions to the resilience of the UK in terms of output, employment and future development potential through their greater autonomy, higher level functions and more strategic roles within their global production networks. If a plant is given greater autonomy, for example, it can develop stronger local linkages to local supply chains and technological support embedding the activity locally and making relocation elsewhere in the UK or beyond more difficult and costly. The question of ownership is an important gap in current discussions about manufacturing in resilience in the UK. Connecting with concerns about 'smart' industrial strategy, in terms of future development to 2050, the issue of ownership raises a number of questions:

- What difference does the domicile of ownership make to the contribution of manufacturing to the resilience of the UK?
- Does it matter in strategic development terms if manufacturing is *in* rather than *of* the UK?
- How could regulation and the institutional context shape the ownership of manufacturing in the UK in developmental ways that contribute to broader resilience?

5.4 Global production networks and broken supply chains

New forms of corporate organisation for manufacturing are understood as 'global production networks' (Coe *et al.* 2004). Global production networks connect manufacturing to broader value chain systems for the supply of goods and services – organised internationally across the world. They contain a range of functions from high-level headquarters, R&D and decision-making centres through inter-mediate co-ordinating activities, bespoke marketing and branding to lower level assembly, production and service delivery functions. Increasingly, businesses are 'fine slicing' their activities into discrete tasks and locating them in the most appropriate places within more internationalised and integrated global production networks (Mudambi 2008). Figure 4 demonstrates the value chain and its potential geographical distribution of activities.

Figure 4: Value creation organisation



Source: Mudambi, R. (2008) "Location, control and innovation in knowledge-intensive industries", Journal of Economic Geography, 8, 699-725.

To understand the contribution of manufacturing to resilience it is important to consider the role and position of the manufacturing activities in the UK within these broader and globally organised systems. Manufacturing activities in the UK can be part of single or multiple global production networks and assume different roles and positions within them. Their respective roles and positions shape the nature of their activities (e.g. output, employment, occupational structure) and their potential for future development (e.g. strategic functions, investment, innovation capacity). The extent and nature of the connection between manufacturing activities in the UK regions and their global production networks strongly shapes their vulnerability and resilience during economic downturns and recessions as the discussion about branch and performance plants demonstrates (See Section 5.3).

Broken supply chains can emerge for particular geographical territories within global production networks and value chains in several ways. First, when manufacturing activities are locked-in to supply relationships that are disadvantageous to their contribution to the resilience of the UK as a result of their role and position within broader global production networks. When, for example, automotive assembly plants are importing engines and transmissions from beyond the UK. These are high value-added manufactures generated as output and employment outside the UK and counted as high value imports in the UK trade balance. Their particular geography of production enables strategic industrial development and innovation potential to be captured by interests outside the UK.

Second, especially in advanced and high volume manufacturing activities, the supply relationships within global production networks often follow lean and Just-in-Time principles with low inventories. Organised over geographically stretched distances, this renders the supply chain vulnerable to breakage in the event of disruptive events such as labour disputes and strikes, hazards and extreme weather events. The knock-on effects of the earthquake and tsunami in Tohoku, north east Japan, in 2011, for example, affected manufacturers of key components and their ability to supply Japanese-owned assembly plants in the UK with Honda and Toyota particularly affected (Bland and Kwong 2011). This demonstrated a lack of resilience in the manufacturing activities in the UK and adversely affected the factories, workforces, companies and other suppliers (Case example 2).

Case example 2: Supply chain disruption

The aftermath of the earthquake and tsunami in Japan in 2011 revealed the dependency of automotive production in the UK and globally upon the transnational organisation and ownership of vehicle assembly and component supply. As the world's second largest automotive producing nation, the disruption to Japan's output of components, particularly electronic, triggered a 4.2 million units reduction in global vehicle production in 2011 (Canis 2011). In the UK, the impact upon Japanese-owned assembly and component plants led to a 12.4% reduction in UK car output in April 2011. With around 10-15% of components sourced from Japan, the disruption led to a 3-day closure at Nissan in Sunderland, reduced working time and output at Toyota's plants in Derbyshire and North Wales and production was more than halved at Honda's Swindon plant between March and August, forcing a two-day week, and the loss of over 22,000 cars in 2011 (Bawden and McCurry 2011, Kollewe 2011). Although rates of UK production and employment recovered within 6 months, the episode served to raise debate about the resilience of supply-chain logistics, including issues around: (re)localising component manufacture ('on-shoring' as opposed to 'off-shoring'); diversifying the supply base; and, mitigating rising costs of insurance for supply-chain disruption. More generally, the case of the automotive sector appears indicative of a broader trend reported within UK manufacturing, with small and medium sized firms increasingly sensitive to the potential vulnerabilities of overseas suppliers compared to domestic suppliers and the resilience of their supply chains (EEF 2012).

As discussed above, ownership and control matter in shaping manufacturing and its contribution to resilience (See Section 5.3 above). Ownership and control issues are integral to the structure and organisation of global production networks and the position and role of places within them. The outsourcing logic of international sub-contracting to lower cost locations globally depends upon the manufacturing activity involved and is shaped by the talent and skills requirements as well as the composition of costs. It is important, then, to recognise the importance of the position and role of manufacturing within global production networks and

how this contributes to – or detracts from – resilience in the UK. In terms of future development to 2050, the issue of global production networks and broken supply chains raises a number of questions:

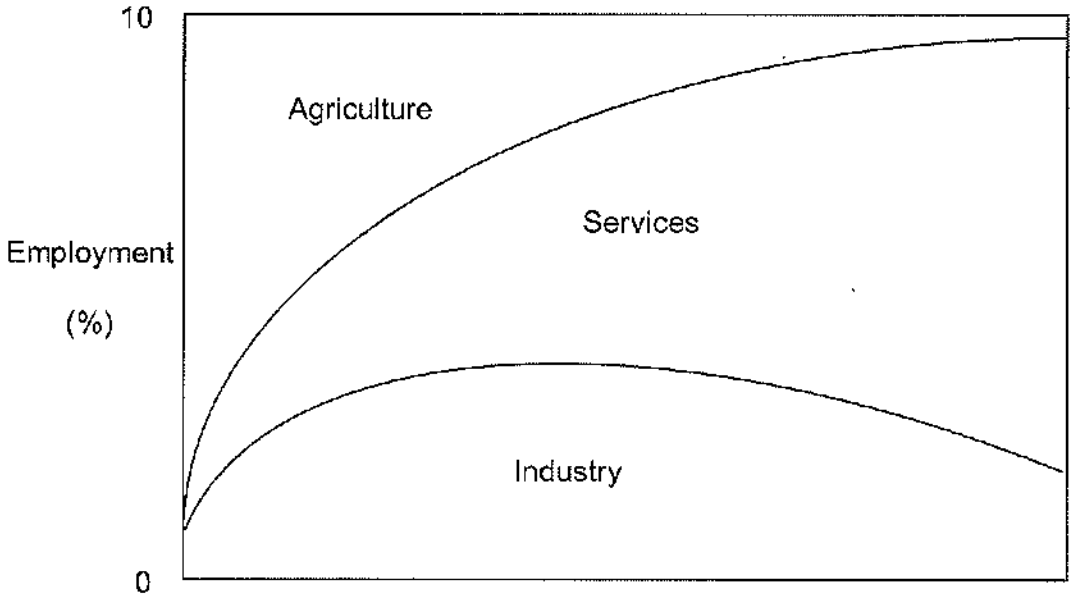
- When and where can supply chain links be mended to support the contribution of manufacturing in the UK to resilience?
- How can 'smart' industrial strategy and policy shape the position and role of manufacturing in the UK within broader global production networks in ways advantageous to resilience?
- What can be done to connect manufacturing in the UK to global production networks in ways that encourage its resilience?

5.5 'Manu-services'

The traditional stages model of economic development foresaw transition through distinct categories from primary (extractive) to secondary (manufactures) to tertiary (services) to quaternary (intellectual, knowledge-based) as part of national economic modernisation (Figure 5). Each stage proceeded sequentially, shaping the structure of employment and economic activity. Greater resilience accompanied the progression through stages. Countries moved on from primary activities dependent upon unprocessed commodities buffeted by world market dynamics toward sophisticated secondary activities adding value by making things and competing by specialisation. Further advance was achieved by developing specialised services adding further value and sophistication and, most recently, the transition toward the knowledge-based economy and the application of sophisticated knowledge in new products and services creating defensible positions against lower cost competition and imitation. This model has received criticism due to its overly simplistic and inexorable temporal logic (i.e. all countries pass through the same stages) and the crude categorisation of activities that has been unable to conceive of the inter-relationships between different kinds of economic activities within particular countries (i.e. the importance of retaining a strong manufacturing sector even in a service dominated economy). The model has been influential, however, for policymakers who identify manufacturing with past economic stages and services and quaternary activities with the future.

A specific area where the stages model falls short is in the emergence of 'manu-services' where firms combine goods *and* services into packages (Sissons 2011). While historically the links between manufacturing and services have been important, especially in relation to finance (Coates 1994), the advent of 'manu-services' represents a new level and character of connection and integration. Examples include manufacturing firms such as Rolls Royce and BAE Systems that do not just sell goods but goods integrated with services packages as 'solutions', 'outcomes' or 'experiences'. Typically, this involves manufacturing businesses used to producing tangible things having to understand and invest in *in*tangible assets such as R&D, design and brand equity (Case example 3). Indeed, many commodities within the economy integrate material goods with services for example mobile phones and laptop computers. 'Manu-services' can potentially benefit from the UK's strengths in having a highly skilled and adaptable workforce, a strong and internationalised service sector, and high quality universities and research and technological development institutions (Sissons 2011).

Figure 5: Changes in employment (%) and per capita income over time by sector



Source: Pike, A. (2011) "Deindustrialisation" in N. Thrift and R. Kitchin (Eds.) International Encyclopedia of Human Geography, Elsevier: Oxford.

Case example 3: Intangibles

Manufacturing has traditionally been seen as an important contributor to capital stock through its investment in tangible assets such as production machinery and factories. Recently, manufacturing is investing higher levels of capital in intangible assets including R&D, design and brand equity (Sissons 2011). This change is because manufacturing increasingly uses knowledge and technology for differentiation and a defence against imitation by lower cost competition. Recent research estimated that UK manufacturing invested 20% of its value-added in intangibles, worth £35bn annually, and this was more than three times higher than the £12bn investment in tangible assets (NESTA 2011). Of the different forms of intangible assets, investment in R&D and design are most important to manufacturing followed by human capital, organisational capital and software. Different forms of intangibles are important for different manufacturing sectors, for example R&D is key in pharmaceuticals whereas branding is critical in clothing. In the context of the knowledge economy, investment in intangibles is becoming a more important element of the competitive success and resilience of manufacturing.

The evolution of manufacturing beyond just making things has implications for its contribution to resilience in the UK. First, manu-services can be seen as an area of non-technological and 'soft' innovation. This raises the challenge for manufacturing businesses in thinking how new packages of goods and services can meet existing, new and unmet needs and how this might be profitably and sustainably delivered. This may involve the ways in which the

manufacturers interact with their customers and suppliers as well as how they organise their innovation activities and marketing. Second, to benefit from the growth of manu-services and underpin their own future resilience, manufacturing businesses will have to adopt different ways of thinking and business strategies and models. This will include fundamental review and reflection on what manufacturing businesses do and how they do it, often requiring new ways of organising and new skills.

While the UK has strengths in several leading high-technology sectors it lags Germany, Japan and France in the number and size of its high- and high-medium technology manufacturing (Sissons 2011). Manu-services therefore provide a particular area where differentiation and competitive advantages may be constructed that can contribute positively to resilience. In terms of future development to 2050, the issue of 'manu-services' raises a number of questions:

- How can smart industrial strategy and policy support the networks for the non-technological innovation required by manu-services?
- How can the barriers of risk, capital and transition faced by manufacturing firms keen to develop manu-services be overcome?
- Will manu-services firms be able to make a stronger contribution to resilience in the UK than just manufacturing firms?

5.7 Adaptive capacity

Adaptive capacity is a key issue in the geographically differentiated resilience of places. Adaptive capacity can be defined as the abilities of actors and institutions to accomplish and shape reinvention when established practices and organisations are undermined by adversely shifting conditions and contexts. This idea connects manufacturing to resilience by exploring how manufacturing can contribute to preparedness or robustness in the context of disruptive change. An important distinction is between adaptation and adaptability. Adaptation refers to the movement toward a pre-conceived path in the short-run, characterised by strong and tight relationships between actors in places. Adaptation occurs, for example, where existing vested interests in a particular manufacturing sector are locked-in to particular ways of thinking, functional supply relationships and political outlooks that underpin their focus solely upon the renewal and rejuvenation of their particular sector. An example is when shipbuilding regions maintain their focus upon modernising their shipbuilding capacity despite changing market contexts (Eich-Born and Hassink 2005). Adaptability, in contrast, refers to the dynamic capacity to initiate and unfold multiple evolutionary trajectories, through looser and weaker relationships between actors in place, that enhance the overall responsiveness of the system to unforeseen changes. Adaptability is evident, for example, where various unlocking strategies such as innovation and diversification are explored as a means to open up new, perhaps diversified, and related economic trajectories connected but not confined by existing interests and specialisations in a specific area of manufacturing. An example here is shipbuilding regions utilising their maritime engineering and manufacturing skills to enter new markets for oil and gas exploration and extraction equipment, sub-sea and renewable energy technologies (Dawley 2012).

Adaptive capacity is important in considering manufacturing's contributions to resilience because it highlights the qualitative and quantitative dimensions of adaptive change over time. In particular, it asks what kinds of manufacturing activity remain after disruptive change and what are their potential contributions to resilience? Feyrer *et al.* (2007), for example,

demonstrated how in the late 1970s and early 1980s auto and steel-dominated localities in the US regained 'pre-shock' employment levels within five years but ended up being displaced onto low growth and less resilient development paths. Lack of manufacturing renewal in former coalfield communities in the UK rendered them less rather than more resilient following the demise of the coal industry. These coalfield communities only regained quantitative levels of employment 20 years after the demise of the pits. But the qualitative nature of employment was markedly different with more women working, lower wages, more service sector jobs, increased use of flexible and temporary contracts and generally poorer terms and conditions (Beatty *et al.* 2006).

Emergent research on adaptive capacity has distinguished a continuum between strong and weak versions with particular implications for manufacturing and its contribution to resilience (Pike *et al.* 2012):

- **'Strong' adaptive capacity** exists in places that are better able to prepare for and cope with disruptive economic change. Typically, such places exhibit related variety – that is economic activities diversified across and between specialisations – in their economic structures enabling cross fertilisation of ideas across sectors, innovation and entrepreneurship for economic renewal. Institutional actors and relationships are adaptive and flexible in interpreting, preparing for and responding to disruptive change. Such characteristics help places maintain advantageous positions in the wider networks of global productive networks and governance systems to access knowledge and resources across geographical scales. This echoes the argument that diversified economies are more adaptable because they act as a 'shock absorber', dissipating negative effects across an array of economic activities and places rather than concentrating and reinforcing them. Boston, US, has demonstrated strong adaptive capacity on the basis of its historical record in recovering strong growth trajectories following episodes of disruptive economic change during the early 1980s (the so-called 'Massachusetts Miracle') and 1990s. Boston demonstrated adaptive capacity and resilience rooted in its deeply embedded innovation strengths, diversified but often cross-fertilising economic structure (bio-sciences, financial services, healthcare, higher education, high-technology), and institutional capacity for collective action during periods of crisis and renewal (Glaeser 2005).

- **'Weak' adaptive capacity** exists in places with overly specialised and insufficiently related economic structures dependent upon a narrow range of specialisms such as chemicals or steel manufacturing. Such places are unable to effect innovation and entrepreneurialism for economic reinvention and are locked-in to attempts at adaptation and modernisation of existing activities rather than adaptability and the fostering of new growth paths. Institutional connections between actors exhibit lock-ins and the institutions are unable effectively to interpret, prepare for and react to change in developmental ways. Actors and institutions are unable or unwilling to reconfigure and adapt their structures and relationships. Overall, increasingly marginal positions within wider networks are reinforced by the lack of adaptive capacity in place. Hainaut, Belgium, has demonstrated weaker adaptive capacity because it has undergone a protracted run-down of its traditional economic activities in coal and steel, and struggled to find and mobilise alternative growth trajectories amidst institutional contestation between regional capital, the regional and national state, and trade unions (Janssens 2002).

Critical here is an understanding that sees disruptive change as ongoing and constant requiring governance actors to establish adaptive institutional arrangements and policy approaches to prepare and proactively shape change rather than just reactively coping and reacting to it.

In terms of future development to 2050, the issue of adaptive capacity raises a number of questions for manufacturing and its contribution to resilience:

- How can the adaptive capacity of manufacturing be shaped in positive ways to enhance its contribution to resilience?
- Where manufacturing is locked-in and unable to demonstrate adaptive capacity what can policy do to promote un-locking and adaptability?
- How can institutions create the kinds of adaptive governance relationships vital to supporting adaptive capacity and its contribution to resilience?

VI. International perspectives

Learning from experience internationally is vital especially from those nations and localities that have demonstrated the value and importance of manufacturing in their resilience, identifying and learning from places that have "bounced back" and "turned a corner" (Pendall et al. 2007: 18). Manufacturing makes different contributions to output and employment in different countries. These differences are important in considering the different contributions of manufacturing to resilience. Manufacturing in the UK in particular has much to learn from international experience given its relative decline as a proportion of UK GDP from 22% to nearly 11% between 1990 and 2009 – a trend more pronounced in the UK in comparison to other industrialised nations (BIS 2010b) (Figure 6).

Davies' (2011) recent analysis of regional experiences of the economic downturn, recession and recovery found a somewhat mixed picture across Europe as well as a particular role for manufacturing. The research found that:

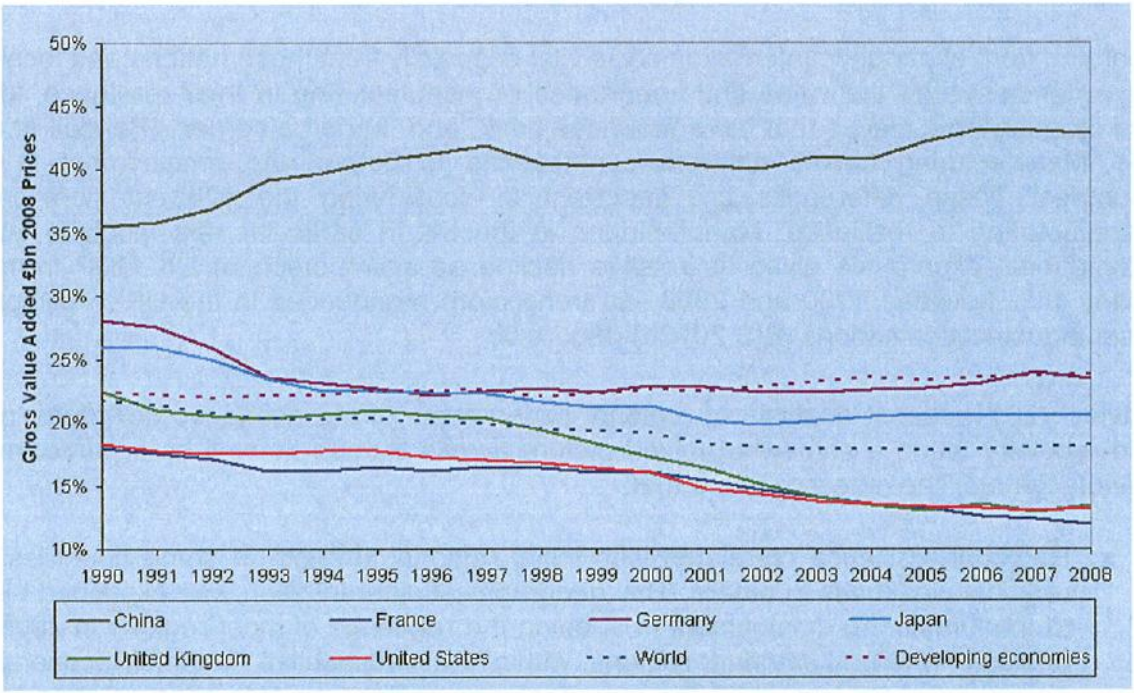
- Regional resilience correlated with initial regional strength in some countries but with regional weakness in others. This geographical differentiation was explained by the role of manufacturing employment in shaping the resilience of most regions in 2009 and the position of manufacturing regions within their respective national economies. The disproportionate impact on the manufacturing sector was also seen as important in the resilience of metropolitan regions in some countries in Europe.

- Non-metropolitan areas were found to be more resilient in 2010 during recovery because of the rebound in manufacturing in some countries, albeit with a more geographically differentiated picture in Germany and Hungary.

- Specific components of fiscal stimulus packages were absorbed more strongly in manufacturing regions and in areas with high population density or with existing strengths in R&D.

Manufacturing, then, appears to contribute to a lack of resilience in some places in coping with initial shocks, rendering places vulnerable, but helps contribute to resilience by making strong contributions to recovery in some places. Looking at these national experiences in more detail is instructive in understanding the context and what shapes these geographically differentiated outcomes. The examples considered here briefly comprise Germany, the US and China.

Figure 6: Manufacturing as a % of GDP globally and across comparator countries



Source: UNCTAD Handbook of Statistics in BIS (2010b: 2)

Case example 5: Germany

Between 2010-12, Germany experienced strong economic growth in recovery and record low levels of joblessness (6.7%) (Atkins 2012). In understanding Germany's economic resilience, renewed attention has been paid to the contribution of manufacturing to economic growth. Manufacturing accounts for 22.3% of GDP in Germany compared to 12.6% in the UK (Marsh 2012). The role of manufacturing in Germany is shaped by its national social market model. A number of defining features help explain the resilience of manufacturing and its contribution to national resilience. First, active federal state intervention through wage subsidies allowed firms hit by the economic crisis to retain capacity and skilled workers on short-time working, or *Kurzarbeit*, contracts to ride-out demand shocks and subsequently respond rapidly to the eventual upturn in global markets. The coordination of state regulation and procurement has also played a key role within German industrial strategy and policy, especially as part of the transition from nuclear to renewable energy. Led by the state's clear commitment and vision, firms such as Bosch and VW are increasingly diversifying products and processes to green energy markets, with investment in renewables accounting for 8% of GDP (Cox 2012). Second, in contrast to the UK's highly-concentrated banking sector, Germany possesses over 200 banks of varying sizes, many publically underwritten and legally obliged to have a local and regional focus. This decentralised network of financial institutions continue to offer longer-term support and patient investment for the *Mittelstand*, the bedrock of family-owned small and medium enterprises underpinning the manufacturing base (Marsh 2011). Third, the strength and public value attached to vocational training, and employee empowerment, continues to contribute towards a manufacturing 'high-skill equilibrium', fit to compete in more resilient and high quality export markets (Cox 2012). Fourth, the federal system provides scale and scope at the sub-national level of the *Lander* to provide hard (e.g. research institutes) and soft (networks) infrastructures for the promotion of adaptive capacity through local and regional

innovation systems. For example, Lander policy intervention continues to support Baden Württemberg's success in precision engineering and automotives (Cooke 2012), and new growth paths in offshore wind in Northern Germany (Fornhal *et al.* 2012).

Case example 6: USA

After a long period of decline, the number of manufacturing jobs in the United States increased by 2.6 percent from December 2009 through to September 2011. Significantly, the bulk of these gains were concentrated in durable goods manufacturing, which is generally the higher-wage, more productive part of the sector. In addition, between 2009 and 2010 manufacturing output grew at more than double the rate of GDP (Helper *et al.* 2012). The durability and causes of this trend and its suggested resilience of manufacturing in the wake of the global financial crisis are contested. There is some evidence, however, that "reshoring" has been a contributor as firms seek to reduce the length and vulnerability of supply chains and respond to rising Chinese wages and product quality deficiencies (Wall Street Journal 2012; The Economist, 2012). At the same time, the Obama administration has made a commitment to an industrial policy that recognises the spill-over effects of manufacturing and which focuses on support for training and innovation in advanced manufacturing, especially in relation to clean-tech and natural gas and which emphasises trade enforcement measures – all of which are intended to contribute to a more resilient post-crisis economy (Sperling, 2012).

Case example 7: China

Table 5 demonstrates how China's strategic manufacturing foresight is focused upon reducing its dependence on imported and external sources of manufacturing technology. In seeking to build up its equipment design and manufacturing capabilities, China's strategy aims to develop new integrated and intelligent systems to underpin its future manufacturing strength and resilience (Lu, 2011; Springut *et al.* 2011). Although it has some way to go before it develops a world class science-base, China is emerging as a global leader in clean energy and transport. Whilst the Chinese government provided the national policy frameworks and resources for these developments, provincial and local governments now spend between 40 and 50 per cent of all government expenditure on R&D. Provincial governments have crafted their own industrial policies to support the development of high-technology industries, and have become important partners with national level institutions in establishing new platforms for R&D, technology diffusion and standards development. In a report for the US Congress, Springut *et al.* (2011: 128) conclude, "Since most Chinese provinces are larger than most countries, the successful establishment of provincial-level innovation systems means that in additive terms, the Chinese *national* system begins to take on a sui generis quality, the likes of which the world has never seen".

Table 5: Manufacturing strategic foresight in China

Category		By around 2020	By around 2030	By around 2050
Advanced Manufacturing	Manufacturing level	Dependence ratio of manufacturing technology on foreign countries <30%	Dependence ratio of manufacturing technology on foreign countries <20%	Dependence ratio of manufacturing technology on foreign countries <5%
	Equipment manufacturing	High dependence of key and important equipment on import will basically be changed	Research, development and production of key and important equipment will basically satisfy the domestic needs	China will have the world top-class ability to design and manufacture key and important equipment
	Manufacturing intelligentization	Automated manufacturing with ubiquitous sending will be extensively used to raise the productivity at 10% more	The intelligent control and management system with man-machine harmony will be established	Production system with intelligent machine and autonomous control will be implemented

Source: Yongxiang, L. (2010) Science & Technology in China: A Roadmap to 2050, Strategic General Report of the Chinese Academy of Sciences, Chinese Academy of Sciences, Science Press Beijing

VII. Conclusion

Manufacturing has the potential to make a positive contribution to enhancing the resilience of the UK: The report has illustrated the ways in which a strong and resilient manufacturing sector can make meaningful contributions to the resilience of the UK overall. While manufacturing sectors may be the first to be affected by economic downturns, struggle to recover output following demand shocks and continue to lose employment, the potential benefits and contributions of this strategic and valuable sector for resilience cannot be ignored or neglected. International experience demonstrates that those countries with strong, export-led manufacturing sectors and supportive industrial strategies and policies have rebounded and started earlier on the path to recovery. Manufacturing has considerable value to the UK now and into the future. Three key areas require further consideration and reflection to maximise the potential benefits and mitigate the possible costs generated by manufacturing. These issues include:

- **The geographical dimension**: Spatial differentiation exists in the ways in which places are vulnerable and able to demonstrate adaptive capacity in response to disruptive change. Manufacturing change is geographically differentiated and the different manufacturing activities in each region are different in their abilities to respond and contribute to resilience challenges. This reinforces the importance of building a geographical dimension into considerations of the role of manufacturing and its contribution to the resilience in the cities, localities and regions of the UK and the UK overall. National 'one-size-fits-all' policies are unlikely to be sufficiently sensitive and tailored to the specific needs and conditions of manufacturing in particular places.

- **Strengthening manufacturing's contribution to UK resilience needs more than just a reliance upon the market**: The report has demonstrated the limits market-led approaches and the importance of states in recognising how 'smart' industrial strategy and policy are critical in nurturing and sustaining the long-term strength, competitiveness and resilience of manufacturing.

- **Building long-term adaptive capacity**: Addressing the gaps in current approaches can begin to contribute to the long-term task of constructing adaptive capacity in the UK, ensuring government policies across departments are resilient to future uncertainties. The gaps identified in this report – 'smart' industrial strategy, geography, ownership, global production networks and broken supply chains, 'manu-services', productive security and adaptive capacity – require thinking and reflection upon the role of the state, industrial strategy and policy and the role and purpose of manufacturing in the UK. This role, it is argued here, goes beyond simply making things – manufacturing is an integral element in the future resilience of the UK. Indeed, in the light of concerns about productive security, it is difficult to envisage how the UK will address future resilience challenges without a strong and vibrant manufacturing sector. It is easier to see how such resilience challenges for the UK could become accentuated and more problematic with weak and declining manufacturing activity in the UK.

References

Adger, W. N. (2000) "Social and ecological resilience: are they related?", Progress in Human Geography, 24, 3, 347-364.

Ashcroft, B. and Love, J. (1993) Takeovers, Mergers and the Regional Economy, Edinburgh University Press: Edinburgh.

Atkins, R. (2012) "Germany: the miraculous machine", The Financial Times, 19 April, The Financil Times: London.

Bawden, T. and McCurry, J. (2011) "Honda considers suspending UK production after Japanese Crisis", The Observer, Guardian Newspapers: London.

Beattie, A. (2010) 'BRICS: the changes faces of global power', Financial Times, 17th January

Beatty, C., Fothergill, S. and Powell, R. (2006) "Twenty years on: has the economy of the UK coalfields recovered", Environment and Planning A, 39, 1654-1675.

BIS (2010a) Manufacturing in the UK: An Economic Analysis of the Sector, Economics Paper 10A, BIS: London

BIS (2010b) Manufacturing in the UK: Supplementary Analysis, Economics Paper 10B, BIS: London

Bland, B. and Kwong, R. (2011) "Supply chain disruption: sunken ambitions", The Financial Times, 3 November, The Financial Times: London

Bowman, A., Froud, J., Johal, S., Law, J., Leaver, A. and Williams, K. (2012) Bringing Home the Bacon: From Trader Mentalities to Industrial Policy, CRESC: University of Manchester.

Bryant, C. (2012) "A model that everyone wants", The Financial Times, 6 August, The Financial Times: London.

Cambridge Econometrics (2010) Vulnerability/adaptability Analysis of Local Economies, Cambridge Econometrics: Cambrigde.

Canis, B. (2011) The Motor Vehicle Supply Chain: Effects of the Japanese Earthquake and Tsunami, Congressional Research Service: www.crs.gov

Carbon Trust (2010) Offshore wind power: big challenge, big opportunity

Maximising the environmental, economic and security benefits. Carbon Trust; London.

Chapple, K. and Lester, B. (2007) Emerging Patterns of Regional Resilience, Working Paper 2007-13, Macarthur Foundation Research Network on Building Resilient Regions, Institute for Urban and Regional Development, University of California, Berkeley.

Chapman, K. (2011) Rebalancing the Economy Sectorally and Spatially, SQW Ltd, Cambridge Econometrics, Centre for Urban and Regional Development Studies, and the Institute for Employment Research, Report for the UK Commission on Employment and Skills.

Christopherson, S. (2011) Riding the Small Wave in Manufacturing to More Good Jobs and a More Diverse Economy, 'Big Ideas for Job Creation in a Jobless Recovery' Conference, The Institute for Labour and Employment, University of California, Berkeley, June.

CLES (2008) Delivering Economic Success: An International Perspective on Local Government as Stewards of Local Economic Resilience, CLES: Manchester

Coaffee, J., Murkami-Wood, D. and Rogers, P. (2008) The Everyday Resilience of the City: How Cities Respond to Terrorism and Disaster, Palgrave/Macmillian.

Coates, D. (1994) The Question of UK Decline, Harvester Wheatsheaf: London.

Coe, N. M., Hess, M., Yeung, H. W-C., Dicken, P. and Henderson, J. (2004) "'Globalizing' regional development: a global production networks perspective", Transactions of the Institute of British Geographers NS, 29, 468–484.

Colbourne, L. (2008) Sustainable Development Think Piece for the SDC, Sustainable Development Commission: London.

Cooke, P. (2012) "Transversality and transition: green Innovation and new

regional path Creation", European Planning Studies, 20, 5, 817-834.

Cork, S (Ed.) (2009) Brighter prospects: Enhancing the resilience of Australia. Australia21, Weston, ACT

Cox, J. (2012) What Britain Can Learn from the German Economic Recovery Compass: London.

DTI (2001) Business Clusters in the UK – A First Assessment, DTI: London.

Davies, S. (2011) "Regional resilience in the 2008-10 downturn: comparative evidence from European countries", Cambridge Journal of Regions, Economy and Society, 4, 369-382.

Dicken, P. (2011) Global Shift (6th Edition), Sage: London.

Duval, R., Elmeskov, J. and Vogel, L. (2007) Structural Policies and Economic Resilience to Shocks, Economics Department Working Paper 567, OECD: Paris.

Economist (2012) "The end of cheap China: what do soaring Chinese wages mean for global manufacturing", The Economist, 10th March

Edwards, C. (2009) Resilient Nation, Demos: London.

Eich-Born, M. and Hassink, R. (2005) "On the battle between shipbuilding regions in Germany and South Korea", Environment and Planning A, 37, 4, 635-656.

Elliot, L. (2011) "Germany's new boom: making money by making stuff", The Guardian, 14 March, Guardian Newspapers: London.

Engineering Employers' Federation (2012) Be Prepared: Monitoring Supply Chains; Maximising Resilience, EEF: London.

Dawley, S. (2012) Creating New Paths? Renewables, Policy Activism and Peripheral Region Development, Unpublished Paper, CURDS: Newcastle University.

Feyrer, J., Sacerdote, B. and Stern, A. D. (2007) "Did the rustbelt become shiny? A study of cities and counties that lost steel and auto jobs in the 1980s", Brookings-Wharton Papers on Urban Affairs, Brookings Institution: Washington, 41-102.

Firn, J. (1975) "External control and regional development: the case of Scotland", Environment and Planning A, 7, 393-414.

Folke, C. et al. (2002) Resilience and Sustainable Development, Report for the Swedish Environmental Advisory Council: Stockholm.

Fornahl, D., Hassink, R., Klaerding, K., Mossig, I. and Schröder, H. (2012) "From the old path of shipbuilding onto the new path of offshore wind energy? The case of northern Germany", European Planning Studies, 20, 5, 835-855.

Foster, K. A. (2007a) A Case Study Approach to Understanding Regional Resilience, Working Paper 2007-8, Macarthur Foundation Research Network on Building Resilient Regions, Institute for Urban and Regional Development, University of California, Berkeley.

Foster, K. A. (2007b) "Snapping back: What makes regions resilient?", National Civic Review, 184, Fall, 27-29.

Froud, J., Johal, S., Law, J., Leaver, A. and Williams, K. (2011a) Rebalancing the Economy or Buyer's Remorse, CRESC Research Report, CRESC: University of Manchester.

Froud, J., Johal, S., Law, J., Leaver, A. and Williams, K. (2011b) Knowing What to Do? How Not to Build Trains, CRESC Research Report, CRESC: University of Manchester.

Glaeser, E. (2005) "Reinventing Boston: 1630-2003", Journal of Economic Geography, 5, 119-153.

Hassink, R. (2007) "The strength of weak lock-ins: the renewal of the Westmünsterland textile industry", Environment and Planning A, 39, 5, 1147-1165.

Helper, S., Kreuger, T. and Wial, H. (2012) Why Does Manufacturing Matter? Which Manufacturing Matters? Metropolitan Policy Program, Brookings Institution, Washington, DC.

Hill, E. W., Wial, H. and Wolman, H. (2008) Exploring Regional Resilience, Working Paper 2008-04, Macarthur Foundation Research Network on Building Resilient Regions, Institute for Urban and Regional Development, University of California Berkeley.

Industrial Communities Alliance (2009) The Impact of Recession on Unemployment in Industrial Britain, Industrial Communities Alliance: Barnsley.

Janssens, J. (2002) Impact of Community Policies on Regional Cohesion: Hainaut, DG REGIO: Brussels.

Kaldor, N. (1972) "The Irrelevance of Equilibrium Economics", The Economic Journal, 82, 328 1237-1255.

Kaplan, H. B. (1999) "Toward an understanding of resilience: A critical review of definitions and models" in M. D. Glantz and J. L. Johnson (Eds.) Resilience and Development: Positive Life Adaptation, Kluwer Academic/Plenum: New York, 17-83.

Kay, J. (2004) "The brands that are a matter of national interest", The Financial Times, 26 October, The Financial Times: London.

Kollewe, J. (2011) "Toyota UK factories cut working hours in Japan's quake aftermath", The Guardian, 22 April, Guardian Newspapers: London.

Marsh, P. (2011) "Call for 'German approach' to manufacturing", The Financial Times, 29 August, The Financial Times: London.

Martin, R. (2012) "Regional economic resilience, hysteresis and recessionary shocks", Journal of Economic Geography, 12, 1-32.

Martin, R. and Sunley, P. (2003) "Deconstructing clusters: chaotic concept or policy panacea?", Journal of Economic Geography, 3, 1, 5-35.

Mazzucato, M. (2011) The Entrepreneurial State, Demos: London.

Morgan, K., Marsden, T. and Murdoch, J. (2006) Worlds of Food, Oxford University Press: Oxford.

NESTA (2011) Driving Economic Growth: Innovation, Knowledge Spending and Productivity Growth in the UK, NESTA: London.

North Eastern Local Economic Partnership (2011) North East England Centre for Offshore Renewable Engineering: Tyneside.

OECD (2009) 'Globalisation and Emerging Economies', Policy Brief, March. OECD; Paris. (http://www.oecd.org/trade/tradedev/42324460.pdf)

Pendall, R., Foster, K. A. and Cowell, M. (2007) Resilience and Regions: Building Understanding of the Metaphor, Working Paper 2007-12, Macarthur Foundation Research

Network on Building Resilient Regions, Institute for Urban and Regional Development, University of California, Berkeley.

Pike, A. (2011) "Deindustrialisation" in N. Thrift and R. Kitchin (Eds.) International Encyclopedia of Human Geography, Elsevier: Oxford.

Pike, A. (1998) 'Making performance plants from branch plants? In-situ restructuring in the automobile industry in UK Region', Environment and Planning A 30: 881–900

Pike, A. and Dawley, S. (1998) Exit and Re-Entry to Employment, Report for ONE North East, CURDS: Newcastle University.

Pike, A., Rodríguez-Pose, A. and Tomaney, J. (2007) "What kind of local and regional development and for whom?", Regional Studies, 41, 9, 1253-69

Pike, A., Cumbers, A., Dawley, S., Hassink, R., MacKinnon, D. and Tomaney, J. (2012) Adaptive Capacity and Resilience in Local and Regional Development, CURDS: Newcastle University.

Rodrik, D. (2011) The Manufacturing Imperative, Project Syndicate, www.project-syndicate.org.

Roos, G. (2011) What does the future hold for manufacturing in South Australia?, Public Lecture, Adelaide Town Hall, September.

Rowthorn, R. and Martin, R. (1986) The Geography of De-industrialisation, Macmillan: Basingstoke.

Rowthorn, R. and Ramaswamy, R. (1997) Deindustrialisation: Causes and Consequences, WP/97/42/, IMF Research Department, Washington, DC.

Sissons, A. (2011) More Than Making Things: A New Future for Manufacturing in a Service Economy, The Work Foundation: London.

Sperling G (2012) "Remarks By Gene Sperling Before The Conference on the Renaissance of American Manufacturing", March 27th, National Economic Council, White House, Washington, DC. (http://www.whitehouse.gov/sites/default/files/administration-official/sperling_-_renaissance_of_american_manufacturing_-_03_27_12.pdf)

Storper, M., Thornadakis, S. and Tsipouri, L. (2007) (Eds.) Latecomers in the Global Economy, Routledge: Abingdon.

Streeck, W. (1991) "On the Institutional Conditions of Diversified Quality Production" in E. Matzner and W. Streeck (Eds.) Beyond Keynesianism: The Socio-Economics of Production and Full Employment, Elgar: Gloucester, pp. 2-61.

Springut, M, Schlaikjer, S and Chen, D (2011) China's Program for Science and Technology Modernization: Implications for American Competitiveness. Prepared for the US-China Economic Security and Review Commission. Arlington, VA: CENTRA Technology Inc.

UN Food and Agriculture Organisation (2012) Food Security: Concepts and Measurement, FAO: Rome.

Vale, L. J. and Campanella, T. H. (2005) The Resilient City: How Modern Cities Recover from Disaster, Oxford University Press: New York.

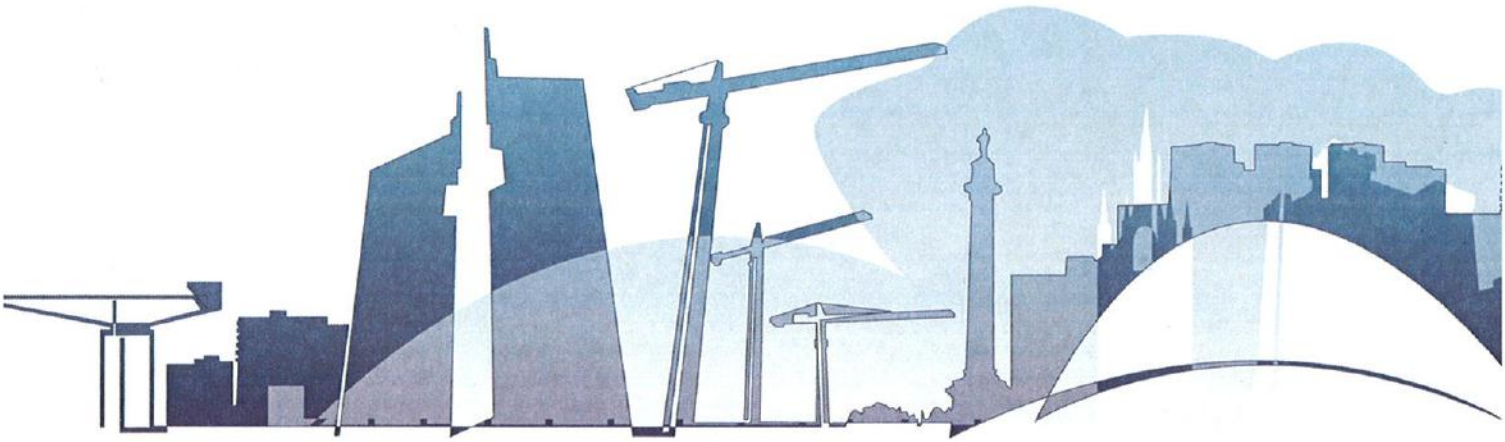
Wall Street Journal (2012) "Some Firms Opt to Bring Manufacturing Back to U.S", 17th July

Yongxiang Lu (2010) Science & Technology in China: A Roadmap to 2050. (Strategic General Report of the Chinese Academy of Sciences.) Berlin: Springer/Beijing: Science Press

Foresight
1 Victoria Street
London SW1H 0ET
www.foresight.gov.uk
URN

Centre for Urban & Regional Development Studies
CURDS

Newcastle University



Centre for Urban & Regional Development Studies (CURDS),
School of Geography, Politics and Sociology,
Claremont Bridge,
Newcastle University
NE1 7RU

Tel: 0191 208 7691
Fax: 0191 208 7741
www.ncl.ac.uk/curds/
www.ncl.ac.uk/gps/geography/