Regional Resilience: Are recessionary shocks persistent or transitory?

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Thesis Summary
Justin Doran - Regional Resilience: Are recessionary shocks persistent or transitory?

The response by regional and national economies to exogenous impulses has a well-established literature in both spatial econometrics and in mainstream econometrics and is of considerable importance given the post-2008 economic crisis, which is characterised by a period of severe global instability resulting from unprecedented economic shocks. Martin et al. (2016) note that in economic geography resilience describes regions' reactions to, and recovery from, negative economic shocks, based on a concept which has been widely used in the engineering and ecological sciences and which has been increasingly adopted in economic geography.

This PhD provides an empirical analysis of resilience at the national, regional, and individual level. Four empirical Chapters are presented which feature econometric analysis in the form of vector error correction (VEC) models, dynamic spatial panel models, and pooled cross sectional models. The national analysis focuses on European counties and the US and analyses the impact of shocks from within the EU and from the US on each country. The second empirical Chapter focuses on US metropolitan statistics areas and analyses the impact of industry structure on the resilience of US metropolitan areas. The third empirical Chapter focuses on the resilience of wages in the US to the global economic crisis. The final empirical Chapter analyses the impact of the crisis on individual's employment outcomes in select European countries.

The results of the analysis clearly indicate that industry structure plays an important role in explaining the resilience of nations, regional, and individuals (who reside within broader regions). The findings suggest that diversity of economic structure and structural change can result in more resilient regions. At the individual level there is significant evidence that education plays a critical role in explaining the resilience of individuals' wages and employment outcomes.

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Preface

- This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.
- It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text.
- It does not exceed the prescribed word limit for the relevant Degree Committee. This thesis does not exceed the regulation length, including footnotes, references and appendices.

Chapters of this PhD have been published in conjunction with my primary Supervisor Professor Bernard Fingleton throughout my study for the PhD. The following co-authored papers have been published based on the following Chapters.

Elements of Chapter 3 have been published in the journal *Papers in Regional Science* as: "Doran, J., & Fingleton, B. (2014). Economic shocks and growth: Spatio-temporal perspectives on Europe's economies in a time of crisis. *Papers in Regional Science*, 93(S1), S137-S165".

Elements of Chapter 4 have been published as "Doran, J., & Fingleton, B. (2018). US metropolitan area resilience: insights from dynamic spatial panel estimation. *Environment and Planning A: Economy and Space*, 50(1), 111-132".

Elements of Chapter 5 have been published in the *Cambridge Journal of Regions, Economy and Society* as: "Doran, J., & Fingleton, B. (2015). Resilience from the micro perspective. *Cambridge Journal of Regions, Economy and Society*, *8*(2), 205-223".

Elements of Chapter 6 have been published in the journal *Regional Studies* as: "Doran, J., & Fingleton, B. (2016). Employment resilience in Europe and the 2008 economic crisis: insights from micro-level data. *Regional Studies*,*50*(4), 644-656".

In all Chapters I have performed the literature review, collected the data, performed the empirical estimations, and written the conclusions. This has been conducted under the supervision of and in consultation with Professor Fingleton.

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Chapter 1: Introduction

1.1 Context of the Study

The response by regional and national economies to exogenous impulses has a well-established literature in both spatial econometrics and in mainstream econometrics and is of considerable importance given the post-2008 economic crisis, which is characterised by a period of severe global instability resulting from unprecedented economic shocks. The impact of global recessions on countries' output growth paths is a highly relevant topic for analysis in light of the 2008 economic crisis. The IMF notes that the 2008 crisis is the "most dangerous financial shock in mature financial markets since the 1930s" (IMF, 2008: pp xv). They further suggest that while a recovery is expected "the pickup is likely to be unusually gradual" (IMF, 2008: pp 1). The crisis, which began in August 2007 after the collapse of the US subprime mortgages market, intensified in September 2008 due to deepening solvency concerns which triggered large scale public intervention in the US and Europe (IMF, 2008). According to figures from the World Bank (2012) average GDP growth for the global economy for 2002 to 2007 was approximately 5%[1] while this slowed to approximately 1.3% in 2007 and contracted by approximately 2% in 2008. The aim of this PhD is to analyse the resilience of countries, metropolitan areas and individuals to the 2008 economic crisis.

One of the motivations of this PhD is the work of Cerra and Saxena (2008) who suggest that different types of macroeconomic shocks can have a permanent effect on economies' growth paths. However, they highlight that not all economies respond in the same way. I do not distinguish between alternative types of shocks, instead focusing specifically on the impact of economic recessions. Assessing whether these shocks result in economies' output being permanently depressed or whether output rebounds following a shock to its pre-shock growth path. In doing so I analyse a variety of countries, regions and individuals[2].

The PhD is also motivated by Fingleton et al. (2012), who explore the regional rather than national dimensions of resilience, and also by the review of the concept of regional resilience by Martin (2012), Martin and Sunley (2014) and Martin et al. (2016). Fingleton et al. (2012) use vector error correction (VEC) modelling techniques to analyse the persistence of output

[1] Using GDP in dollars at constant 2000 level prices.

[2] While economic output is used for analysing the resilience of countries and regions to the 2008 economic crisis, wages and employment are used for individuals.

shocks on regional employment. Using a VEC framework allows for an analysis of the persistence of shocks and the extent to which shocks and crises spillover from one economy to another, which is the topic of interest to this PhD. However, VEC techniques limit the number of countries and regions which can be analysed, due to requiring a long time series for robust estimation and a small number of variables to facilitate tests for cointegration, but by utilising spatial panel techniques, it is possible to analyse a large number of observations, while at the same time taking account of the persistence of shocks through time, and controlling for spillover effects, and the spatial transmission of shocks across countries. Controlling for these spatial effects is an important way to avoid biased estimates and inferences (Corrado and Fingleton, 2012; LeSage, 1998).

The approach used by this PhD in the empirical analysis of resilience is to employ causal economic models as a framework for estimating empirical models. The results of these empirical models are used to generate counterfactual forecasts of what economic outcomes could have been had the economic crisis not occurred. These counterfactual predications are then compared to the actual values to assess resilience to the crisis. A number of alternative outcome measures are used as the PhD progresses through different spatial scales. At the national level productivity is used as the key indicator. When analysing city regions GDP is used as the outcome indicator. Finally, at the individual level wages and employment are considered.

The general approach used in this PhD is as follows. Initially, vector error correction (VEC) modelling is used, as is standard in the literature, to assess the responses of countries to economic shocks in the 1980s and 1990s and to assess whether spatial spillovers in shocks are present. Having established that shocks appear to be permanent in nature, that the responses to the shocks vary across countries, and that there is spatial transmission of shocks the analysis progresses to assess the impact of the 2008 economic crisis. Following the country level analysis, metropolitan area resilience is analysed as, even within countries, there is substantial heterogeneity in the responses of regions to crises. Dynamic spatial panel estimation and forecasting techniques are utilised and a series of possible explanatory factors which may convey resilience are assessed with a specific focus on industry structure. The final element of this PhD is the analysis of the resilience of individuals to the 2008 economic crisis. In this instance wage data (in a US context) and employment data (in a European context) are used and again econometric techniques are employed to generate counterfactual series to compare with the actual series. Individual level characteristics, such as experience and education, are then assessed to understand their contribution to resilience.

1.2 Contributing to Existing Literature

The contributions of this PhD to existing literature are detailed below. The contribution of each empirical Chapter is outlined. The final section (the Conclusions) draws together the contributions and findings of each Chapter.

The contribution of the initial empirical Chapter (Chapter 3), which focuses on time series techniques to analyse resilience to shocks from 1960 to 2011 are threefold. In this Chapter the focus is on pre-2008 shocks to provide a context for the latter Chapters of the PhD which focus on the 2008 economic crisis. First, it extends the work of Cerra et. al. (2008; 2009), but differs significantly in that it is concerned with non-stationary series (i.e. uses VEC not VAR models). Thus it contributes to the hysteresis and resilience literature focussing on the potentially permanent, rather than transient, impact of shocks on subsequent growth. Second, it extends the work of Fingleton et. al. (2012) by modelling both GDP and employment levels combined to give productivity levels, applying this to the international level rather than being restricted to UK regions. And thirdly, it focuses on contagion and spillover effects, asking the question, 'do shocks in neighbouring countries have a major effect domestically?'

The fourth Chapter contributes to the existing literature in a number of ways. First, the modelling approach, involving both dynamic and spatial interaction, is relatively unusual and a clear advance on static spatial panel approaches which do not take account of time-dependency in spatio-temporal series. Secondly, and somewhat unusually, the dynamic spatial panel model (DSPM) estimation takes account of the potential endogeneity of the regressor, output, with respect to employment. Thirdly, the focus is essentially on city-region (i.e. MSA) resilience, in contrast to the more usual region- or country-specific estimates of resilience found in the literature. Fourthly, the analysis seeks to avoid omitted variables bias by introducing covariates, and allows for endogeneity in the regression analysis, in an attempt to obtain consistent causal effects of industrial structure on resilience.

The fifth Chapter contributes to the existing literature by considering individual level resilience to the 2008 economic crisis. The idea is to use individuals as the fundamental unit of analysis, rather than regions, cities or nations. This allows for the examination of the impacts of recent economic shocks focusing on an important aspect of the local economy, namely the level of individual wages. The starting point for modelling individual wages is the wage equations derived from New Economic Geography (NEG) and Urban Economics (UE) theory, where wages are a function of market potential and employment density respectively. Expanding from the typical NEG and UE wage equations individual-specific factors which could influence wages are controlled for, as typically modelled in a Mincerian wage equation, such as experience, gender, qualifications and job-type, which when combined with the aggregate NEG and UE indicators allows for an assessment of the resilience of individuals, controlling for their intrinsic characteristics, to shocks in their local labour market.

The sixth Chapter extends the work of Chapter 5 by considering employment resilience at the level of the individual. It is one of few pieces of research which to date analyses resilience in the regional context using the individual as the unit of analysis. This Chapter provides insights into how individual specific characteristics and regional variations can help explain the resilience of employment outcomes during an economic crisis. The Chapter focuses on the crisis as it was experienced in 2010, following crisis impacts going forward from 2008.

1.3 Structure of the PhD

The structure of this PhD is as follows. Chapter 2 provides a review of existing literature on economic resilience. It focuses on a number of concepts which are central to this PhD. The first is engineering resilience (anti-hysteresis), the second is ecological resilience (hysteresis), and the third is adaptive resilience. It then provides a discussion of the three key theories used to develop econometrics models in the later Chapters of the PhD. Specifically it discusses Verdoorn's law, New Economic Geography (NEG) theory, and Urban Economics (UE) theory.

Chapter 3 is the first of the empirical Chapters of this PhD. It focuses on the resilience of European countries to economic shocks since 1960. Verdoon's law is used as the theoretical lens through which the empirical analysis is conducted. Shocks originating from different sources are considered. The Chapter uses vector error correction models to derive dynamic forecasts and orthogonalized impulse response functions (OIRFs) to analyse the resilience of countries to negative shocks. Elements of this Chapter have been published in the journal *Papers in Regional Science* as: "Doran, J., & Fingleton, B. (2014). Economic shocks and growth: Spatio-temporal perspectives on Europe's economies in a time of crisis. *Papers in Regional Science*, 93(S1), S137-S165".

Chapter 4 is the second empirical Chapter and progresses the analysis from country level to city level. The main contribution of this Chapter is to focus on cities as the unit of analysis, which is rare in empirical studies of resilience. Specifically US metropolitan statistical areas (MSAs) are analysed. Also Verdoon's law is again used as the theoretical lens for the analysis. In total 373 US MSAs are analysed to provide insights into their resilience to the 2008 economic crisis. Elements of this Chapter have been published as "Doran, J., & Fingleton, B. (2018). US metropolitan area resilience: insights from dynamic spatial panel estimation. *Environment and Planning A: Economy and Space*, 50(1), 111-132".

Chapter 5 is the third empirical Chapter of this PhD. It progresses the analysis by considering the individual as the unit of analysis. Using data from the American Community Survey (ACS) a model of individual's wages is estimated and individuals' wage resilience to the 2008 economic crisis is analysed using pooled regression analysis. Due to the use of the individual as the unit of analysis, it is inappropriate to consider Verdoon's law as the theoretical lens for analysis and instead Mincer's wage equation is used. Elements of this Chapter have been published in the *Cambridge Journal of Regions, Economy and Society* as: "Doran, J., & Fingleton, B. (2015). Resilience from the micro perspective. *Cambridge Journal of Regions, Economy and Society*, *8*(2), 205-223".

Chapter 6 is the fourth and final empirical Chapter of this PhD. It builds upon the previous Chapter by considering employment resilience to the 2008 economic crisis using the European Social Survey (ESS). Again the individual is the unit of analysis. The main contribution of this Chapter is to consider, at an individual level, what factors convey employment resilience in the face of an economic crisis. Elements of this Chapter have been published in the journal *Regional Studies* as: "Doran, J., & Fingleton, B. (2016). Employment resilience in Europe and the 2008 economic crisis: insights from micro-level data. *Regional Studies*,*50*(4), 644-656".

Chapter 7 presents the conclusions drawing together the different empirical Chapters of this PhD.

Chapter 2: Literature Review

In this Chapter I provide an overview of the three prevalent conceptual foundations of resilience; engineering, ecological, and adaptive resilience. Following the discussion of these factors the Chapter presents the conceptual framework proposed by Martin et al (2016) for the process of adaptive resilience which can be summarised in four components; (i) risk, (ii) resistance, (iii) reorientation, (iv) recovery. I present a brief summary of this model and outline the advances this PhD dissertation makes in terms of re-interpreting this through the application of formal economic models and counterfactual forecasting techniques to analyse the role of reorientation in promoting resistance and recovery. This is followed by a discussion of the existing literature on resilience which summarises key articles in this area and provides a wider context for this PhD research. Finally, the economic models which are used throughout this dissertation (Verdoorn's law, new economic geography theory, and urban economics theory) are presented and discussed.

2.1 Regional Resilience – an Overview

Davis and Weinstein (2008) note that the concept of multiple equilibria is a hallmark of modern economics extending to diverse areas of the discipline. However, they suggest that it is not an easy phenomenon to test as, at any moment in time, only the actual equilibrium is observable, not the innumerable potential equilibria which could have existed had the economy followed a different development path. Moreover changes over time may be due to changing fundamentals within the economy and do not necessarily indicate the evolution to new equilibria. However, following the 2008 crisis there has been increasing interest in resilience (sometimes defined in part as the ability to resist moving to new, lower equilibrium points). Examples of recent studies are Fingleton et al. (2012), Martin (2012) and Fingleton and Palombi (2013), Martin et al. (2016), Brown and Greenbaum (2017), and Bristow and Healy (2018). This PhD proposes to analyse the resilience of countries, regions and individuals to economic shocks.

Simmie and Martin (2010) note that there is no universal definition of resilience. Martin (2011) and Fingleton et al. (2012) define resilience based on its Latin root, *resilire*, which is to "leap back or rebound" (Martin, 2011: pp 4). They note that resilience can be defined as the ability of an entity or system to recover from a shock of some kind. Foster (2007: pp 14) defines resilience as "the ability of a[n economy] to anticipate, prepare for, respond to and recover from a disturbance". While Hill et al. (2008: pp 4) defines a resilient region as having the ability "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".

Cross et al. (2010) note that within this definition of resilience two possible views can be adopted. The first is referred to in the literature as engineering resilience and suggests that resilience defines the ability of a system to recover to its pre-shock state following a shock. Typically the system is viewed as being in equilibrium before the shock and resilience relates to the time taken to return to this equilibrium position following a disruption. Alternatively, resilience can be viewed as a system's ability to adjust to a new state following a shock. Again, this can assume that a system is in equilibrium prior to the shock and the resilience of the system relates to its ability to transition from the pre-shock equilibrium to a new equilibrium post-shock. This is referred to as ecological resilience. Simmie and Martin (2010) note that there are a number of lenses through which resilience can be considered; these being equilibrium and evolutionary theory. While this discussion makes use of the assumption of equilibrium positions Martin (2010) argues that, even discounting equilibrium theory, for these concepts of resilience to hold all that is required is that following a shock the economy returns to where it would have been in the absence of that shock, regardless of whether or not that position is an equilibrium point, or adjusts to a new stable growth path.

Simmie and Martin (2010) raise the question as to whether resilience should measure not only an economy's ability to recover from shocks or transition to a new equilibrium but also their ability to resist shocks. They note that economies which can resist shocks are much more likely to recover than an economy which is severely affected by the shock. They also question whether resilience relates to the ability of the economy to retain its structure throughout the shock or whether resilience should also consider the ability of an economy to restructure its industries and firms in order to recover. They also point out that the resilience of an economy is likely to vary over time and may be dependent on the nature of the shock and may change as the economy becomes more advanced and evolves. This has led them to extend upon the two measures presented in Cross et al. (2010) by including a third concept of resilience, adaptive resilience.

The following sub-sections describe in detail three concepts of resilience, which have their foundation in sciences outside of economics, and relates them to economic theories. The concept of engineering resilience is similar to Friedman's plucking model of growth while ecological resilience can be related to the concept of hysteresis. The final concept is that of adaptive resilience which relates to evolutionary economic theory. A concise summary of these three concepts is present in Martin and Sunley (2014) and is summarized, based on their typology, in Table 2.1.

Table 2.1 Definitions of Resilience

Title	Definition/Type	Interpretation	Main Field of Use	Economic Link
Engineering, Anti-Hysteresis, Plucking Model	Resilience as bounce back from shocks	Shocks are transitory in nature, bounce back occurs, the emphasis is on the speed of recovery	Engineering resilience found in physical sciences.	Classical economics. Output set by factors of production. Shock does not destroy these factors.
Ecological, Hysteresis	Resilience as an ability to absorb shocks	Multiple equilibria. The focus is on the size of the shock which can be absorbed before the system moves to a new equilibrium. Shocks can have permanent effects.	Ecological resilience found in ecology.	Multiple equilibrium where shocks push the economy from one equilibrium to another. Hysteresis. Path Dependence.
Adaptive, Evolutionary Resilience	Resilience as positive adaptability in anticipation or response to shocks	Ability of a system to adapt its structure before, during or after shocks to resist and/or recover before/following a shock.	Adaptive resilience found in physological and organisational theory.	Evolutionary economics where the economy evolves to shocks.

Based on and adapted from Martin and Sunley (2014)

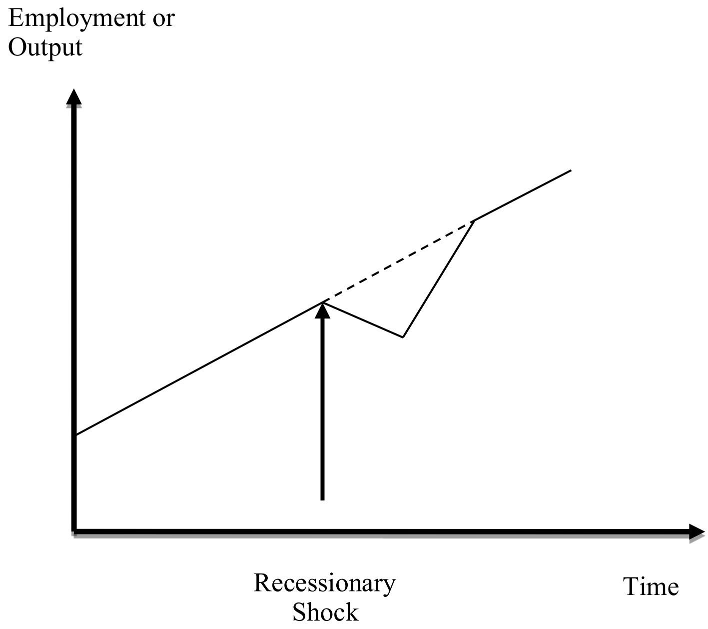
2.2 Engineering Resilience/Anti-Hysteresis

Perrings (1998) identifies two types of resilience. The first is concerned with the time taken for a disturbed system to return to some initial state and arises from Pimm (1984). Perrings (1998) refers to this type of resilience as engineering resilience. Cross et al. (2009) identifies that this form of resilience has become referred to as engineering resilience as it is based on premises arising from the engineering discipline. The definition draws heavily on the concept of the conservation of energy. Taken in terms of economics the conservation of energy implies that nothing is lost or permanently changed if an individual, a market or an economy as a whole faces a temporary disturbance no matter how large. It implies that shocks have a transient effect on economies, with the economy returning to its pre-shock equilibrium position following the shock.

Engineering resilience can be thought of as an economy's ability to rebound after a shock. Essentially, this definition of resilience relates to the ability of an economy to resist a shock and the subsequent speed of return following the shock to the economy's pre-shock state. One can think of the system as being in equilibrium prior to the shock and that the shock temporally knocks the system off this equilibrium. An economy is more resilient than another if it is able to better resist the initial shock and if it returns more quickly to its pre-shock equilibrium state (Martin, 2011; Fingleton et al., 2012). Martin (2011) links this notion of resilience with economic theories relating to self-correcting forces in mainstream economics. The economy is assumed to be self-equilibrating so that any shock that moves it from its equilibrium point automatically engages compensating mechanisms that brings the economy back to equilibrium. These self-correcting forces may take a while to activate but the assumption is that the economy will eventually return to its pre-shock levels.

Fingleton et al. (2012) and Martin (2011) note that engineering resilience displays characteristics which are similar to Friedman's (1993; 1964) plucking model. Figure 2.1 displays a stylised diagram of the plucking model. This model of growth can be likened to a string attached to the underside of an upward sloping board. The string can be plucked downward at times by shocks, however, the string will always rebound to the level of the board. The board represents the slowly increasing ceiling level of output set by an economy's factors of production. While the extent of the decline in output will vary from shock to shock, output is assumed to rebound in all cases to the ceiling level. This model therefore assumes that shocks are temporary in nature and have no permanent effect on an economy's long-run growth ceiling or growth trend.

Figure 2.1: Anti-hysteresis



Source: redrawn from Fingleton et. al. (2012)

2.3 Ecological Resilience and Hysteresis

Perrings (1998) identifies the second conceptualisation of resilience as referring to the size of a shock that can be absorbed by the system before the system is shifted from one equilibrium to another. It assumes that systems are characterised as possessing numerous equilibria. Martin (2011) refers to this as ecological resilience. This conception of resilience focuses on the role of shocks in pushing the system beyond its recovery threshold to a new domain. In this instance, one way to measure resilience is the magnitude of the shock required to push the economy from one path to another. Martin (2011) notes that this implies that ecological resilience is the capacity of a system in equilibrium to tolerate shocks without reorganising into an new equilibrium position. The underlying assumption is that there are a number of equilibrium positions and that if a sufficiently strong shock occurs the economy is pushed to a new equilibrium point. As noted already, one way of measuring resilience in this instance is by determining the strength of the shock required to force the economy to a new equilibrium. Therefore, one economy is more resilient if it can absorb a larger shock than another before adjusting to a new equilibrium. Alternatively, this concept of resilience can relate to the ability of an economy, when pushed beyond its threshold, to move quickly to a new equilibrium position. Resilience under this view depends on the point at which the economy ends up. If the post-shock position is worse than the predecessor then such an economy would be deemed to have a lower resilience than an economy which was able to move to a relatively better post-shock position.

Martin (2011) notes that this definition of ecological resilience is similar to the economic concept of hysteresis. This is characterised as a system which has multiple equilibria and which can be moved from one equilibrium to another as a result of a shock. Romer (2001) defines hysteresis as a situation where "one time disturbances permanently affect the path of the economy" (pp 471). Essentially the memory of the shock is left behind in the economy even after the shock has faded away. This process can also be termed remembrance. This can involve structural change within the economy. It implies that a temporary shock can have permanent effects on an economy, which can be thought of as a form of path dependence. Martin (2011), Fingleton et al. (2012) and Cross et al. (2010) note that it is possible to envisage a number of different possible hysteretic outcomes of a shock and that the outcome may depend on the variable considered as well as the underlying structure of the economy. Two possible negative hysteric outcomes can be identified. In the first instance, the shock causes a downward shift in the variables growth path, but the growth rate returns to pre-shock levels. This may result from a shock destroying a significant proportion of the economy's productivity capacity and jobs (see Figure 2.2 a). The second negative outcome is where, not only is there a downward shift in the level of the variable, but also a reduction in the growth rate of the variable. This may result from the destruction of large sections of an economy's industrial base which may have a negative multiplier effect on other sectors; reducing not only the level but also the growth rate of the variable post-shock (see Figure 2.2 b).

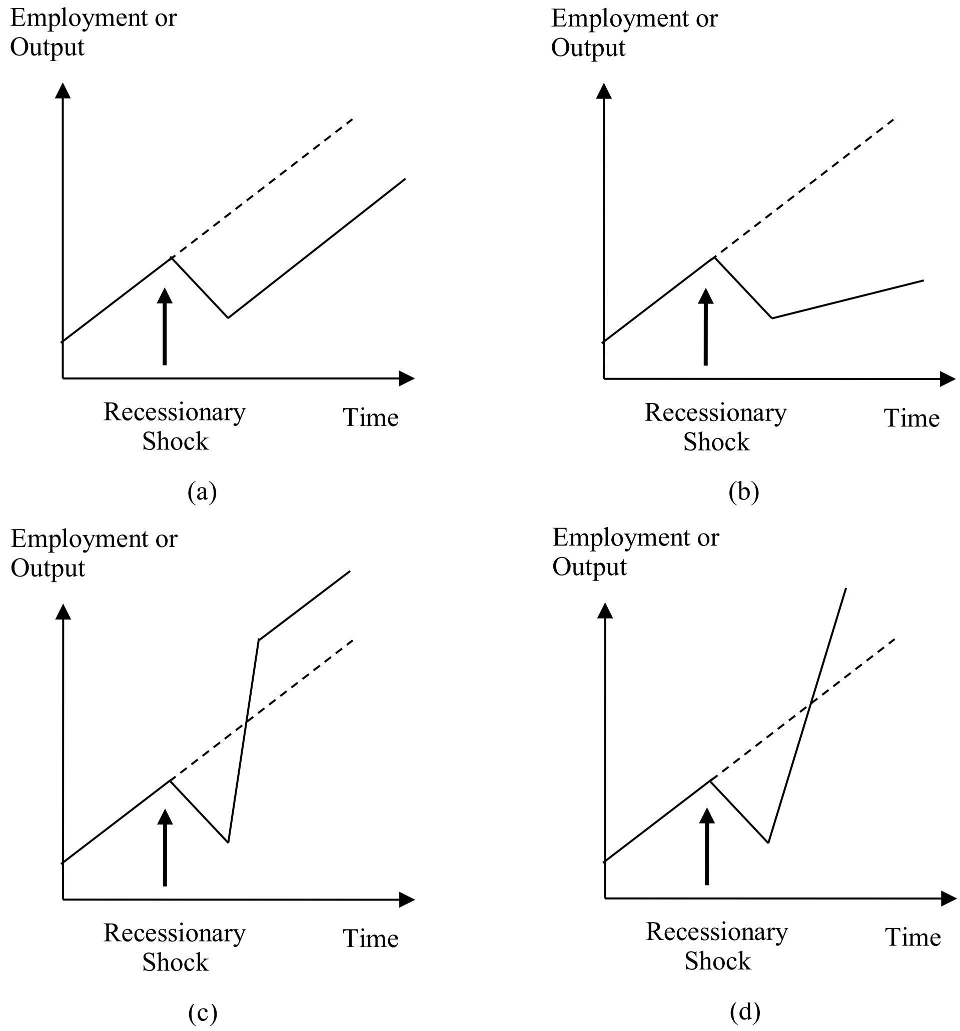
However, Martin (2011) and Cross et al. (2010) note that not all hysteric effects need be negative. Two positive hysteretic reactions can also materialise following a shock. In both instances, the economy more than rebounds from the shock and initially experiences rapid growth, in excess of the pre-shock level, following the initial downward effects of the shock. This may be due to optimistic business expectations, the availability of spare capacity to expand or new firm foundations. The distinction between the two possible positive hysteric effects is whether the post-shock growth rates can be maintained. If the scope for continued rapid expansion becomes exhausted, the economy may return to pre-shock growth levels, albeit at a higher level (see Figure 2.2 c). However, if the economy can maintain the post-shock growth rates this implies continued growth at a rate in excess of the pre-shock level (see Figure 2.2 d). Stylised versions of all of these responses are depicted in Figure 2.2.

Cross et al. (2010) appeal to a Schumpeterian point of view of creative destruction to explain these hysteresis effects. If the creative destruction aspects of the recession were sufficient to outweigh the destructive aspects the outcome would be an increase in potential output levels. This would mean a stronger growth in output during the recovery from the recession with the growth rate returning to normal post-recovery. However, if the growth rate can be maintained Cross et al. (2010) term this a Schumpeterian super recession in that while output falls during the recession, the growth rate of the economy is permanently increased, resulting in the economy overtaking its previous equilibrium position. Alternatively, if the destructive elements outweigh the creative elements the recession may cause a shift downward in the level of the economy. As before the growth rate may return to post-shock levels or may be permanently depressed.

Blanchard and Summers (1987), in the context of unemployment, note that the concept of hysteresis can refer to "the development of alternative theories of unemployment embodying the idea that the equilibrium unemployment rate depends on the history of the actual unemployment rate. Such theories may be labelled hysteresis theories after the term in the physical sciences referring to situations where equilibrium is path-dependent" (pp 290). Thus a negative shock leading to permanently higher unemployment may occur if the long term unemployed lose skills and miss out on job training, so that they ultimately become unemployable. In contrast, the employed continue to benefit from learning-by-doing. This viewpoint of hysteresis in unemployment is supported by Jaeger and Parkinson (1994) and Jacobson, Vredin and Warne (1997). Krugman (2011) provides a similar argument.

Insight into hysteretic shocks is also provided by studies relating to real business cycle theory which are also concerned with the persistence of shocks and also asymmetries in the responses of positive and negative shocks. For example, Beaudry and Koop (1993) analyse the persistence of shocks to national output, noting that while there are asymmetries in the responses of economies to positive and negative impulses, both are persistent (specifically they find positive shocks to be more persistent than negative shocks). Hamilton (1989) provides further evidence that recessionary shocks result in a permanent negative drop in countries' output. Diebold and Rudebusch (1989) also support this permanent shock-effect hypothesis.

Figure 2.2: Stylised Responses to Shocks



Source: redrawn from Fingleton et. al. (2012)

2.4 Adaptive Resilience

Tóth (2015) notes that when discussing various frameworks of resilience, the concept of socio-economic resilience should not be neglected. This concept according to Folke (2006) incorporates the idea of adaptation, learning, self-organization and the ability to persist despite disturbance. Tóth (2015) states that this approach is based on the adaptive notion of resilience, which originates in the theory of complex adaptive systems preferred by scholars working in evolutionary economic geography and he notes Holling and Gunderson (2002), Folke (2006), Martin and Sunley (2007), and Simmie and Martin (2010) are proponents of this approach.

Martin and Sunley (2014) notes that the concept adaptive resilience can be related to the notion of 'positive adaptive resilience', which they trace to the behavioural psychological literature. This is used within this literature to describe how individuals maintain or regain their psychological wellbeing following some form of shock (not a shock in the economic context but one to their wellbeing such as a personal trauma or crisis). They note that in this literature resilient individuals are those that are found to demonstrate dynamic self-renewal whereas less resilient individuals are negatively impacted by their stressors. They note that although not explicitly stated in some of the resilience literature the concept of adaptive resilience is built into much of the discussion of resilience. The idea of recovering following a shock typically involves some degree of reorientation of the economy and this has led to this sometimes being referred to as evolutionary resilience or bounce forward. It is also linked with the idea of complex adaptive systems, although Martin and Sunley (2014) note that this literature does not typically use the phrase resilience but instead focuses on what they term robustness as a feature of a system. Martin and Sunley (2014) relate the idea of robust adaption to that of organisational change to restore a pre-shock growth path.

2.5 The Elements of Resilience

In a series of papers Martin (2012), Martin and Sunley (2014), and Martin et al. (2016) propose a conceptual model arising from their discussion of adaptive resilience. This model, which breaks resilience down into four components (i) risk, (ii) resistance, (iii) reorientation, and (iv) recovery describes the process of how regions are exposed to shocks, behave during shocks, and recover following shocks [see Martin et al. (2016) page 565 for the complete model]. They note that these steps are sequential and recursive.

The first step is in terms of the risk a region faces. This is essentially the vulnerability of the region to shocks and its potential exposure. This can be the exposure of firms, individuals, institutions, or governance structures, amongst others, to shocks. Different regions may have more exposure to different types of shocks based on a variety of these factors.

The second stage of the process is the resistance of the region to the shock. This is dependent upon the scale, nature and duration of the shock to hit the region. More severe shocks may be expected to have a stronger impact on the region than less severe shocks. Likewise, the length of the shock may vary. These factors impact on the possible ability of a region to resist the onset of a shock. Of course, the region's structure, capabilities, resources etc. may also help resist the shock (or may possibly make it less resistant).

The reorientation of the region following the onset of the shock relates to the extent and nature of the adjustment to the shock. Martin et al. (2016) note the adaptive element of resilience in their concept enters here in the form of reorientation. Following the shock the region reorganises its structures, industries, institutions etc.

The degree of reorientation may impact on the recoverability of a region. This is the post-crisis recovery of the region which may be to its previous growth path, or a new higher or lower growth path. A region's post-crisis recovery to a new growth path, or its lack of recovery, can have long run implications in terms of widening or reducing regional inequalities (Martin et al., 2016).

2.6 A typology of Resilience Studies

In this section I provide a typology of resilience studies, based upon, and extending, the typology presented in Martin and Sunley (2014). A summary of these are presented in Table 2.2. These alternative methods are briefly defined as follows. The case study approach is essentially descriptive in nature and focuses on one or a small number of regions. Typically a regional specific shock is studied such as the decline of a particular industry (Bailey and Berkeley, 2014). When more regions are considered a common approach is the construction of resilience indices. These provide insight into the severity of shocks as well as the extent of recovery. They are based around the identification of a particular time period when a shock occurs and are sensitive to the exact specification of this period (Martin, 2012), and usually capture the extent of decline followed by the speed of recovery. Time series analysis, often in the form of vector autoregressive or vector error correction models, is typically employed for regional resilience studies which focus on a relatively small number of regions but over a long time period (usually utilising quarterly data). An advantage of these models is their statistical robustness, however, they are limited to small numbers of regions (or else the methodology becomes unwieldy) and also necessitate a long time period for analysis (Fingleton et al., 2012). Fourthly, an analysis based on formal economic models utilising spatial panel econometric techniques can be employed. The types of regional economic models utilised vary from those based on the Wage Curve (Fingleton and Palombi, 2013) to the wide family of models whose provenance is the Dixit-Stiglitz theory of imperfect competition [see Chapter 4 for an example of this which has been published as Doran and Fingleton (2018)]. The final type of analysis is relatively new and is based on merging individual level data with regional data to analyse the impact of economic shocks on individuals [see Chapter 5 and 6 for examples of this type of analysis which have been published as Doran and Fingleton (2015) and Doran and Fingleton (2016)]. Analysis at the individual level is still relatively rare but it advantageously allows one to capture effects which might otherwise be difficult to model, and the necessary individual level data are increasingly accessible. Also, increasingly, techniques to exploit such data are being developed and becoming more readily available.

"One of the main contributions of this PhD is to extend the standard methodological analysis of resilience. This has been done by focusing on causal economic models and the analysis of individual level data. To date this type of analysis has, to the author's knowledge, not been conducted. In Chapters 3 and 4 Verdoorn's law is used to provide the framework for a causal economic analysis of resilience, while in Chapters 5 and 6 the analysis is conducted at the level of the individual. As highlighted in Martin and Sunley (2014) the introduction of causal economic models in resilience analysis in Chapter 4 marks a significant departure from the typical use of case studies or indices and provides a distinct framework for the analysis of regional economic resilience. While the use of individual level data in Chapter 6 is highlighted by Bailey and Turok (2016) as making an "important contributions to ongoing debates, including … considering resilience from the perspective of the individual"."

Table 2.2: Summary of Existing Methodologies and Results

Type of Study	Method Used	Area of Analysis	Results	Authors
Case Study	Qualitative analysis. Interviews with regional agents. Policy analysis.	Munich	Resilient economy due to strong knowledge institutions, innovation systems and networks.	Evans and Karecha (2014)
Indices	Resilience and recovery indices measure the initial impact of a crisis and subsequent recovery.	UK Regions	The lower a region's resistance to a recession, the slower the region's subsequent rate of recovery.	Martin (2012)
		US Cities and Counties	Differences in resilience explained by varying industry structure. Manufacturing concentration promotes resilience.	Augustine et al. (2013)
Time Series Analysis	Statistical time series models such as VAR and VEC models are utilised.	UK Regions	National shocks had a permanent effect on the growth path of employment within regions.	Fingleton et al. (2012)
		European Countries	Shocks to GDP had a permanent effect on productivity levels across European countries.	Doran and Fingleton (2014)
Formal Economic Models	Spatial panel models are utilised.	UK Cities	Hysteretic effects are found to be present but industry structure can aid in explaining resilience.	Fingleton and Palombi (2013)
		US Cities	Hysteretic effects are found to be present but factors such as size and sectoral	Doran and Fingleton (2018)

			concentration effect resilience.	
Pooled Individual Data	Pooled probit and regression models are utilised.	US Regions	Shocks impact individual wages but different regional and individual level factors can aid in explaining resilience.	Doran and Fingleton (2015)

Based on Martin and Sunley (2014) Table 4 page 17

2.7 A Review of Previous Analythical Studies

This section provides a review of existing analysis of regional economic resilience. The previous section discussed the general typologies. This section discusses papers which have used the above types of analysis. It presents the scope of their analysis, their methods, their findings, and any relevant conclusions. This provides a context for the following Chapters.

Beginning with the conceptualisation and analysis of resilience Martin (2012) provides what he describes as a 'preliminary' empirical analysis of UK regions' economic resilience. It is here that Martin (2012) first argues that there are four dimensions are needed to capture the idea of regional economic resilience in relation to recessionary shocks, namely: resistance, recovery, renewal and re-orientation. The results presented indicate that regional resilience varies over time. Martin (2012) attributes this to differences in the causes and nature of individual recessionary shocks, but also suggests that this may be caused by the factors and mechanisms that shape economic resilience evolving themselves. This conclusion is drawn as Martin (2012) finds that the impact of the 2008 economic crisis was less differentiated between northern and southern regions compared with the previous two recessions.

Following this Martin et al. (2016) use data for 40 years to analyse how UK regions have responded to four major recessions. They focus their analysis on the role of industry structure as a possible cause and consequence of resilience. The analysis focuses on the use of indices of resistance and recovery. They also note the importance of a region's own competitiveness in determining its ability to be resilient. They conclude that the concept of the economic cycle is far from dead and that the impact of this cycle is varied at a sub-national level. They further suggest that shocks impact different regions in different ways throughout time, with regions not responding in the same way to each shock. They note that some regions of the UK have bounced back more strongly in general from shocks and that these are typically the regions of the South-East.

In a broader European context Sensier et al. (2016) provide an analysis of selected European countries (this is actually the majority of EU countries) focusing on identifying the duration of the shock and its impact. The focus is on regional economies within Europe and when they experienced a shock and for how long this shock lasted. It does not, as the authors note, aim to identify why certain regions were resilient but instead focusses on the identification of resilient regions, noting that identifying factors which determine resilience was an avenue for future research.

Courvisanos et al. (2016) provide an analysis of resilience focusing on the Australian economy. They focus on identifying resilience by industrial categories and regions using an adaptive resilience conceptual framework. They identify two major shocks in their data, a natural drought and also the global financial crisis. They identify certain industries as more resilient than others (noting that these are mining and then typically service sectors). Noting that these sectors may draw their resilience from Australia's competitive advantage based on exports of raw material and commercial services.

An example of an application of time series econometric techniques to the study of resilience can be found in Fingleton et al. (2012). They provides an empirical analysis of 12 UK NUTS1 regions for the period 1971 to 2010 using a seemingly unrelated regression analysis and a vector error correction model. The analysis indicates that UK regions respond differently to economic shocks and that the differences are mainly a result of differences in their initial ability to resist the onset of a shock. They find that employment shocks typically have a permanent effect and that there are inter-regional spillovers, but that these are typically confined to proximate regions.

Cellini and Torrisi (2014) provide an empirical analysis of Italian regions using a time series which spans from 1890 to 2009. The analysis used by the authors is essentially the same as that of Fingleton et al. (2012) with the exception that it focuses on annual GDP per capita rather than quarterly employment to analyse resilience. The authors note that shocks across Italian regions have permanent effects on the growth paths of the regions. However, they note that recovery following shocks is approximately the same across regions, with no region showing signs of above average recoverability.

Di Caro (2017) consider engineering resilience and ecological resilience and propose a methodology to test between them using VAR models as opposed to the VEC models used by

Cellini and Torrisi (2014) and Fingleton et al. (2012). They note that up until 2007 from the 1970s the main focus of economics was that employment shocks were temporary in nature. However, post 2007 there has been an increase focus on the view that these shocks may be more permanent in nature. The authors note that there are a number of determinants of regional economic resilience. They suggest that this is still an open question and that there is much research focused on the role of differing factors on the promotion of resilience.

There is a significant body of work which relates industry structure to economic performance at the regional level, much of it following the seminal work of Glaeser et al. (1992). In their work, Glaeser et al. (1992) provided a comprehensive analysis of the role of local competition, urban variety, and regional specialisation on economic growth using data for 170 US cities across a variety of industries from 1956 to 1987. Their findings provided support that knowledge spillovers occur between diverse industries as opposed to within industries which they suggest can be linked with Jacobian theories of the importance of diversity for regional growth.

This finding of the importance of diversity received further support from subsequent research by Feldman and Audretsch (1999). They note that an extensive literature "has recently emerged which focuses on the implications of the concentration of economic activity for economic growth" (pp. 410). However, they propose that a related, important question is "does the specific type of economic activity undertaken within any particular geographic region matter" (pp. 410). They suggest that within this there are two competing views. The first is in line with Marshall-Arrow-Romer externalities which point towards specialisation and concentration of particular industries within a region promoting knowledge spillovers across firms. The second relates to Jacobs (1969) types of externalities, which is the argument that it is complementary knowledge from diverse firms across different sectors which will results in the greatest return to new knowledge through spillovers. In their paper Feldman and Audretsch (1999) test these two competing hypotheses regarding industry structure and knowledge spillovers using data from the US on cities and industries, in total having 5,946 city-industry observations. Their findings suggest that it is diversity across what they identify as complementarity economic activities which drives innovation as opposed to specialisation. Their results suggest that there is no evidence to suggest that specialisation promotes the generation of new innovations.

Further research on the role of industry structure highlights the emphasis placed by the literature on the concept of clusters, as developed by Porter (1990; 1998). Where benefits accrue to the firm from the geographic concentration of related businesses, suppliers, and associated institutions. Porter (2003) provides an empirical analysis of the impact of clusters on regional development across US regions. He highlights that there are significant differences across regions in terms of ‘cluster mix’ which he defines as “represents the portion of the wage difference that can be explained by the region’s particular employment distribution across clusters” (pp577). His findings suggest that regional performance differences are explained by the presence of clusters in a region, and that no particular ‘cluster mix’ was identified as optimal. However, research such as Martin and Sunley (2003) highlights that while the role of industry structure within the cluster literature has been appealing to policy makers, it is relatively under developed in terms of conceptualising clusters from a theoretically perspective which in turn has contributed to an underdeveloped empirical research agenda in the area.

An alternative viewpoint to cluster theory in urban studies is linked with the concept of agglomeration economies. Parr (2002) highlights that agglomeration economies can be divided into six components, but that all components involve spatial concentration. Three of these are internal to the company and three are external. The three external components are what is relevant in this case as they relate to industry structure. The first is localisation economies which relates to the co-location of firms in the same sector. The second is urbanisation economies which relates to the co-location of firms across a diverse variety of sectors. Finally activity-complex economies relate to the co-location of a set of firms that operate in a production chain. These suggest the importance of industry structure could be from specialisation (localisation) or from diversification (urbanisation).

As discussed in Martin et al. (2016) the debate surrounding specialisation versus diversification remains unresolved in existing literature with some arguing that industrial specialisation is one of the main drivers of regional economic growth [see for example Storper (2013) and Storper et al. (2015)]. While others support the view that it is diversity which stimulates higher rates of regional growth [see for example Hausmann et al. (2014)].

These concepts of industry structure are related to resilience in Martin et al. (2016), as discussed earlier.

Brown and Greenbaum (2017) build on this concept by noting that as the economic recovery from the great recession continues scholars are again focused on the pace and sustainability of recovery and on efforts to identify what might minimise the severity of future shocks. This paper analyses the relationship between industry structure diversity and economic resilience over time. The focus of Brown and Greenbaum (2017) on industry structure is similar in focus to the analysis conducted by Martin et al. (2016). They note that shocks of various natures can have almost immediate impacts on local economies and that this is combined with business cycle fluctuations as well which threaten stability. The analysis uses 35 years of data for Ohio counties between 1977 and 2011. They focus on a regions ability to bounce back following a shock. The results indicate that while more specialized counties had lower unemployment rates when times were good, counties with more diverse industry structures fared better during time of national or local employment shocks. There is also a relationship between concentration in certain industries and an ability to resist shocks.

Davies (2011) provides an analysis of resilience across European regions for the period 2008 to 2010. They find that there is evidence of a link between resilience and industry structure, with resilience being weaker in regions with a strong manufacturing base. They further note that resilience in the construction sector was low in countries which had experiences bubbles in construction prior to the onset of the crisis.

Continuing with the discussion of industry structure Brakman et al. (2015) use regional data from 22 different countries to analyse the impact of urbanisation on regional economic resilience. They focus on the 2007/08 economic crisis and NUTS2 regions as the unit of their analysis. The key resilience indicators used are unemployment and GDP. Their analysis notes that more urbanised regions, with a large commuter share, are more resilient to the 2007/08 crisis than less urbanised regions. They also find that industry structure plays an important role in explaining resilience. Their analysis suggests that regions with a higher share of output in medium-high technology industries are more resilient.

Diodato and Weterings (2014) provide an empirical analysis of supply factors, interregional labour mobility, and inter sectoral labour mobility. Their analysis focuses on Dutch data and on the initial resistance of regions to shocks and their subsequent recovery. Their findings suggest that regions where there is a strong concentration of supply factors within their own regions are more exposed to internal regional shocks but less exposed to external shocks with an opposite effect for export orientated regions. Regions with a higher concentration of employment or movement of employment into services sectors were also found to be more resilient.

Lagravinese (2015) provides an empirical analysis of recessions in Italian regions over the period 1970 to 2011. Their focus is on employment and their empirical analysis suggests that regions which were specialised in manufacturing or had a high degree of temporary workers were less resilient to economic crises. However, regions with a higher degree of specialisation in the public sector or services sector were more resilient. Their analysis of the 2007/08 crisis suggests that the crisis has resulted in a widening of the gap between the north and south of Italy.

Fingleton et al. (2015) analyse the impact of the recent economic crisis on EU regions. Their focus is on the role of monetary union in explaining the propagation of shocks across regions. They use a spatial panel model to generate counterfactuals of the impact of the crisis. They find that more geographically isolated regions are more negatively affected by the crisis. These regions also happen to be the regions most effected by the debt crisis. This leads the authors to discuss the implications of monetary union in restricting countries in their responses to the crisis.

Psycharis et al. (2014) design a composite regional resilience indicator for Greek regions to identify the ability of these regions to resist the 2007/08 economic crisis. They consider pre- and post crisis socio-economic variables in the construction of their index. They find that metropolitan regions or regions which possess a high degree of manufacturing employment are the most exposed to the crisis while specialism in tourism is found to be a factor which imparts resilience.

In another analysis of the Greek economy Giannakis and Bruggeman (2017) utilise shift-share and input-output models to analyse the impact of the economic crisis on Greek regions. The results are similar to those of Psycharis et al. (2014) and indicate that rural regions are more resistant to recessionary shocks than urban regions. They also find again that the tourism sector in the island regions showed heightened levels of resilience.

Studies also focus on specific sectors as opposed to studying general industry structure. Holm and Østergaard (2015) provide an empirical analysis of resilience amongst the ICT sector in Denmark to the bursting of the dot.com bubble. They find that where regions possessed small and young ICT companies, these regions were relatively more resilient. Perhaps due to the adaptability of these young firms. While regions which were highly urbanised or diverse actually experienced a more negative response to the crisis. They classify their regions according to their findings between adaptively resilient, rigidly resilient, entrepreneurially resilient and non-resilient regions.

Bellini et al. (2017) analyses the contribution of tourism to regional economic resilience and focuses on the concept of smart specialisation. The focus is on how policy makers recognise the relevance of tourism and integrate it into the regional development strategies in order to increase the resilience potential of their regions. Bellini et al. (2017) identify that the role of tourism in determining resilience lies in its own growth dynamics, its own resilience and also with its linkages to other sectors of the economy. Tourism is viewed as possessing the ability to sustain economies in a stable and reliable way and may be able to compensate for declines in other sectors of the economy.

In addition to industry structure studies have also focused on factors such as innovation and entrepreneurship. Regarding innovation, Bristow and Healy (2018) link the concept of regional innovation capacity to that of regional economic resilience. It proposes that more innovative regions can be more resilient. The analyse using data for EU regions for 28 countries. They follow Martin's (2012) definition of resilience as the extent of recovery from the economic shock of 2008 using data from Cambridge econometrics. Employment data is used as the indicator of resilience. They use NUTS2 level data. Their findings indicate that innovation is strongly related to resilience. Regions which are more innovative are more likely to be better able to recover following an economic shock.

Williams and Vorley (2014) analyse the link between economic resilience and entrepreneurship in city regions specifically the Sheffield City Region. They utilise a case study approach focusing on interviews of policy-makers to draw conclusions regarding the importance of entrepreneurship for developing a resilient city region. They suggest from their analysis that entrepreneurship is integral to promoting the diversification and capacity building of regional economies, traits which are characteristic of resilient economies.

Eraydin (2016) presents an empirical analysis of the impact of recessions on NUTS2 regions of Turkey. They use data from the 1970s to 2011 to analyse the impact of a series of recessionary shocks on the GVA of regions. They note that shocks impact differently on regions over time. They attempt to explain resilience to shocks using a series of control variables such as diversity, specialisation, and innovativeness of regions. They highlight the importance of human capital for resilience while also pointing to the importance of high technology sectors and research and development. This is a similar argument to that of Bristow and Healy (2018) discussed earlier. Again Christopherson et al. (2010) also notes innovation as a potential driver of resilience.

Crescenzi et al. (2016) considers the EU27 countries and the relevance of pre-2008 economic conditions on regional resilience during the crisis. They consider a number of national factors and the impact these have on the respective country's regions. They note the importance of human capital as an important determinants of regional economic resilience. Some national factors such as a strong current account balance lead to better resilience.

Huggins and Thompson (2015) analyse the role of community culture in explain regional economic resilience. Their focus is on entrepreneurial activity. They use British data from 2004 to 2011 to analyse resilience to the 2007/08 economic crisis. They find that a more open and diverse regional culture is positively related to the level of entrepreneurial activity within a region. They suggest a role for education in promoting an open culture within regions and highlight the importance of policy in shaping culture.

Looking at resilience from the perspective of human psychology Obschonka et al. (2016) provide an analysis based on psychological factors and their impact on economic behaviour. They generate a regional level psychological indicator and correlate this with regional economic resilience. Their study focuses on the US and UK where large scale psychological data is available and can be regionalized. Their findings suggest that more emotionally stable regions and regions with a more prevalent entrepreneurial personality were more resilient to the economic crisis. However, they note the difficulty of identifying causation and the possible impact of the crisis on individuals psychology.

Different spatial scales are also considered with Östh et al. (2015) arguing for an analysis at lower spatial scales than is typically adopted in the resilience literature. They focus their analysis on the municipality level while also arguing for more consideration of accessibility. They conduct their analysis for 290 Swedish regions. Their findings suggest that the major cities and areas of economic activity and concentration are the most resilient regions.

Different methodologies have also been applied such as case study approaches. Brooks et al. (2016) are one such example of this type of analysis. They analyse the importance of civic leadership, rather than economic factors, in determining the resilience of city regions. They provide a case study analysis of the Sheffield city region. The central results of the paper are that effective leadership can lead to increased cooperation amongst local actors, facilitating increased resilience. Specifically the authors find that leadership has the potential to stimulate collective action between the public, private and third sectors to develop strategies aimed at promoting economic resilience.

Another example of a case study approach is Cowell (2013) who focus on the importance of resilience for economic development officials and planning scholars. Their analysis explores case studies of two regions; Buffalo, New York and Cleveland, Ohio using interviews with past and present planning and economic development leaders. These regions were chosen due to their deindustrialization and their responses to this using economic development strategies. They highlight how economic development planning can lead to the development of adaptive resilience in distressed regions.

Wrigley and Dolega (2011) provide a descriptive analysis of 250 town centres/high streets across four regions of the UK to provide insight into how these centres adjusted to the global economic crisis. Their analysis finds that diversity in the retail centres analysed contributed significantly to their resilience to the shock.

Another alternative methodology is utilised in Capello et al. (2015) who analyse the role of cities as drivers of regional economic resilience across Europe. The focus is on the 2007/08 economic crisis. Their analysis is based on scenario analysis coupled with the use of a macroeconomic regional growth forecasting model. Their findings suggest that there is a need for policy intervention in the recovery phase post crisis, without which there are likely to be differentiated regional impacts with some regions recovering much more strongly than others.

Rose and Liao (2005) take another different approach in their consideration of shocks and focus on natural disasters and their impact on regional economies. They employ Computable General Equilibrium (CGE) models which allow them to analyse the impact of disruptions of critical inputs. Their analysis focuses on the sectoral and regional economic impacts of a disruption to the Portland Metropolitan Water System in the aftermath of a major earthquake, highlighting the negative economic impact this natural disaster would have.

Giesecke et al. (2012) provide another application of the CGE methodology to the regional resilience literature. Again they focus not on an economic shock but a man made disaster. They distinguish between two different types of effects; a reduction in effective resource supply and (ii) shifts in the perceptions of economic agents. They find that the latter of these two, which they classify as behavioural effects, can have a more lingering negative long-term impact on regional output and that this effect is much greater than that generated by resource loss effects.

Looking at resilience from a more mico-foundation Nyström (2017) discusses the extent to which a series of factors impact on the ability of individuals to be re-employed in the same region in which they lost their employment. The author focuses on the use of agglomeration indicators, such as related and unrelated variety to explain the change of reemployment. The analysis focuses on Swedish data and focuses on the period 2001-2009. The general results suggest that industrial structure is an important indicator of re-employability with both related variety and unrelated variety increasing the resilience of regions with low re-employment capacities. However, they note that variety is negatively related to re-employment capacity in regions that have the highest re-employment capacity.

Eriksson and Hane-Weijman (2017) provide an analysis of Swedish regions by linking micro data on employment flows. They focus on the recession which occurred in Sweden in the 1990s. The authors note that even though Sweden has experienced strong national employment growth since the economic crisis, the recovery has mainly been confined to a small number of city regions. The authors find that regions with a more diverse or concentrated industry structure are more resilient to the economic crisis. They also find that resilience to future shocks may be linked to regions' resilience to previous shocks.

Kakderi and Tasopoulou (2017) note that there is increased awareness of resilience in both theory and practice with this interest triggered by the fact that regional economies have responded so diversely to the 2007 economic crisis. Some regional economies were particularly vulnerable to the shock while others were able to resist and recovery quickly. They note that term resilience has become increasingly popular in both theory and practice. They suggest that shocks and disturbances are rarely spatially equitable there are increasing discourses on the role of local, regional and urban resilience as opposed to national resilience.

2.8 Relevence of this Literature to this PhD

Throughout this PhD the main focus is on the ability of a nation, region or individual to exhibit resilience. Depending on the context and the available data I attempt to focus on the resistance, reorientation and/or recoverability of the unit of analysis and link it with the discussion of resilience provided in this Chapter.

A central theme emerging from the review of existing literature is the importance of industry structure and reorientation of this structure. Therefore, in Chapters 3, 4, 5, and 6 I explicitly consider the importance of industrial structure for national, metropolitan, and individual level resilience. This is highlighted by authors such as Martin et al. (2016), Brakman et al. (2015), Lagravinese (2015), Courvisanos et al. (2016), Bellini et al. (2017), and Davies (2011).

Another theme which emerges is the importance of human capital and individuals for resilience. Specifically, in Chapters 5 and 6, this PhD focuses on the resilience of the individual to economic shocks. I explicitly account for education (human capital) as well as a range of other factors when considering the determinants of resilience. This is a relatively novel approach and I am amongst the first to consider resilience at the level of the individual.

The concept of resistance, reorientation, and recovery is also discussed extensively within each Chapter. It is not always possible to analyse each of these factors with the data available. However, in Chapter 3 I analyse resistance, reorientation, and recovery from a national perspective. All three factors are also analysed in Chapter 4. When considering Chapters 5 and 6, where the main contribution is the analysis of the individual, it is not possible to discuss reorientation as no data is available at the individual level to identify whether they have returned to training or have become employed in a different capacity or sector. Therefore, reorientation is not discussed in these Chapters.

2.9 Theoritical Models Underpinning the Resilience Analysis

In order to analyse resilience, I utilise time series analysis, formal economic models, and pooled cross sectional data approaches as documented in Table 2.2 above. Specifically, underpinning the empirical modelling are three theoretical concepts: (i) Verdoorn's law, (ii) New Economic Geography (NEG) theory, and (iii) Urban Economics (UE) theory. Chapter's 3 and 4 utilise Verdoorn's law as the underpinning theoretical framework. While Chapter 5 utilises NEG and UE theory.

The different theoretical bases underpinning the analysis provide a starting point for adaptation and modification in order to make them more realistic, in other words to provide data from empirical models that is not to dissimilar to data observed in the real world. It turns out that the three different theories have much in common, in that there is a focus on increasing returns to scale as a possible outcome. While increasing returns was a phenomenon well known to economic geographers and heterodox economists, notably in the form of Verdoorn's Law, it scarcely entered the realm of more orthodox economic analysis until the intervention of Krugman and new economic geography. Krugman showed how one could reconcile increasing returns with the micro foundations of more mainstream economics and this provided a major breakthrough in our understanding of why cities exist, why regions are different and how they might evolve. Urban Economics is very much related to NEG theory, but without the dynamics and without the role of trade costs, but both UE and NEG theory has the same market structure assumptions, with imperfect competition and the constant elasticity of substitution production function leading to internal scale economies in the firm which drives aggregate increasing returns. It also turns out that the reduced form which is know as Verdoorn's Law can also be derived from the same underlying theory, as explained in Fingleton (2003) and McCombie et al. (2017). In this sub-section I provide a more detailed review of these theories and within each Chapter they are directly applied in the context of the research questions that Chapter addresses.

2.9.1 Verdoorn's Law

As noted by Castiglione (2011: pp 160) "Dutch economist P.J. Verdoorn published the results of his research on productivity and output growth in an article entitled "Fattori che regolano lo sviluppo della produttività del lavoro" in the Italian journal *L'Industria*". When referencing Verdoorn's Law this refers to a causal relationship from the long run growth rate of output to the long run growth rate of labour. This relationship was proposed to hold particularly in the case of the manufacturing sector. The work of Verdoorn was used by Kaldor to explain the slow rate of growth in the UK. Indeed, León-Ledesma (2000) notes Verdoorn's law is typically taken as Kaldor's (1966) second law of growth which is that the manufacturing sector is subject to substantial increasing returns to scale and that the growth of productivity in manufacturing is an endogenous result of the growth of output.

McCombie and Roberts (2007) highlight that in the case of Kaldor (1966) the law is dynamic rather than a static. However, the law has also been specified in static form (McCombie et al., 2017). Beginning with the concept of the dynamic law Fingleton and McCombie (1998) describe the relationship as traditionally being between the exponential growth rate of labour productivity and the exponential growth rate of output such that:

$$p = b_0 + b_1 q \tag{2.1}$$

Where p is the exponential growth rate of labour productivity, q is the exponential growth rate of output, b_1 is what is typically call the Verdoorn coefficient, and b_0 is exogenous growth in labour productivity. Typically the Verdoorn coefficient in empirical estimation takes a value of approximately 0.5 (Fingleton and Lopez-Bazo, 2006). A coefficient of this value would imply that a one percentage increase in output growth results in an increase in the growth of employment of 0.5 percent and an equivalent increase in the growth of productivity. McCombie and Roberts (2007) notes that this is taken to imply increasing returns to scale.

A criticism of the Verdoon's law is that it excludes the accumulation of capital. However, it can be shown that the above equation (2.1) can be derived from the standard Cobb-Douglas production function so as to include capital stock. Beginning with the following production function specification:

$$Q = A_0 e^{\lambda} K^{\alpha} L^{\beta} \tag{2.2}$$

Talking the natural logarithm of this equation and differentiating with respect to time yields:

$$q = \lambda + \alpha k + \beta l \tag{2.3}$$

Where q is the exponential growth rate of Q (given as the differentiation on the natural logarithm of Q with respect to time). k is the exponential growth rate of capital and l is the exponential growth rate of labour. It is possible to rearrange this as follows to yield a Verdoorn's Law type equation with capital included.

$$q = \lambda + \alpha k + \beta l \tag{2.4}$$

$$q + \beta q = \lambda + \alpha k + \beta l + \beta q \tag{2.5}$$

$$\beta q = \lambda + \alpha k + \beta l + \beta q - q \tag{2.6}$$

$$\beta q = \lambda + \alpha k + \beta l + (\beta - 1)q \tag{2.7}$$

$$\beta q - \beta l = \lambda + \alpha k + (\beta - 1)q \tag{2.8}$$

$$q - l = \frac{\lambda}{\beta} + \frac{\alpha k}{\beta} + \frac{(\beta-1)}{\beta} q \tag{2.9}$$

$$p = \frac{\lambda}{\beta} + \frac{\alpha}{\beta} k + \frac{(\beta-1)}{\beta} q \tag{2.10}$$

Where *p=q-l* the exponential growth rate of productivity. In this instance to Verdoorn's coefficient is given as $\frac{(\beta-1)}{\beta}$ and the effect of capital is included. While it is possible to include capital in this way it is generally regarded as unnecessary. This is due to the fact that in advanced economies the capital stock grows either at approximately the same rate as that of output or slightly slower. As emphasised in McCombie and Thirlwall (1994) and Fingleton and McCombie (1998) the relationship between the growth of capital and the growth of output is approximately unity. If the relationship between the two is assumed to be

$$k = w + \gamma q \tag{2.11}$$

And setting *w=0* and $\gamma = 1$ and substituting (2.11) into (2.10) this yields:

$$p = \frac{\lambda}{\beta} + \frac{(\alpha+\beta-1)}{\beta} q \tag{2.12}$$

If the Verdoorn coefficient, given as $\frac{(\alpha+\beta-1)}{\beta}$, is greater than and statistically different from zero then the model exhibits increasing returns to scale. If it is assumed, for the purposes of illustration, that the elasticities of capital and labour are approximately equal then a Verdoorn coefficient of 0.5 yields $(\alpha + \beta) = 1.33$.

It is important to note that while the dynamic Verdoorn's law equation can be derived from a Cobb-Douglas production function there are differences between the Verdoorn equation and the standard neo-classical view obtained from the Cobb-Douglas function. As noted by McCombie and Roberts (2007) under Verdoorn's law output growth is assumed to be exogenous as opposed to the result of the growth of input factors which is the case in the neoclassical perspective. In the case of Verdoorn's law the growth rate of output depends on a region or country's competitiveness. The supply of inputs responds to the growth in demand (McCombie and Roberts, 2007).

It is also possible to obtain the static form of Verdoorn's law which can also be derived from the Cobb-Douglas production function displayed in equation (2.2). A similar approach is used as displayed in equations (2.4) to (2.10) however in this instance one does not differentiate with respect to time. This yields the following once natural logarithms are taken.

$$lnQ = \lambda + \alpha lnK + \beta lnL \tag{2.13}$$
$$lnQ + \beta lnQ = \lambda + \alpha lnK + \beta lnL + \beta lnQ \tag{2.14}$$
$$\beta lnQ = \lambda + \alpha K + \beta lnL + \beta lnQ - lnQ \tag{2.15}$$
$$\beta lnQ = \lambda + \alpha lnK + \beta lnL + (\beta - 1) lnQ \tag{2.16}$$
$$\beta lnQ - \beta lnL = \lambda + \alpha lnK + (\beta - 1) lnQ \tag{2.17}$$

$$lnQ - lnL = \frac{\lambda}{\beta} + \frac{\alpha}{\beta} lnK + \frac{(\beta-1)}{\beta} lnQ \quad (2.18)$$

$$lnP = \frac{\lambda}{\beta} + \frac{\alpha}{\beta} lnK + \frac{(\beta-1)}{\beta} lnQ \quad (2.19)$$

An alternative specification of this final Verdoorn's law can be obtained which relates output to labour, rather than labour productivity. In this case one is left with:

$$\beta lnQ - \beta lnL = \lambda + \alpha lnK + (\beta - 1) lnQ \quad (2.20)$$

$$-\beta lnL = \lambda + \alpha lnK - lnQ \quad (2.21)$$

$$lnL = -\frac{\lambda}{\beta} - \frac{\alpha}{\beta} lnK + \frac{1}{\beta} lnQ \quad (2.22)$$

One can utilise either equation (2.10), (2.19) or (2.22) in the estimation of Verdoorn's law (McCombie and Roberts, 2007).

Numerous empirical applications of Verdoorn's law exist. León-Ledesma (1999) provides an analysis of 17 Spanish regions using pooled data from 1962 to 1991, grouping the date into sub periods. Alternative specifications of Verdoorn's Law are estimated, consistent with those presented above. The results of the pooled panel estimation provide significant of increasing returns to scale in the Spanish case.

In a following paper León-Ledesma (2000) extends the analysis of Verdoorn's Law beyond the manufacturing sector to other sectors of the economy and to the overall economy. The same regions and time periods as in León-Ledesma (1999) are used. The author notes that it is important to extend the analysis of Verdoorn's law beyond the manufacturing sector as "in modern economies, it may be possible to identify some activities, especially in the services sector, that could also be subject to increasing returns" (León-Ledesma, 2000: pp 61). The author's results suggest substantial increasing returns for manufacturing, the services sector and for the overall economy. I return to the extension of Verdoorn's law beyond manufacturing in Chapters 3 and 4.

Michl (1985) provides a series of OLS estimations for developed, Western economies to identify whether they exhibit increasing returns to scale in the manufacturing sector. The data used is from 1950 to 1983. The author finds some support for Verdoorn's law holding across the manufacturing sector of the countries studied.

Hildreth (1989) presents an early regional analysis of Verdoorn's law for UK regions. Data is used on 11 UK regions for the time period 1970 to 1983 and OLS estimation is employed. The author concludes that some increasing returns to scale are observed. The author suggests that in their analysis it is not possible to assume that employment growth during the period was exogenous and that by treating the variable as exogenous in their analysis this may have resulted in the results not being consistently strongly significant.

Millemaci and Ofria (2014) provide an analysis of Verdoorn's Law for a sample of developed countries including Western European countries and other OECD members. National data for 1973 to 2006 are used and the dynamic Verdoorn's Law specification is tested using instrumental variable estimation. The authors' find evidence that Verdoorn's law holds across their sample of countries and the time period considered. In my treatment of Verdoorn's law in Chapters 3 and 4 I explicitly account for endogeneity.

Harris and Lau (1998) provide an empirical analysis of Verdoorn's law for UK regions using cointegrating vectors. The focus is solely on the industrial sector. Their justification for the use of a cointegration methodology is that it overcomes problems associated with endogeneity in many specifications of Verdoorn's Law. Harris and Lau (1998) identify three typical issues associated with Verdoorn's law these being; (i) the omission of capital stock, (ii) the identification of the parameters of the model controlling for endogeneity, and (iii) the differences which exist in results when considering the dynamic versus static specifications of Verdoorn's Law. In order to implement their approach the authors estimate a Vector Error Correction (VEC) model (this is consistent with the approach adopted by this PhD in Chapter 3). In total 10 regions are considered for a variety of manufacturing sectors and the results suggest that significant increasing returns to scale are present for many manufacturing sectors.

Alexiadis and Tsagdis (2006) provide a series of Verdoorn's Law estimations using what they term 'conventional' specifications of the law but also spatial specifications. They utilise data on NUTS3 Greek regions for the period 1970 to 2000. They find strong support of Verdoorn's law in their analysis with the Verdoorn's coefficient taking the expected sign and value in their empirical estimations. They also find evidence of spatial dependence in their models and estimate a series of spatial error models to control for spatial error dependence.

Fingleton and Lopez-Bazo (2006) provide an analysis of European regions using Verdoorn's law as one of the lenses of analysis. They utilise data from 108 regions across 12 countries for the period 1980 to 1996 utilise a spatial error model to estimate the impact of output on labour productivity. Their results indicate that Verdoorn's law is supported in their analysis of EU regions. A similar approach in the application of Verdoorn's law using spatial models is implemented in this PhD in Chapter 4.

2.9.2 New Economic Geography Theory

Chapter 5 of this PhD utilises New Economic Geography (NEG) theory. Specifically, the wage equation, which likes regional wages to market potential. In this sub-section I present a summary of the derivation of this equation as well as briefly summarising some of the empirical work which uses this theory. The exact specification of the NEG equations used in Chapter 5 are discussed in Chapter 5.

The foundations of new economic geography theory are presented in Fujita et al. (1999). It is based on the Dixit-Stiglitz model of monopolistic competition. It is assumed that the economy is divided into two sectors. One a competitive sector (*C*) the other a sector which exhibits monopolistic competition (*M*). The starting point is an equation which explains wages in the *M* sector as a function of the 'market potential' of the location.

$$w_i^M = \frac{\bar{W}_i^M}{E_i^M} = \left[\sum_r Y_r (G_r^M)^{\sigma-1} (T_{ir})^{1-\sigma}\right]^{1/\sigma} = P^{1/\sigma} \tag{2.23}$$

Where $\bar{W}_i^M$ is region *i*'s total wage bill for sector *M*, E_i^M is region *i*'s total sector *M* employment and the summation is over the set of regions including region *i*. Transport costs are assumed to equal T_{ir}. G_r^M is region *r*'s price index for sector *M* and Y_r is region *r*'s income. The elasticity of substitution is given as σ for the *M* varieties. An assumption typically applied in this context is that *C* goods are freely transported and are produced under constant returns. Therefore, wages in the *C* sector are constant across regions.

The price index can be defined as follows:

$$G_i^M = [\sum_r \lambda_r (w_r^M \bar{T}_{ir})^{1-\sigma}]^{1/(1-\sigma)} \tag{2.24}$$

The number of varieties produced in region r is indicated by λ. This is equal to the share in region r of the total supply of M workers.

Income can be defined as follows:

$$Y_r = \theta\lambda_r w_r^M + (1-\theta)\phi_r w_r^C \tag{2.25}$$

Where θ is the share of M workers in region r of total workers in region r. And ϕ_r is defined as the number of competitive sector varieties. w_r^C is the average worker wage in sector C in region r.

If one takes the log format the basic wage equation can be defined as:

$$lnw_i^M = \frac{1}{\sigma} lnP_i \tag{2.26}$$

This equation relates wages in the M sector in region i to the market potential of region i. Where market potential comprises transport costs, income, the price index, and the elasticity of substitution.

This type of model, or variations of it, has been used to explain regional wage variation in a number of alternative settings. I outline briefly below some examples of the empirical application of this wage equation. The relevance of these studies to this PhD are that they show how the wage equation can be used in different contexts to model wages. In Chapter 4 I apply the wage equation to generate counterfactual wage estimates to analyse resilience. While none of the below papers apply the wage equation in this context, the underlying empirical strategy of estimating the wage equation is similar.

Brakman et al. (2006) provide an empirical estimation of the wage equation using NUTS2 data for 13 countries for the period 1992 to 2000. In addition to a market potential variables they also include a series of other control variables which may impact the wage levels across regions. They employ an instrumental variable estimation technique to take account of potential endogeneity between market access and wages (as market access is based on income). They find that market potential has a significant positive impact on wage levels. They subsequently explore other elements which may impact market potential and wages, specifically focusing on openness to trade.

Kiso (2005) use data on 46 Japanese prefectures to estimate a NEG type model to explain differences in wages across regions. Data for five time periods is used to estimate a series of wage equations. A series of instrument variable general method of moment estimations are utilised. The results show that market potential has a significant positive effect on wages across Japanese regions and across the five different time periods used.

Niebuhr (2006) analyses the impact of market potential on regional wage levels for a selection of 158 European regions using data from 1985 to 2000. The author concludes that market potential has a significant positive impact on regional wages across Europe. They do however find some evidence that the importance of market access appears to weaken over time.

Fally et al. (2010) provides an analysis of the impact of market potential on wages across Brazilian states. This paper used micro level data on individuals combined with regional data on market potential. Using data from 1999 they analyse whether market potential has a significant impact on individuals' wages when controlling for individual specific factors. Their findings suggest that, even when controlling for individual specific effects, market potential has a significant positive impact on wages.

Bosker and Garretsen (2010) provide a meta-analysis of the impact of market access on wages and subsequently provide an estimation of the impact of market access on GDP for a sample of countries, with the aim of showing how alternative specifications of transport costs, in the construction of the market access variable, can impact on the relationship between GDP/wages and market access. They show that while market access generally has a positive impact on GDP the significance and size of the coefficient can vary depending upon the transport costs assumed.

Head and Mayer (2006) at a higher level of aggregation use data on 57 NUTS1 EU regions for the period 1985 to 2001 to analyse what they term 'real market potential'. They wish to analyse the impact of this indicator on wages and employment at the NUTS1 level. Additional control variables such as human capital are also included in their empirical estimation. Pooled regression models using fixed effects for year and countries are included. The authors note that wages respond to market potential, but that this effect is not consistent across different industries. They find some evidence, but not consistently, that market potential has a positive effect on employment.

Head and Mayer (2010) provide an analysis at the national level of the impact of market potential on economic development, measured as income per capita. Where they summarize market potential as proximity to large markets. Data for the period 1965 to 2003 is used in their estimation. Their analysis shows that, when controlling for other factors, market potential remains a significant and important determinant of country level income.

Fingleton (2005) tests the effectiveness of NEG theory in explaining wage variation across regions in Great Britain relative to the neo-classical Solow (1956) model. Both are included in a non-nested model and a J-test is employed to assess the relative explanatory power of both models. The data used is at the Unitary Authority - Local Authority Districts level which divides Great Britain into 408 units. He finds that the NEG model has significantly greater explanatory power than a model derived from the Solow (1956) model. Suggesting that the NEG model can provide a superior explanation of regional wage variations than the neo-classical model.

In a following paper Fingleton (2006) provides an analysis of NEG theory in the context of comparing the explanatory power of this theory against 'urban economic' theory. Urban economic theory is considered in the next sub-section of this PhD. The paper uses data for Great Britain at the Unitary Authority - Local Authority Districts level for the year 2000. An artificially nested model is created which incorporates both NEG and urban economics indicators and allows for the relatively explanatory power of both of these theories to be analysed. From the analysis, while market potential does have a significant positive effect on wages, urban economics is found to have more explanatory power.

Fingleton and Fischer (2010) provide an analysis of 255 European NUTS2 regions over 25 European countries for the time period 1995 to 2003. The paper is similar to that of Fingleton (2006) in design except that it tests NEG theory versus neoclassical theory. The neo-classical model is based on the work of Solow (1956). The empirical approach is similar in that a non-nested model is constructed, however, the estimation technique differs given that the data in this context are panel in nature. The analysis focuses on gross value added (GVA) rather than wages. In their analysis they show that while both theories can explain GVA variations across regions, the NEG model outperforms the neo-classical model.

2.9.3 Urban Economics Theory

In Chapter 5 I also use Urban Economics (UE) theory as a possible explanation of differences in individual wages across US regions. The version of urban economics as used here is based on Ciccone and Hall (1996). This model assumes that increasing returns exist in the production of local intermediate goods. It is assumed that the production function for making a final good on a unit of land, say an acre, is:

$$Q = M^{\beta} I^{(1-\beta)^{\alpha}} \tag{2.27}$$

Where *M* is the amount of labour used in making output *Q*, *i* is the amount of composite service input which is used and cannot be transferred outside the area. α is the decreasing returns of the inputs based on the acre which can be thought of as congestion effects. β is the distribution parameter which can be thought of as the agglomeration effect.

It is assumed that the service composite, given as i is produced from different individual services which are represented as $x(t)$. *t* indicates the type. Assuming a constant elasticity of substitution production function this yields the following:

$$I = \left(\int_0^z x(t)^{1/\mu} dt\right)^{\mu} \tag{2.28}$$

Where *z* describes the varieties of intermediate products produced of which there are 0 through *z* available. μ is a parameter which controls the substitutability between intermediate products. It is assumes that $\mu > 1$. A larger value of μ indicates that there is less ability to substitute one product for another and that there is a higher degree of monopoly power for the producer of that product. Ciccone and Hall (1996) note that under the standard assumptions of the underlying Dixit-Stiglitz model the level of output at zero profits is:

$$x = \frac{v}{\mu - 1} \tag{2.29}$$

Substituting this value into equation (2.27) yields:

$$I = z^{\mu} x \tag{2.30}$$

The share of employment in manufacturing is given as:

$$M = \beta N \tag{2.31}$$

Where N is total employment per acre. The remaining share of labour makes intermediate services and is given as $(1-\beta)N$.

Ciccone and Hall (1996) note that as the total amount of labour given over to intermediate services and the amount each one produces is known it is possible to solve for the variety of services which gives:

$$z = (1-\beta)\frac{1-\mu}{\mu}\frac{N}{v} \tag{2.32}$$

This suggests that the intermediate product variety, given as z, is proportional to density, as measured by the number of workers per acre.

If this equilibrium value for z is substituted into equation (2.29) to determine I, and this is substituted into the production function (2.26) for final goods this yields:

$$Q = \phi N^{\gamma} \tag{2.33}$$

Where ϕ is a collection of the constant values in the production function and γ is the elasticity of the production function given as:

$$\gamma = \alpha[1 + (1-\beta)(\mu - 1)] \tag{2.34}$$

Equation (2.33) implies that increased density of employment per acre increased output density.

Numerous empirical studies have provided insights into the impact of density on wages and output. Díaz Dapena et al. (2018) provides an analysis of local labour markets for 2011 for Spain. A series of alternative estimation techniques, including instrumental variable estimation, is utilised to analyse the impact of employment density on wages. The results suggest that increased labour density results in higher wage levels.

Ciccone (2002) analyses the impact of employment density (agglomeration) on wages for five European countries; France, Germany, Italy, Spain and the UK. He compares these results to the results of similar, previous analyses of the US. His results indicate that labour density has a significant positive effect on wages, with this effect being present across the five countries studied. While the average effect is slightly lower than that observed in the US the author concludes that a significant agglomeration effect is present.

Brülhart and Mathys (2008) provide an analysis similar to that of Ciccone (2002) but extend the analysis by utilising dynamic panel estimation techniques and also by disaggregating their analysis by sector. The findings suggest that there is evidence of strong urbanisation effects, but also some evidence of own-sector congestion effects (when considering sector by sector analysis).

Larsson (2014) uses geocoded data to analyse the impact of density on wages in Swedish cities at three alternative spatial scales. He finds that the impact of density varies, dependent upon the spatial scale considered, however, the effect is consistently significant and positive. The analysis is conducted on the neighbourhood, district and agglomeration scale which are $0.06km^2$, $1km^2$, and $10km^2$ respectively.

Faberman and Freedman (2016) use data on US firms to identify what they term the 'urban density premium'. Their data allows them to control for firm level characteristics which may explain productivity. Using panel data for 1992 to 1997 they find that a significant 'urban premium' is present and that density impacts positively on productivity.

Groot et al. (2014) analyse wage data at the micro-level for the Netherlands for the period 2000-2005. They analyse the impact of individual specific characteristics, industry effects, and employment density on wages. They find that, even when controlling for individual effects there is evidence that employment density results in increased wages. This effect also persists when controlling for Porter and Jacob types externalities. This type of analysis, and that of Faberman and Freedman (2016), is particularly relevant for my PhD as in Chapter 5 I also employ micro-level data.

Finally, as noted in the previous section Fingleton (2006) provides an analysis comparing the relative explanatory power of NEG theory against urban economic theory using data for Great Britain at the Unitary Authority - Local Authority Districts level for the year 2000. From the analysis, while market potential does have a significant positive effect on wages, urban economics is found to have more explanatory power. The significance of both indicators, and a rationale for considering both, is discussed further in Chapter 5.

2.10 Conclusion

This chapter has provided an overview of the concept of regional resilience. This was followed by a discussion of the three main conceptualisations of resilience; engineering, ecological, and adaptive resilience. A summary of Martin's et al (2016) conceptualisation of adaptive regional resilience was then discussed which focused on the four pillars of resilience: risk, resistance, reorientation, and recovery. A typology of resilience studies was presented which focused on the methodological contributions of alternative approaches varying from case study types of analyses to the analysis of resilience at the individual level. A review of existing literature is then provided which summarises a number of papers which consider regional resilience from alternative perspectives. Finally, an overview of the main economic theories utilised in this PhD is provided which discusses Verdoorn's law, new economic geography theory, and urban economics.

There has been significant interest in the concept of resilience using engineering and/or ecological resilience as the theoretical underpinning. However, increasingly there is a shift in academic literature towards the adaptive resilience approach which is grounded in evolutionary economic theory (Martin et al. 2016). In a series of papers Martin (2012), Martin and Sunley (2014), and Martin et al. (2016) propose a conceptual model arising from their discussion of adaptive resilience. This model, which breaks resilience down into four components (i) risk, (ii) resistance, (iii) reorientation, and (iv) recovery describes the process of how regions are exposed to shocks, behave during shocks, and recover following shocks. This dissertation uses this conceptualisation of resilience as the starting point of the analysis presented in each of the empirical chapters which follow. However, the conceptual model is re-interpreted through the application of causal economic models and advanced econometric techniques which are discussed in the following paragraphs.

The first contribution to the existing conceptualisation of resilience is in the application of causal economic models. Typically this framework has been applied utilising case studies and indexes of resilience in descriptive, as opposed to causal analysis, as emphasised in Sections 2.6 and 2.7. However, this dissertation proposes to re-interpret this conceptual model through the lenses of causal economic models such as Verdoorn's law, NEG theory, and urban economic theory. In doing so this paper advances the current state of the art in resilience analysis by firmly embedding the concept of regional economic resilience in existing economic theories. While section 2.9 has provided an overview of the causal models used in this dissertation within

Chapters 3 through 6 these causal models are more fully developed and the connections with regional economic resilience more formally specified.[3]

In addition to the use of causal economic models within this PhD, the framework outlined above is further adapted to provide the setup for the empirical analysis of regional economic resilience in Chapters 3 through 6. In doing so the dissertation makes significant contributions to the empirical modelling of resilience by utilising a series of advanced time series econometric (see Chapter 3), spatial panel econometric (see Chapter 4), and pooled cross sectional econometric methods (see Chapters 5 and 6). As noted, traditionally this framework has been applied using descriptive analysis in the forms of case studies or indices. In this PhD the econometric techniques used allow for inferences to be made as they take account of endogeneity, sorting, and other econometric issues detailed throughout the empirical Chapters. An advantage of this approach is that it allows the PhD to not only describe which regions/individuals were resilient or not, but also allows the analyses of the underlying factors which may have contributed to resilience. In doing so this dissertation pays particular attention to the role of industry structure in determining resilience and the reorientation of a region's industrial structure during a crisis.

In each of the following empirical Chapters, which evaluate the impact of economic shocks on regions/individuals the underlying framework is relatively consistent. It is the general consideration of the framework developed in Martin (2012), Martin and Sunley (2014), and Martin et al. (2016). However, the treatment of this framework, and its application, differ significantly from what has previously been considered in existing literature in terms of (i) the application of causal models, (ii) the application of advanced econometric techniques, and (iii) the consideration of the underlying causes of resilience, not merely the identification of the presence or absence of resilience.

[3] See sections 3.2 and 3.5 for Chapter 3, section 4.4 for Chapter 4, section 5.2 and 5.3 for Chapter 5, and section 6.2 and 6.3 for Chapter 6.

Chapter 3: National Resilience since 1960

3.1 Introduction

The question of spillovers and contagion between economies is a highly relevant topic for study in this current era of globalized impulses and responses, and with the prospect of negative shocks in parts of the Eurozone threatening to affect the stability of the whole EU region, regardless of whether countries are Eurozone members or not, it seems timely to give some additional consideration to the possible mechanisms and routes of transmission, focussing on selected EU economies. One of the motivations for this Chapter is the work of Cerra and Saxena (2008) and Cerra et al. (2009), who look at the impact of shocks on national growth rates. Their work suggests that countries that have experienced economic disruption tend to lower growth rates over the long run. However, every country does not react in the same way, and the differentiated reaction to severe economic shocks in different countries may have an effect on the convergence or divergence of national economies. Thus this Chapter is interested in whether some EU economies' productivity[4] growth paths may be affected by the severe downturn in 2007 experienced across the EU and other developed economies. To do this, it looks at reactions to previous recessions, which may provide insights regarding relative economic vulnerability. It examines two aspects of the impact of shocks. First it looks at the post-recession path of productivity relative to what might have been expected given previous trends. Second, it looks at the responses of economies to hypothetical shocks within their own economy, and in addition it considers responses to shocks spilling over from other economies. It asks the questions, are some economies more influential in terms of the responses they invoke, and, are some economies more exposed to negative spillover effects?

The Chapter is also motivated by Fingleton et al. (2012), who explore the regional rather than national dimensions of impulse response analysis, and also by the review of the concept of regional resilience by Martin (2012). One feature of Fingleton et al. (2012), is the application of vector-error correction (VEC) models to produce forecasts and impulse-response graphs. In contrast, the use of vector autoregressive (VAR) models would embody a presumption of stationarity so that shock-effects are only transient. The approach adopted in this Chapter allows the possibility that shocks can have permanent effects. A further advantage of this approach is that it allows for an assessment of the impact of shocks in one country on another country without needing to appeal to a W matrix, as is common in the spatial econometrics literature.

[4] Defined as GDP divided by employment.

By not needing to specify a W matrix this Chapter avoids having to impose a-priori expectations on the mechanisms through which shocks are transmitted between countries.

The empirical analysis shows that shocks have permanent effects, so that economies tend not to return to the pre-shock path but rather adjust to new levels, and that shocks in one country can have an impact on other countries' growth paths. This indicates that the post-2007 recession will be embodied permanently within the memory of some of Europe's economies as a hysteretic effect, so that they are evidently being shifted permanently to different productivity paths.

This Chapter choses to study national economies over European regions for two reasons. The first is that by using national economies quarterly data from 1960 Q1 to 2011Q1 can be accessed, allowing a more detailed and accurate analysis of the impact of shocks over this time period than if annual data for a shorter time period had been used. Annual data would smooth out some of the variation observed in quarterly data and a shorter time period would prohibit the use of VEC models. Secondly, policy is formulated at a national and European level, with implications for regional economies. This analysis provides insights into how national shocks affect national economies, with these national shocks having implications for the composite regions of the national economy.

To summarise, the original contribution of the Chapter is threefold. First, it extends the work of Cerra and Saxena (2008) and Cerra et al. (2009), but differs significantly in that it is concerned with non-stationary series (i.e. uses VEC not VAR models). Thus it contributes to the hysteresis and resilience literature focussing on the potentially permanent, rather than transient, impact of shocks on subsequent growth. Second, it extends the work of Fingleton et al. (2012) by modelling both GDP and employment levels combined to give productivity levels, applying this to the international level rather than being restricted to UK regions. And thirdly, it focuses on contagion and spillover effects, asking the question, 'do shocks in neighbouring countries have a major effect domestically?'

3.2 Theoretical Background and Preliminary Data Analysis

The analysis is framed through the lens of Verdoorn's law, which in its dynamic form posits a positive relationship between the rate of output growth and the rate of productivity growth. Verdoorn's law suggests economies of scale in production, such that higher levels of output result in higher levels of productivity. This Chapter focuses on the effect of a negative shock to output on countries' productivity. In doing so this Chapter provides an empirical analysis of whether output shocks have a permanent or transitory effect on countries' productivity. Verdoorn's law, which can be traced back to Verdoorn (1949), is typically expressed as:

$$r_j = r_a + \lambda g_j \tag{3.1}$$

Where r_a is the autonomous rate of growth, and r_j and g_j are the growth rates of labour productivity and output, respectively, for country *j*, and λ is the so-called Verdoorn coefficient, which typically takes a value of 0.5, implying increasing returns to scale (McCombie, 1983; Thirlwall, 1983; Angeriz et al., 2008; Fingleton and McCombie, 1998). It is not proposed to estimate equation (3.1), but instead to appeal to Verdoorn's law as the theoretical underpinning of the analysis[5]. Essentially the Chapter assesses whether negative shocks to g_j, as a result of recessions, have a permanent effect on the growth path of r_j.

Consideration of Dixon and Thirlwall's (1975) circular causation model, which embodies the Verdoorn law, points to international interaction between productivity and output growth. The model can be summarised thus:

$$\begin{array}{ll} \text{output growth} & g_{jt} = \gamma x_{jt} \\ \text{export growth} & x_{jt} = \eta p_{jt} + \delta p_{ft} + \varepsilon z_{ft} \\ \text{domestic price growth} & p_{jt} = w_{jt} - r_{jt} + \tau_{jt} \\ \text{productivity growth} & r_{jt} = r_{ja} + \lambda g_{jt} \end{array} \tag{3.2}$$

in which x_{jt} is domestic export growth, p_{jt} is the growth rate of domestic prices, p_{ft} is the growth rate of foreign (competitor) prices and z_{ft} denotes real income growth in foreign markets. Also w_{jt} denotes domestic wage growth (the nominal wage inflation rate), and τ_{jt} is

[5] Traditionally Verdoorn's law applies to the manufacturing sector, so there is only approximate concordance with the analysis presented in this Chapter which is at the level of the overall economy.

the rate of change of the mark up on labour costs. The subscript t indicates the time period. From this it is easy to show that if abs$(\gamma\eta\lambda) < 1$ then an equilibrium[6] exists at which

$$\begin{aligned} r_j &= a_0 r_{ja} + a_1(w_j + \tau_j) + a_2 p_f + a_3 z_f \\ g_j &= b_0(w_j - r_{ja} + \tau_j) + b_1 z_f + b_2 p_f \end{aligned} \tag{3.3}$$

This shows that domestic productivity growth and domestic output growth depend on the growth of foreign (competitor) prices and real income growth in foreign markets. While in this Chapter I do not formally embody the Dixon and Thirlwall (1975) model within the econometric model, it does suggest possible and plausible mechanisms of international contagion and transmission allowing a shock to foreign markets to have repercussions domestically.

To illustrate the impact of the recession on the EU and US economies' productivity, and on specific countries, I focus on the case of Ireland, which is a small open economy which one would anticipate would be quite exposed to external shocks.

Figure 3.1 through Figure 3.3 display the actual and counterfactual level of productivity for Ireland, the EU15 and the US, with the solid vertical line representing the onset of the 2007 recession. Examine Figure 3.1, one can see the drop in Ireland's productivity since 2007q3. It could be suggested that the recession's impact in Ireland was more a reflection of internal conditions, with a bubble economy leading into 2007q3, than the shock itself. However while this might have contributed to the strength of the negative response, it is clear that the shock was a mainly exogenous phenomenon affecting economies across the globe rather than being principally the consequence of over-rapid internal expansion. For example, the EU15 economies were not expanding quite so fast, and yet one can still see a significant downturn in relation to expectation after 2007q3, likewise the US economy (see Figure 3.2 and Figure 3.3)[7].

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[6] This is the general solution to a difference equation in g showing the transition dynamics to equilibrium when a single period time lag is introduced to one of the equations.

[7] The dynamic forecasts in Figure 3.1 are based on the estimates of a VEC model with two cointegrating vectors and two lags, with GDP and employment series for Ireland, EU-14 and the US. The forecasts in Figure 3.2 and Figure 3.3 are based on the estimates of a VEC model

Figure 3.1: Actual and counterfactual quarterly Productivity series for Ireland

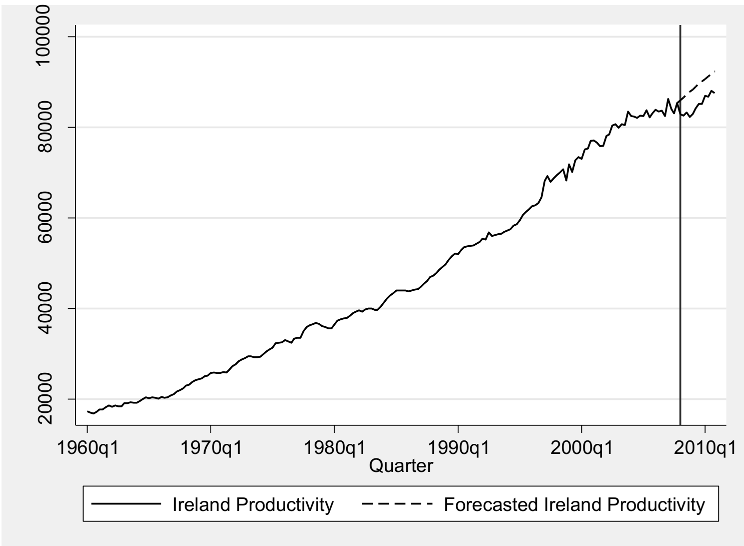
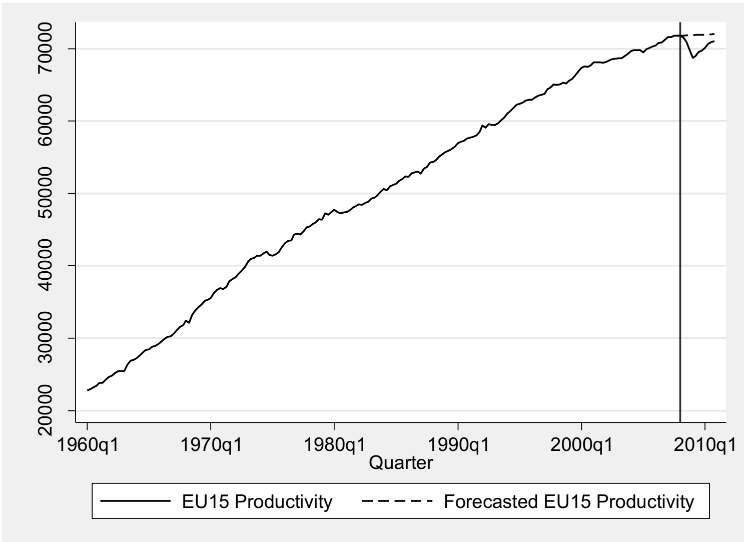
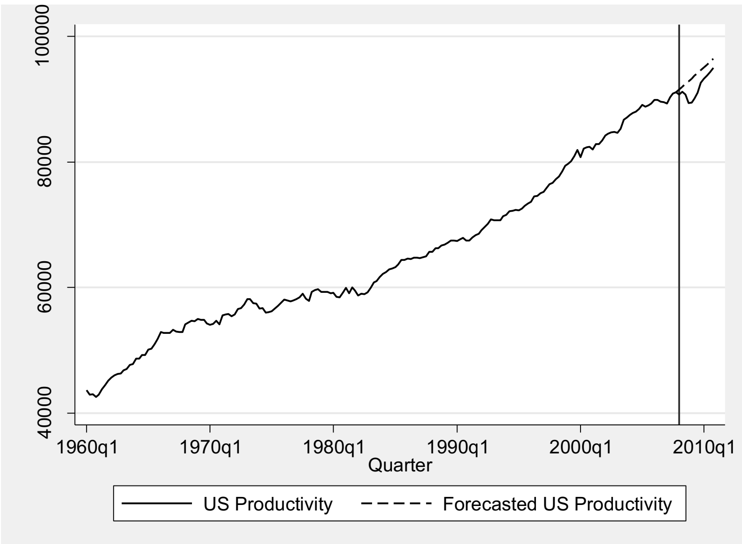


Figure 3.2: Actual and counterfactual quarterly Productivity series for EU15



with three cointegrating vectors and one lag with GDP and employment series for the US and the EU-15. Productivity is calculated following the estimation of the VEC models as GDP/employment.

Figure 3.3: Actual and counterfactual quarterly Productivity series for the US



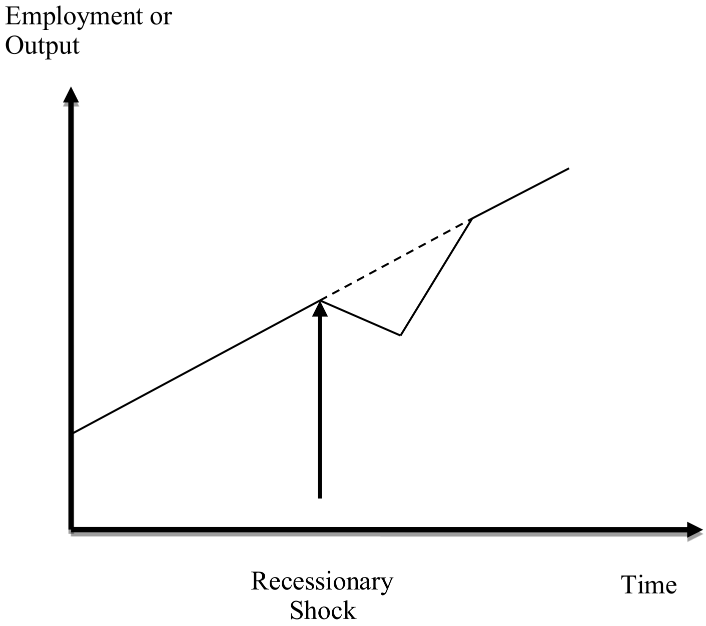
This Chapter explores data for major EU economies by fitting a (suite of) VEC model(s) to give the likely post-recession counterfactual path. It looks at the historical evidence going back to the recession of the early 1990s (or in the case of Ireland the 1980s) in order to examine what the data suggests about shock impacts. Subsequently, it shows that shocks to one economy spill over to others with differentiated impacts that do seemingly reflect differing internal conditions. With negative shocks, it might be said that some economies are more exposed than others to outside shocks; on the other hand a positive boost to an outside economy may have greater benefits internally. Thus the analysis of Ireland, which is a small, open economy, is particularly interesting, because it is more likely to be more vulnerable, but on the other hand is likely also to benefit more from a surge in growth in other economies.

3.3 Hysteresis

This Chapter is interested in the following questions. What is the likely long term effect of the 2008 economic crisis? Will it produce a permanent reduction in productivity, or will it have the effect of stimulating productivity as an outcome of a process of creative destruction. By considering the response of productivity to output shocks it is implicitly considering the response of output and employment to output shocks as productivity is given as output divided by employment. The model used embodies the possibility of hysteresis, which is a long established concept transgressing the various sciences which typically has been applied to explain the persistence of negative shocks to unemployment. Thus according to Blanchard and Summers (1987) the concept of hysteresis refers to "the development of alternative theories of unemployment embodying the idea that the equilibrium unemployment rate depends on the history of the actual unemployment rate. Such theories may be labelled hysteresis theories after the term in the physical sciences referring to situations where equilibrium is path-dependent" (pp 290). Thus a negative shock leading to permanently higher unemployment may occur if the long term unemployed lose skills and miss out on job training, so that they ultimately become unemployable. In contrast, the employed continue to benefit from learning-by-doing. This viewpoint of hysteresis in unemployment is supported by Jaeger and Parkinson (1994) and Jacobson, Vredin and Warne (1997).

More recently Paul Krugman (2011) has argued that "there is a real concern that if the slump goes on long enough, it can turn into a supply-side problem, because investment will be depressed, reducing future capacity, and because workers who have been unemployed for a long time become unemployable". Thus "hysteresis can mean that the costs of failing to pursue expansionary policies are much greater than even the direct effects on employment. And it can also mean, especially in the face of very low interest rates, that austerity policies are actually self-destructive even in purely fiscal terms: by reducing the economy's future potential, they reduce future revenues, and can make the debt position worse in the long run" (Krugman, 2011).

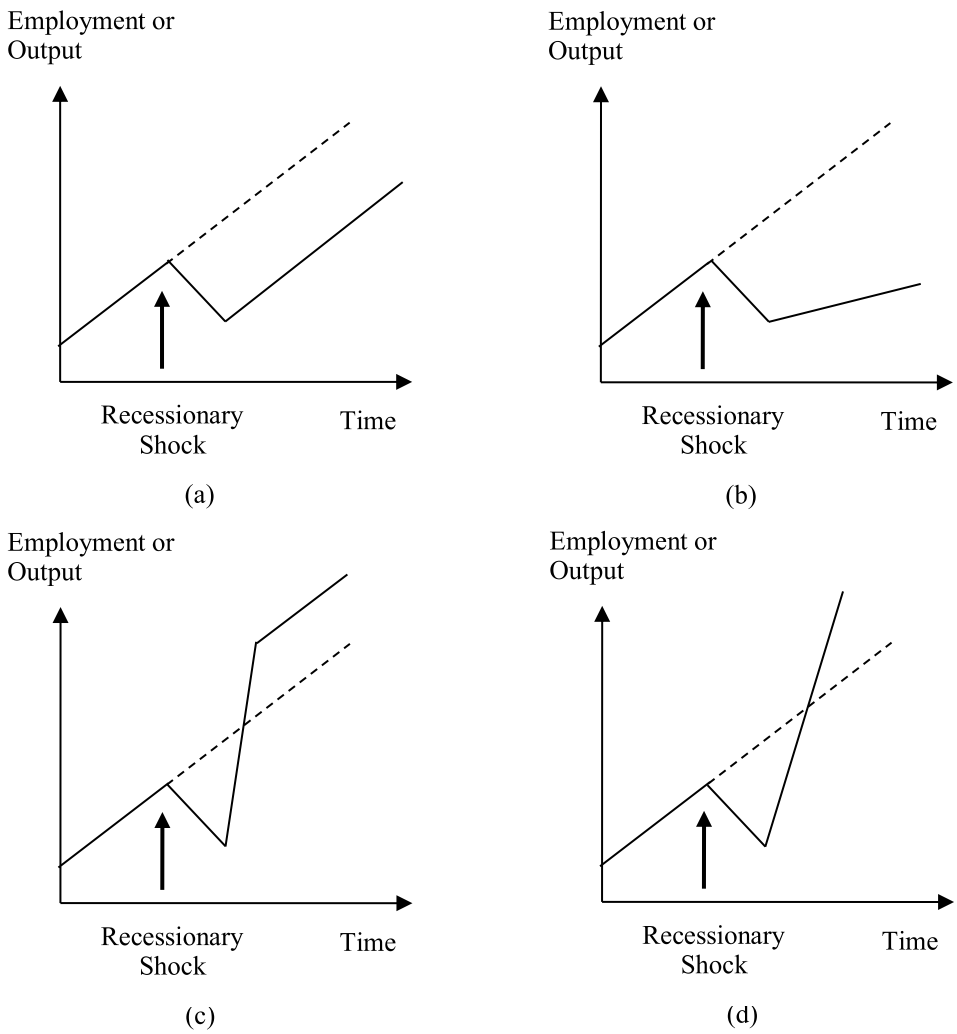
Figure 3.4: Anti-hysteresis



The opposite of hysteresis, or what is termed anti-hysteresis, is embodied in Friedman's (1993; 1964) so-called plucking model, which assumes that shocks are temporary in nature and have no permanent effect on an economy's long-run growth ceiling or growth trend (see Figure 3.4). This return to the pre-shock growth path is not what is anticipated for the EU economies, with the prospect of long-term 'damage' as the result of a negative shock, although a negative shock could also produce long-term positive benefits. Martin (2012), Fingleton et al. (2012) and Cross et al. (2009) note that it is possible to envisage a number of different possible hysteretic outcomes of a shock and that the outcome may depend on the variable considered as well as the underlying structure of the economy. Cross et al. (2010) appeal to a Schumpeterian point of view of creative destruction to explain these hysteresis effects.

Two possible negative hysteretic outcomes can be identified. In the first instance, the shock causes a downward shift in the variable's growth path, but the growth rate returns to its pre-shock rate. This may result from a shock destroying a significant proportion of the economy's productivity capacity and jobs. This is depicted in Figure 3.5(a). The second negative outcome is where, not only is there a downward shift in level, but also a reduction in growth rate. This may result from the destruction of large sections of an economy's industrial base which may have a negative multiplier effect on other sectors. This is displayed in Figure 3.5(b). Two positive hysteretic reactions can also materialise following a negative shock. In both instances, the economy more than rebounds from the shock and initially experiences rapid growth, in excess of the pre-shock rate, following the initial downward effects of the shock. This may be due to optimistic business expectations, the availability of spare capacity to expand, or new firm foundations. The distinction between the two possible positive hysteretic effects is whether the post-shock growth rates can be maintained. If the scope for continued rapid expansion becomes exhausted, the economy may return to pre-shock growth rates, albeit at a higher level. This is depicted in Figure 3.5(c). However, if the economy can maintain the post-shock growth rates this implies continued growth at a rate in excess of the pre-shock rate. For instance the shock may have released productive resources that were formerly employed in other now defunct low growth and low productivity sectors, causing permanently faster output and productivity growth than hitherto. This is depicted in Figure 3.5(d). These concepts have been discussed in greater detail in Chapter 2 and are summarized here as they relate to this Chapter.

Figure 3.5: Stylised Responses to Shocks



Source: redrawn from Fingleton et. al. (2012)

3.4 The data

The analysis focuses on using employment and GDP series over the period from 1960q1 to 2011q1 to study the impact of shocks to GDP on productivity. The quarterly data for GDP for all the EU countries and the US are obtained from the OECD's historical quarterly national accounts series. In order to derive a quarterly historical time series the most recent OECD national accounts are linked to older historical series. The method utilised to link the differing series, which on occasion are assembled using different methodologies, starts by identifying the ratio between the newest series and the older series in the first common year. This ratio is then multiplied along the older series to render it comparable to the newest series. This method is applied across all breaks in methodology for all countries (OECD, 2011b). The GDP data are converted by the OECD into US dollars and are adjusted for purchasing power parity (PPP). Specific PPPs are utilised to convert European countries' GDP and its components in national currencies into US dollars. When converted by means of PPPs, the expenditure on GDP for different countries is measured using the same set of international prices so that comparisons between countries reflect only differences in the volume of goods and services purchased. National converted data can then be aggregated to obtain aggregates for groups of countries, which are expressed at the same set of international prices (OECD, 2011a).

While data are available for GDP from 1960q1 to 2011q1, quarterly employment data are not as readily available. Employment data for the US and Italy are available quarterly back to 1960, however, this is not the case for the remaining fourteen countries considered. In the case of Ireland, data are only available from 1997 to present. However, annual employment data are available from 1960 for all countries contained in the sample from the Total Economy Database (The Conference Board, 2012). This presents an opportunity to construct quarterly employment series for all countries going back to 1960q1 using the Chow-Lin best linear disaggregator.

Quarterly data on employment for the majority of the sixteen countries (EU15 plus the US) considered by this Chapter are only available for shorter periods of time than the quarterly GDP figures obtained from the OECD's historical quarterly national accounts, which are available from 1960q1 to 2011q1. Table 3.1 displays the availability of employment data. In total it is necessary to to impute approximately 40% of the employment data.

Table 3.1: Availability of Quarterly Data Series

Country	United States	Germany	United Kingdom	France	Italy	Spain	Nether.	Belgium
Start of Data	Q1 1960	Q1 1962	Q2 1969	Q1 1995	Q1 1960	Q3 1972	Q1 2000	Q1 1999
End of Data	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011

Country	Austria	Greece	Portugal	Norway	Denmark	Finland	Ireland	Luxem.
Start of Data	Q1 1969	Q1 1998	Q2 1983	Q1 1972	Q1 1995	Q1 1964	Q4 1997	Q1 2003
End of Data	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011	Q1 2011

Note 1: Source OECD Employment data series
2: Quarterly data for Luxembourg are actually also available from Q1 1985 to Q4 1997 however there are gaps in the data series between Q4 1997 and Q1 2003.

However annual series are available, and Chow and Lin (1971) develop a procedure for converting annual into monthly time series, which can be adapted to convert annual to quarterly series as demonstrated by Abeysinghe and Lee (1998) and Abeysinghe and Rajaguru (2004). As data for US and Italian Employment are available quarterly from 1960, it is possible to disaggregate the other countries' annual employment series from 1960 into quarterly data, taking care to match to known annual totals for each country. Therefore, the approach models the available non-stationary cointegrated employment series to produce otherwise unavailable quarterly estimates, ensuring that the annual values of the predicted quarterly data equal the observed annual data in each country. However, as noted by the OECD, quarterly employment data does not sum to annual data, but is averaged to annual data. In order to ensure that the employment data averages, as oppose to sums, to equal the annual data, further adjustment to the series is carried out. Where there are quarterly series available, these actual data have been used in place of the Chow-Lin based estimates, although the differences between the two are very minor.

The reliability of imputation methods has been the subject of much study, with the Chow-Lin method producing what the literature regards as accurate imputations of quarterly data from annual data, as shown for example by Miralles, Lladosa and Vall´es (2003). Santos Silva and Cardoso (2001) further note that the Chow-Lin method, despite being over 30 years old, is one of "the most widely used methods to disaggregate time series [data]" (pp 269). I therefore conclude that the employment estimates are robust and suitable for the purposes intended.

Prior to estimating the empirical models it is necessary to assess whether any of the series possess a unit root. Table 3.2 presents the diagnostic statistics for the VEC model estimates for the full sample. This ranges from 1960Q1 to 2011Q1. The augmented Dickey-Fuller tests on GDP and employment levels for the six log GDP and employment series for each specific ‘target’ country, the EU-15 minus the ‘target’ country, and the US are presented. In the case of all countries and EU14 aggregates it is not possible to reject the null of a unit root for levels, but the null can be rejected for differences, indicating that shocks to levels have a permanent effect, they are I(1) series.

Table 3.2: Results of Augmented Dickey Fuller Tests – Full Sample

	US	Ireland	EU14-Ireland	Germany	EU14-Germany	UK
Output - Level	-2.599	-1.485	-1.721	-1.456	-1.929	-2.192
Output - FD	-6.571***	-4.431***	-5.247***	-7.394***	-4.592***	-6.145***
Employment - Levels	0.205	-1.770	-1.641	-0.804	-1.650	-2.611
Employment - FD	-4.822***	-4.614***	-4.522***	-5.603***	-4.369***	-3.702***

	EU14-UK	France	EU14-France	Italy	EU14-Italy
Output - Level	-1.858	-2.725	-1.554	-1.217	-1.835
Output - FD	-5.135***	-6.059***	-5.331***	-5.864***	-5.416***
Employment - Levels	-1.668	-2.300	-1.638	-3.049	-1.708
Employment - FD	-4.962***	-5.004 ***	-4.508 ***	-7.038***	-4.188***

Note 1: All Dickey-Fuller tests applied to GDP and employment levels include a constant and trend term. The critical values for Dickey-Fuller tests which include trends are -4.006, -3.437 and -3.137 for the 0.01, 0.05 and 0.1 levels of significance respectively.
2: All Dickey-Fuller tests applied to GDP and employment in first differences include only a constant. The critical values for Dickey-Fuller tests, excluding trends are -3.476, -2.883 and -2.573 for the 0.01, 0.05 and 0.1 levels of significance respectively.
3: All variables are expressed in natural logarithms.
4: ***, ** and * indicate rejection of the null hypothesis at the 0.01, 0.05 and 0.1 level of significance respectively.
5: The null hypothesis is that the data possesses a unit root.
6: FD indicates first differences.

Table 3.3 presents the results of the augmented Dickey Fuller tests for the sub periods considered. These sub-periods all begin in 1960 and run until an incident of recession. In the Irish case the recession chosen is in the 1980s as Ireland showed no sign of recession in the 1990s. While in the case of all other countries the sub-period runs until the 1990s. As before, all the countries analysed are included as well as the EU14 countries excluding the ‘target’ country. While for the full period Dickey Fuller tests presented previously the only showed one test for the US, for the sub periods it is necessary to present five different US Dickey Fuller tests. This is due to the length of the specific sub periods varying depending upon which country is the ‘target’. For example, the VEC estimation for Ireland uses data from 1960 Q1 to 1982q3 and it is necessary to carry out a Dickey-Fuller test for the US data based on this time period (given as US-Ireland). For Germany on the other hand data is used from 1960 Q1 to 1992q1 and a separate Dickey-Fuller test is performed for the US data using this time period (given as US-Germany).

Table 3.3: Results of Augmented Dickey Fuller Tests – Full Sample

	US-Ireland	Ireland	EU14-Ireland	US-Germany	Germany	EU14-Germany
Output - Level	-1.366	-2.642	0.283	-2.806	-1.871	-1.819
Output - FD	-4.544***	-4.442***	-3.775***	-5.453***	-6.81***	-4.077***
Employment - Levels	-2.985	-1.993	-2.400	-2.977	-0.299	-1.456
Employment - FD	-3.730***	-5.291***	-4.181***	-4.507***	-4.345***	-4.503***

	US-UK	UK	EU14-UK	US-France	France	EU14-France
Output - Level	-2.828	-1.884	-1.753	-2.599	-1.928	-1.627
Output - FD	-5.419***	-5.508***	-4.533***	-6.571***	-5.849***	-4.669***
Employment - Levels	-2.170	-1.929	-1.053	-2.941	-1.797	-1.183
Employment - FD	-4.599***	-2.770*	-4.939***	-4.554***	-4.269***	-4.274***

	US-Italy	Italy	EU14-Italy
Output - Level	-2.849	-1.689	-1.734
Output - FD	-5.481***	-5.462***	-4.825***
Employment - Levels	-2.941	-2.202	-1.828
Employment - FD	-4.555***	-6.044***	-3.657***

Note 1: All Dickey-Fuller tests applied to GDP and employment levels include a constant and trend term. The critical values for Dickey-Fuller tests which include trends are -4.006, -3.437 and -3.137 for the 0.01, 0.05 and 0.1 levels of significance respectively.
2: All Dickey-Fuller tests applied to GDP and employment in first differences include only a constant. The critical values for Dickey-Fuller tests, excluding trends are -3.476, -2.883 and -2.573 for the 0.01, 0.05 and 0.1 levels of significance respectively.
3: All variables are expressed in natural logarithms.
4: ***, ** and * indicate rejection of the null hypothesis at the 0.01, 0.05 and 0.1 level of significance respectively.
5: The null hypothesis is that the data possesses a unit root.
6: FD indicates first difference.

While generating quarterly data at a national level on employment has some negative consequences (such as having to use imputed values and constraining the analysis to the national level) for the analysis conducted in this Chapter the benefits associated with its use are significant. Firstly, the use of quarterly data allows for an analysis to be conducted using vector error correction models. Using annual data, which is available and not imputed, would restrict the analysis considerably and there would be insufficient observations to be sufficiently confident as to the reliability of any vector error correction model estimation. For countries such as the US, France, the UK, Italy, and Germany, the counterfactual dynamic forecasts would have to be based on annual data from 1960 to the 1990s (1980s in Ireland's case) which would result in estimations using only 25 to 35 observations. The accuracy of the results of these estimations would be questionable given the small number of observations.

The second advantage of using quarterly data is linked with the first. While it allows the use of vector error correction estimation due to increasing the number of observations it also allows for the consideration of alternative shock events, and not simply the 2008 economic crisis. While significant attention has been paid to the 2008 economic shock in existing literature (and in the remaining Chapters of this PhD) by using quarterly data an analysis can be conducted of earlier shocks which would not be possible had annual data been employed. So this Chapter, by using quarterly data, is able to analyse the economic shocks of the 1980s and 1990s. This provides a context for the latter Chapters of the PhD which focus on the 2008 economic crisis by showing that industry structure has played a role in explaining the impact of crises prior to 2008.

A third advantage is that it allows for the identification of the precise period in which the country entered a recession. Most analysis of resilience focuses on annual data (as is the case in Chapters 4 through 6 of this PhD). By using quarterly data it is possible to distinguish more clearly for each country under consideration the point in time in which they entered recession. Therefore, while the recession of the 1990s is discussed as the predominate focus on the initial empirical analysis of this Chapter, as highlighted in Figure 3.4, the onset of the 1990s recession differed across countries. Therefore, the use of quarterly data facilitates a more precise timing of recessionary shocks than annual data allows.

3.5 Econometric Model

Following the empirical framework adopted by Fingleton et al. (2012), I attempt to capture the likely effects of negative shocks on productivity econometrically through the implementation of VEC models, which are designed to model nonstationary series. As a prelude to the VEC modelling exercise, I have tested for unit roots in the employment and GDP series, and from this shown that shocks to these series do have permanent rather than transient effects, as implied by the VEC model (see the Section 3.4 for these tests).

3.5.1 Specification

The counterfactual prediction of productivity levels and of the impact of hypothetical shocks depends on the underlying VEC model being an accurate description of reality. The VEC model specification is determined by the number of lags in the model (the order) and by the rank of the long-run response matrix, in other words the number of linearly independent rows, as indicated by the number of non-zero eigenvalues (or characteristic roots) or cointegrating vectors. In each of the VEC models there are six series, so the rank is the number of independent cointegrating relationships between these six series. Having determined the number of lags[8], I consider the outcome of applying the so-called Pantula principle (Pantula, 1989) used by Johansen (1992), Hansen and Juselius (1995) and others to identify the exact model structure including the rank. The Pantula principle allows a joint test of whether there are deterministic variables (a trend and constant) within the cointegration space together with a test of cointegration rank. However it is not a panacea for model choice (Doornik et al., 1998; Hjelm and Johansson, 2005). In their Monte Carlo study, Hjelm and Johansson (2005) find that the Pantula principle is "heavily biased towards choosing the model with an unrestricted constant when the model with a restricted trend is the true one" (pp 691). Accordingly, rather than confine analysis to a single, 'optimal' model for each country chosen via the Pantula principle, I also estimate a range of different supplementary models with different orders and different ranks. From this it is possible to indicate the degree of robustness of the predictions and impact analysis to model misspecification.

The intuition behind the Pantula principle is that while a number of possible specifications of the VEC model are feasible it is possible to identify one specification which best describes the data. The specifications of the VEC model vary depending on the number of cointegrating vectors identified and on whether it is appropriate to include a constant or trend term in the short run or long run component of the model. The Pantula model starts with the most restrictive model specification and progresses to the most relaxed specification sequentially testing for cointegration rank in each specification. The first instance in which the null hypothesis of rank $\leq$ r is not rejected is taken as the most appropriate model and number of cointegrating vectors. Therefore, following the Pantula principle allows for the identification of the model specification and cointegration rank simultaneously.

Detailed consideration of the issues surrounding the application of the Pantula principle points towards specifications that appear to be feasible for the data. The approach involves a sequence of nested models based on restrictions on the full model, as given in equation (3.4). It starts with the most restrictive specification and moves through to the least restrictive, testing whether the number of cointegrating vectors satisfy $r = 0$. This is then repeated, moving across from most to least restrictive specification, checking for $r = 1$, and so on repeating for $r = n - 1$,

[8] See Table 3.4 for the results of these lag length tests.

where n = 6 series[9]. For each test the null hypothesis is that the true rank $\leq r$, in other words that the columns of β in equation (3.4) greater than r are null. The alternative is that $r <$ rank $\leq$ full rank. Thus the trace test compares the likelihoods of the rank r model and the full rank model. If the difference is significant, it cannot be assumed that the true rank is r and eliminate higher ranks. If the difference is not significant, it can be assumed that the rank is r. Going through the sequence of model comparisons, the stopping point is the first occasion on which it is possible to 'accept' the null that the rank $\leq r$.

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-k-1} + \mu_1 + \delta_1 t + u_t + \alpha\left(\beta' Z_{t-1} + \mu_2 + \delta_2 t\right) \qquad (3.4)$$

Equation (3.4) is the full, unrestricted model in which Z_t is an n x 1 vector comprising six endogenous variables observed at time t, namely a (target) country's log GDP and log employment levels, the log of aggregate GDP and employment in the other 14 countries of the EU15 (which are refered to as EU14, although of course this variable changes as the 'target' country excluded from EU15 changes), and log GDP and log employment levels in the US. The Γs are n x n matrices, μ_1 and δ_1 are n x 1 vectors of parameters, and u_t is an n x 1 vector of disturbances. Also α and β are n x r rank matrices, so that μ_2 and δ_2 are r x 1 vectors of parameters. Since the variables are in logs, the first differences ΔZ_t are exponential growth rates.

The number of lags k is first identified by fitting VAR models, which are mathematically equivalent to VEC models with full rank[10]. Given k it is possible to proceed to consider, jointly with the determination of rank, hypotheses about the inclusion or exclusion of the constant

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[9] Failure to reject $r = 0$ implies that the appropriate model is a VAR in stationary first differences. On the other hand rejecting all hypotheses regarding r implies that the data are stationary in levels, i.e. Z~I(0).

[10] The results of the SBIC tests applied to each VAR model are displayed in Table 3.4. It can be noted that for the full sample Ireland, Germany, France and Italy models an optimal lag length of two is identified whereas for the UK an optimal lag length of one is identified. For the sub-periods lag lengths of two apply for Ireland and Germany and one for the remaining countries.

terms μ_2 and the trend terms $\delta_2 t$ in the long run cointegrating vector (CE), and the presence or absence of the constant terms μ_1 and trend terms $\delta_1 t$ in the short run (VAR) model.

There are five possible models which can be obtained by placing various restrictions, or none, on the parameters of equation (3.4) and comparing likelihoods[11]. Assume that one places a restriction on both the VAR and the CE (corresponding to the terms within brackets), so that there is no constant and time trends in either, hence $\mu_1 = \delta_1 = \mu_2 = \delta_2 = 0$. This would only be appropriate if each variable had a zero mean. Similarly, it is possible to exclude consideration of the totally unconstrained model in which $\mu_1 \neq 0, \delta_1 \neq 0, \mu_2 \neq 0, \delta_2 \neq 0$, even though this is likely to fit the data quite well. It implies quadratic trends so that if the variables are entered as logs, as in the case of the data used in this Chapter, this implies an ever increasing or ever decreasing rate of change and one which is likely to produce poor out-of-sample forecasts. There is also some discussion in the literature about the general plausibility of model (3.5), in which $\mu_1 = \delta_1 = \delta_2 = 0$, in macroeconomic analysis because of the exclusion of linear trends, so this so-called restricted constant model is also excluded from consideration, leaving a choice between models (3.6) and (3.7), namely the models with unrestricted constants in both CE and VAR components, and restricted trends in the CE component respectively. However even here there is reason to doubt the validity of the trace test used to compare models (3.6) and (3.7) (Johansen, 1995; Ahking, 2002; Hjelm and Johansson, 2005). Johansen (1992) only suggests the use of the Pantula principle for choosing between Models (3.5) and (3.6). This therefore casts some doubt on the Pantula principle as a valid model selection procedure, although the issues relating to its application do point to the consideration of just two feasible rivals, namely models (3.6) and (3.7):

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k-1} + u_t + \alpha(\beta' Z_{t-1} + \mu_2) \tag{3.5}$$

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k-1} + \mu_1 + u_t + \alpha(\beta' Z_{t-1} + \mu_2) \tag{3.6}$$

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[11] The log likelihood for the VEC is derived assuming the errors are independently and identically distributed (i.i.d.) normal. However normality can for practical purposes be replaced by weaker assumptions that the errors are merely i.i.d , since these alone support many of the asymptotic properties that are the basis of the inferences made in this Chapter (Johansen, 1995).

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k-1} + \mu_1 + u_t + \alpha(\beta' Z_{t-1} + \mu_2 + \delta_2 t) \quad (3.7)$$

These models are increasingly less restrictive. In the case of (3.5), which has a (restricted) constant within the cointegration space $\mu_1 = \delta_1 = \delta_2 = 0, \mu_2 \neq 0$, there are no time trends in the model, and only intercepts in the CE, with none in the VAR. In this Chapter further consideration of this model is excluded. The model (3.6) specification with (unrestricted) constants entails that $\delta_1 = \delta_2 = 0, \mu_2 \neq 0, \mu_1 \neq 0$hence it contains no trends in either VAR or CE, but each has intercepts. With differences in logs, this implies constant growth in levels and hence this model is a plausible option. Likewise model (3.7) has (restricted) trends within the cointegration space so that $\delta_1 = 0, \delta_2 \neq 0, \mu_2 \neq 0, \mu_1 \neq 0$, hence there are intercepts in both VAR and CE, and trends in CE but no trends in VAR. The trend in CE therefore picks up some additional growth that is not captured by (3.6).

Table 3.4: Results of SBIC for Ideal Lag Length – Full Sample

Lag Length	Ireland	Germany	UK	France	Italy
0	-18.827	-22.3703	-22.7322	-25.1242	-23.1711
1	-43.8362	-45.3327	-46.2541*	-46.8068	-45.454
2	-44.0435*	-45.3679*	-46.0292	-46.9223*	-45.5294*
3	-43.4651	-44.8036	-45.3812	-46.4106	-44.8834
4	-42.994	-44.1679	-44.7884	-45.8484	-44.2966

Note 1: The ideal lag length as selected by SBIC is given as the lowest value derived from the various lags.

2: * indicates the ideal lag length.

Table 3.5: Results of SBIC for Ideal Lag Length – Sub Periods

Lag Length	Ireland	Germany	UK	France	Italy
0	-27.8889	-25.2874	6.2392	-28.9839	-25.8788
1	-43.6816	-44.2692	-44.549*	-46.2996*	-43.9249*
2	-44.0362*	-44.745*	-43.7621	-46.0819	-43.7904
3	-42.7584	-43.9037	-42.747	-45.0576	-42.8334
4	-41.718	-43.0457	-41.8429	-44.2193	-41.9265

Note 1: The ideal lag length as selected by SBIC is given as the lowest value derived from the various lags.

2: * indicates the ideal lag length.

3.6 Results

The chosen models on which the predictions and impulse-response analysis are based are versions of models (3.6) and (3.7) with an appropriate rank and order. The selected, or more or less 'typical', models are highlighted in Table 3.6 and 3.7 alongside the results of the Johansen trace tests for each VEC model estimated. Although the main results are presented based on choosing models for which the null hypothesis $\text{rank} \leq r$ is not rejected, additional predictions and response functions of different specifications are illustrated in Figures 3.4 through 3.7. This shows a panoply of outcomes because of the criticism that can be laid against formal application of the Pantula principle, as outlined above. In cases where different specifications produce essentially the same outcomes as are produced by the preferred model, it is possible to be more confident in the interpretations than in cases where there is more variability in outcome. Therefore, the alterative traces on the graphs allow for some form of quality control, enabling a form of weighing the interpretations below according to their relative stability across different specifications.

For the main results two sets of VEC models are estimated, one for the dynamic forecasts and one for the IRFs. In the first instance the VEC models are estimated using data up to the point of a recession and subsequently the forecasts are obtained by predicting forward using dynamic forecasts. So, for example, data from 1960 to 1991 is used to estimate a VEC model for

Germany in order to derive a counterfactual forecast of what productivity could have looked like post 1991. For the IRFs the VEC models are estimated using all the available data, from 1960 to 2011, allowing for an analyse of the response of countries to hypothetical shocks over the full time period.

Table 3.6: Results of Johansen's Trace Tests for Cointegration – Full Sample

Time	Ireland		Germany	
r	**Constant**	Restricted Trend	**Constant**	Restricted Trend
0	155.6241	186.4354	94.15	181.8287
1	87.948	116.6207	81.6651	110.1217
2	47.7997	72.9546	48.2338	72.9939
3	**19.5923***	37.8381*	**22.9943***	39.6381*
4	4.5857	13.9452	7.752	19.9041
5	1.0427	2.9466	0.4209	6.4678

	UK		France	
r	Constant	**Restricted Trend**	**Constant**	Restricted Trend
0	328.9186	272.7849	140.4167	175.9147
1	186.1572	127.7704	82.8238	109.6807
2	86.543	65.2663	48.1935	74.382
3	32.3905	**34.0089***	**27.9065***	45.2676
4	11.8507*	15.0622	12.7941	26.0269
5	0.0748	3.3871	0.2717	10.9173*

	Italy	
r	Constant	Restricted Trend
0	94.15	104.94
1	93.0449	92.1989
2	58.2097	59.4825
3	30.1078	28.9822
4	**10.4921***	14.9299*
5	0.0034	2.2543

Note 1: * indicates failure to reject the null hypothesis of no more than *r* cointegrating relationships at the 0.05 level of significance.
2: The lag length used in each of the estimations is determined through the use of the SBIC.
3: Bold highlights indicate the rank and model used in the 'optimal' estimation of the VEC model.

Table 3.7: Results of Johansen's Trace Tests for Cointegration – Sub Periods

	Ireland		Germany	
r	Constant	**Restricted Trend**	**Constant**	Restricted Trend
0	146.0341	165.0341	122.1625	114.9
1	96.4512	115.093	79.0052	103.3847
2	56.3435	72.0123	**45.0672***	63.4054
3	30.6338	**41.1221***	23.4963	41.5542*
4	16.006	16.121	8.2173	20.8811
5	6.208	6.3199	0.9968	6.3779

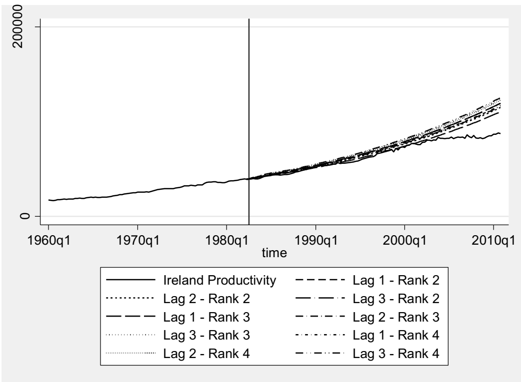
	UK		France	
r	**Constant**	Restricted Trend	**Constant**	Restricted Trend
0	178.7014	114.9	234.1767	254.371
1	95.2899	115.5817	125.8346	145.8483
2	56.9138	76.0378	74.9049	94.815
3	**28.9730***	48.0931	40.027	58.6389
4	7.9687	25.47	18.2651	31.513
5	1.2209	6.6621*	**1.5740***	13.2189*

	Italy	
r	**Constant**	Restricted Trend
0	94.15	114.9
1	93.3226	116.9929
2	55.8901	77.1673
3	**22.3803***	42.9151
4	6.1647	20.9014*
5	0.2957	5.5171

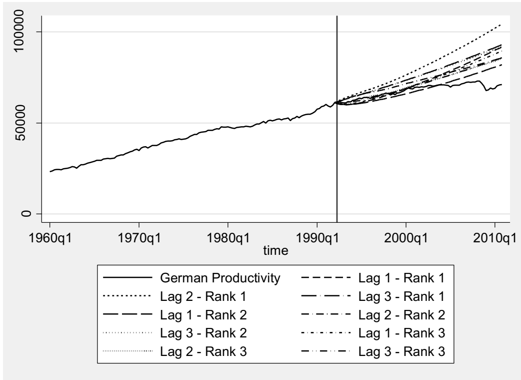
Note 1: * indicates failure to reject the null hypothesis of no more than *r* cointegrating relationships at the 0.05 level of significance.
2: The lag length used in each of the estimations is determined through the use of the SBIC.
3: Bold highlights indicate the rank and model used in the 'optimal' estimation of the VEC model.

Figure 3.4: Dynamic Forecasts for Productivity derived from Alternatively Specified VEC models

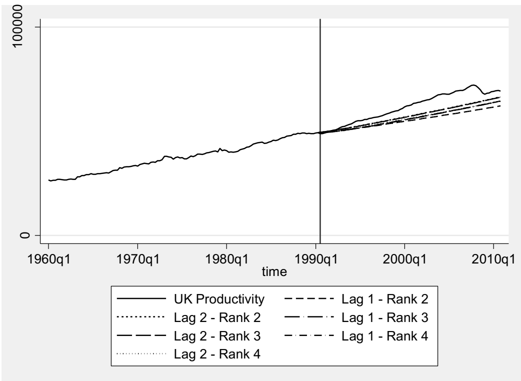
Ireland



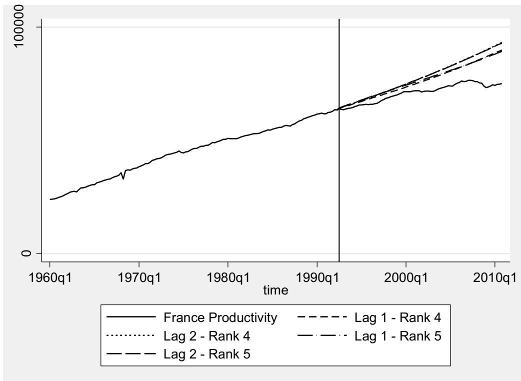
Germany



UK



France



Italy

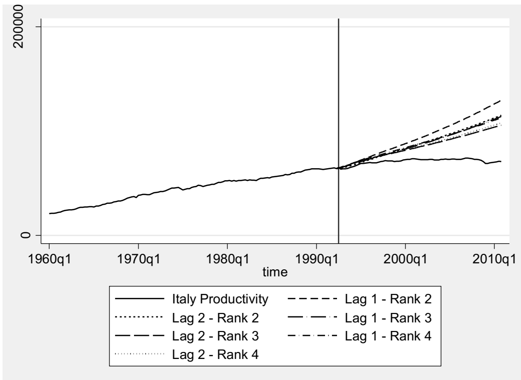


Figure 3.5: IRFs based on Alternative VEC models for US GDP -> Productivity

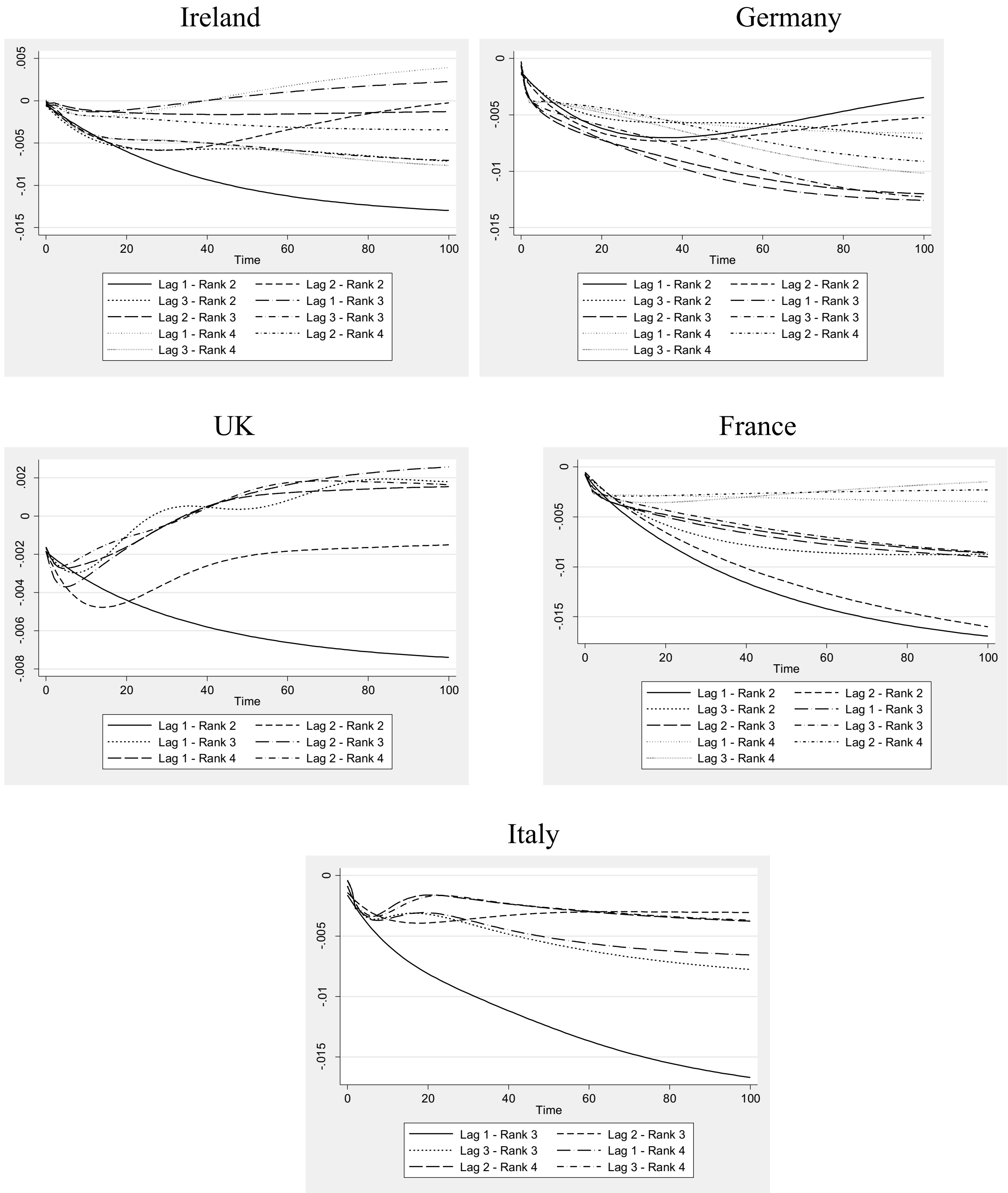


Figure 3.6: IRFs based on Alternative VEC models for EU14 GDP -> Productivity

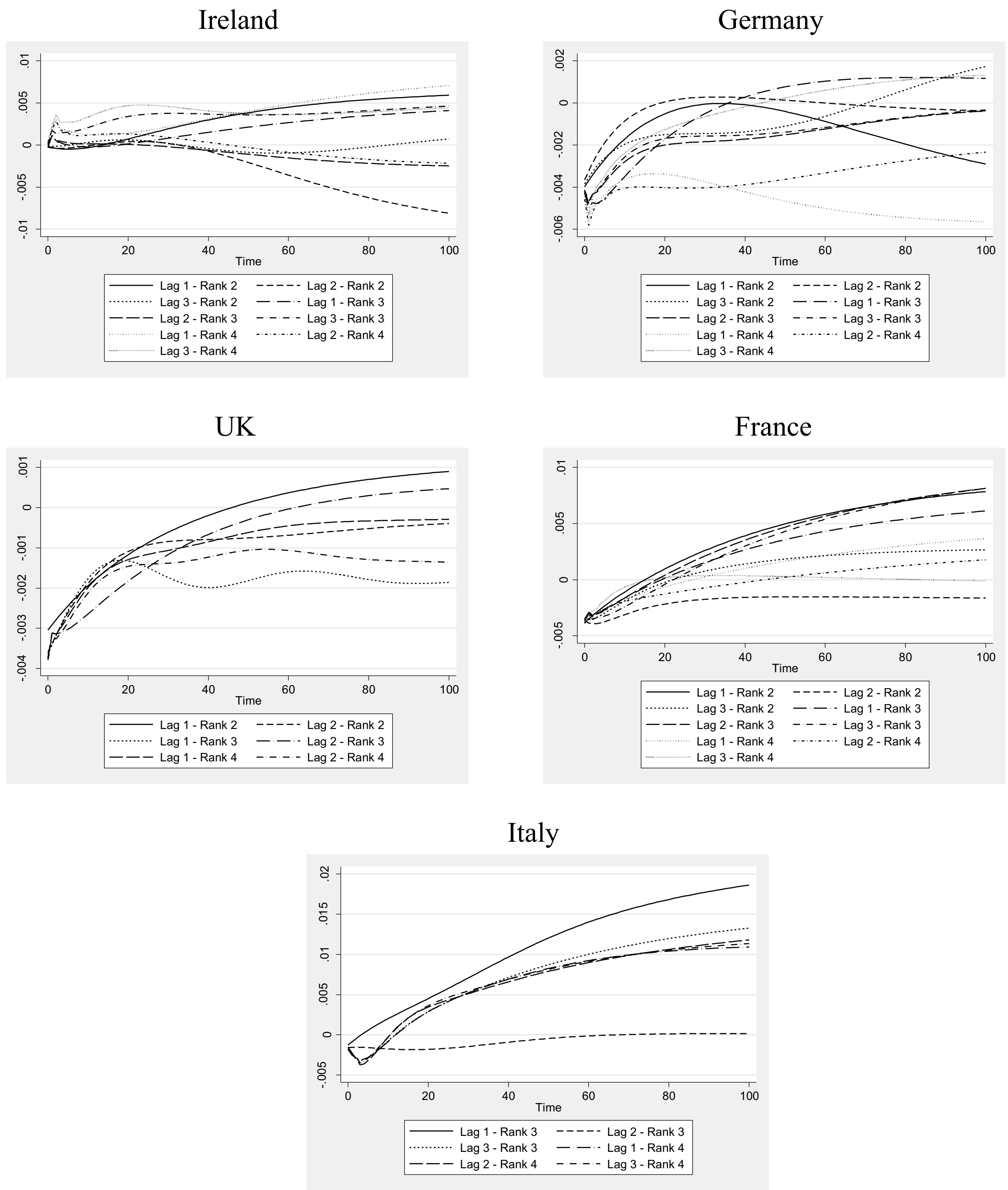
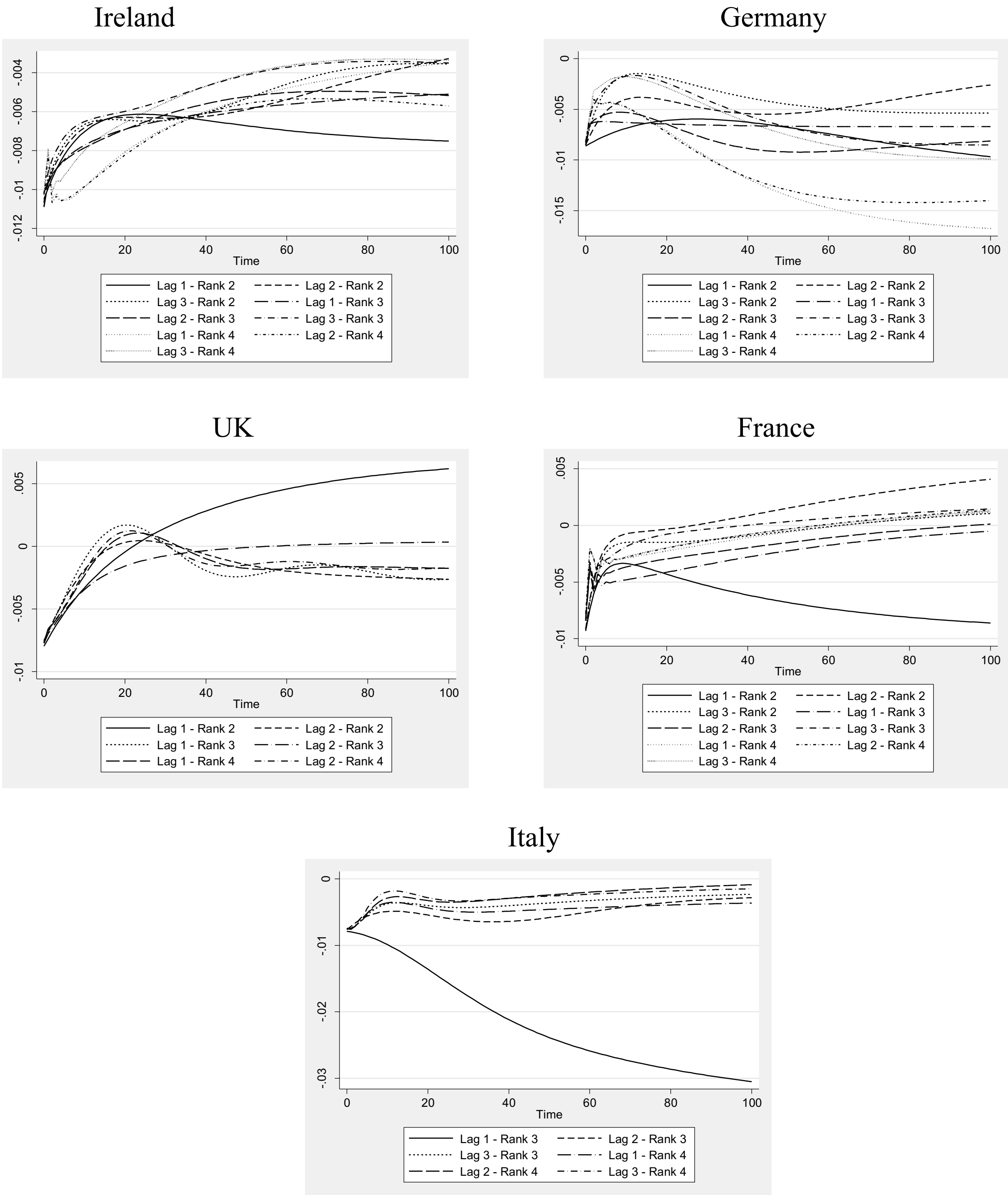


Figure 3.7: IRFs based on Alternative VEC models for Domestic GDP -> Productivity



3.7 Actual and counterfactual responses to shocks

This section presents historical evidence of the response of Ireland, Germany, the UK, France and Italy's productivity to recessionary shocks. The counterfactual and actual productivity series for each country following a recession are displayed in Figure 3.8. As the onset of recessions occur at different times in each country, VEC models based on different time periods must be analysed. For Ireland, which barely showed sign of recession in the 1990s, the recession chosen commenced in 1982q3. The other countries went into recession at different times in the 1990s, commencing with 1990q2 for the UK, 1992q1 for Germany, and finally 1992q2 for France and Italy. These periods are based on the IMF data used in this Chapter. As stated previously, while the results presented here are based on one preferred model, a series of alternative models are estimated to indicate the degree to which the analysis is robust to model respecification. The dynamic forecasts generated from these alternative specifications are presented at the end of the previous sub-section, 3.6.

3.8 Response of Productivity to Recession

Figure 3.8 shows actual and counterfactual quarterly productivity series, with the counterfactual growth rates based on dynamic forecasts showing the hypothetical growth path of productivity for the country should the recession not have occurred[12]. Of interest is whether actual productivity remains permanently lower than the counterfactual productivity, signifying a permanent fall in productivity, or whether the actual level returns to or exceeds the counterfactual level. If productivity remains below its counterfactual level or indeed rises above it, a hysteretic effect can be deemed to have occurred, where the recessionary shock has resulted in a permanent lowering/raising of the country's productivity growth path.

As Ireland barely suffered a recession in the 1990s the more severe 1980s recession is used. It can be observed that following the recession productivity in Ireland dipped temporarily but appears to return to the pre-shock productivity level. This is not dissimilar to anti-hysteresis (Figure 3.4), since Irish productivity more or less returns to its pre-shock growth path, implying only transient shock effects that fade away over time. However, during the late 1990s and following the 2007 crisis Ireland again falls below the counterfactual productivity forecast.

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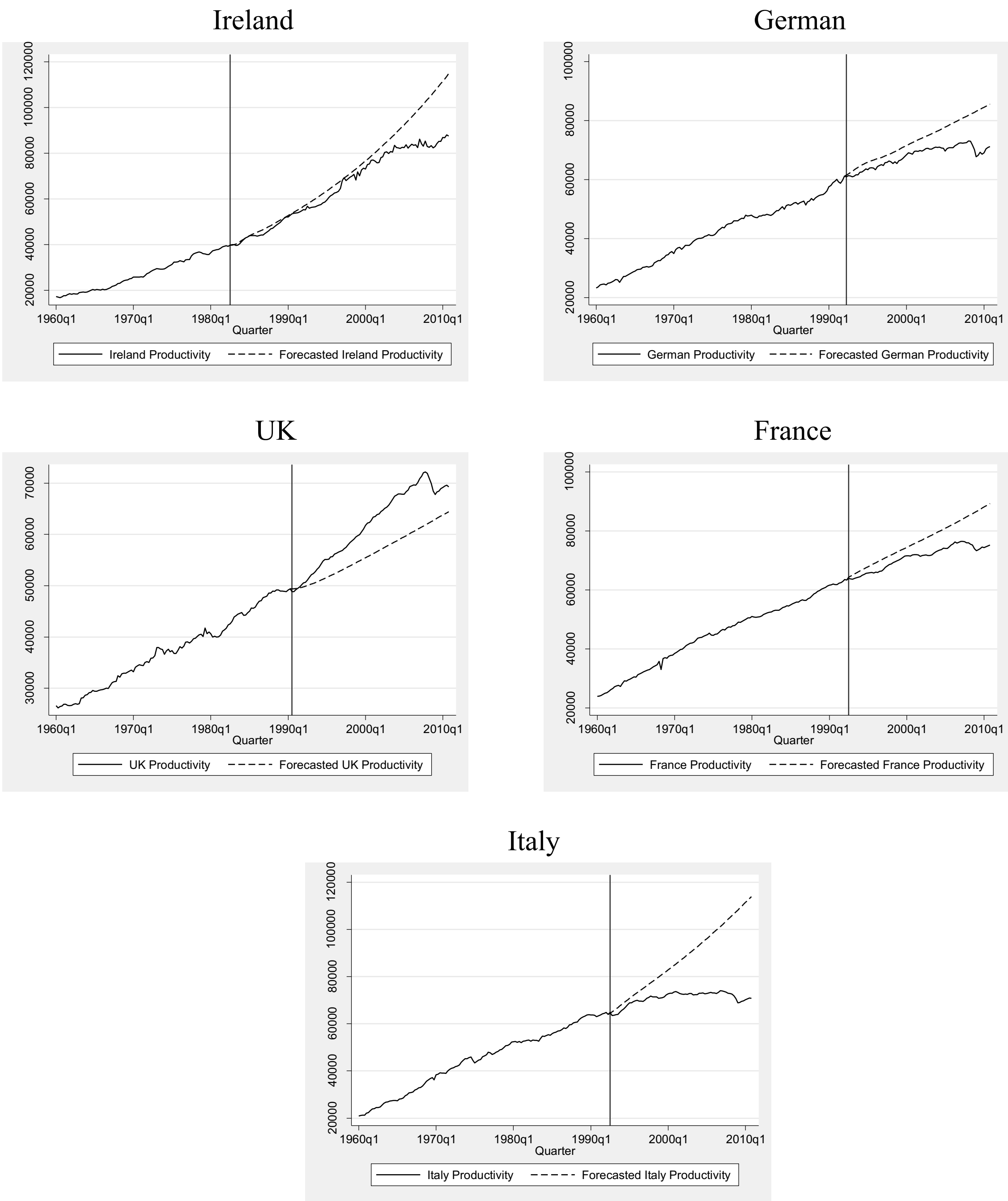
[12] Based on coefficient estimates from the preferred specifications obtained from the data prior to the onset of recession.

A similar pattern emerges for the other four countries considered. Following the recession, actual productivity falls away from the counterfactual level but in the case of Germany, France and Italy it remains permanently lower. This suggests that the recessions experienced by these three countries resulted in a permanent lowering of the productive ceiling, implying that the shocks had a negative hysteretic effect. However, in the case of the UK, actual productivity quickly converges to the counterfactual path after approximately two quarters, and then subsequently superseded the counterfactual level. This suggests that the UK economy responded differently to the recessionary shock of the early 1990s than the other countries considered. The picture emerging for the UK's productivity path is not unlike Figure 3.5 which shows the eventuality where the creative elements of a recession outweigh the destructive elements (Cross et al., 2010). This may be partly the result of optimistic business expectations, the availability of spare capacity to expand or new firm foundations. However, the fundamental reason is possibly the shake-out of employment, with jobs evidently being replaced by capital and to a greater extent than in the other economies, rather than there being a surge in production and productive capacity. This is the story told by the underlying data of employment and of GDP. While the UK's GDP tracked expectation fairly closely, employment fell permanently well below expectation, the net outcome being above expectation productivity levels through the projection period. In contrast, in the post-recession period, employment levels in Germany, France and Italy were closer to and even exceeded the counterfactual expectations, whereas GDP remained below the counterfactual. Because it is an outcome based largely on lower employment than expected, despite the positive hysteretic effect on productivity there is reluctance to suggest that the UK economy was more resilient than that of Germany, France and Italy to the recessionary shock in the 1990s.

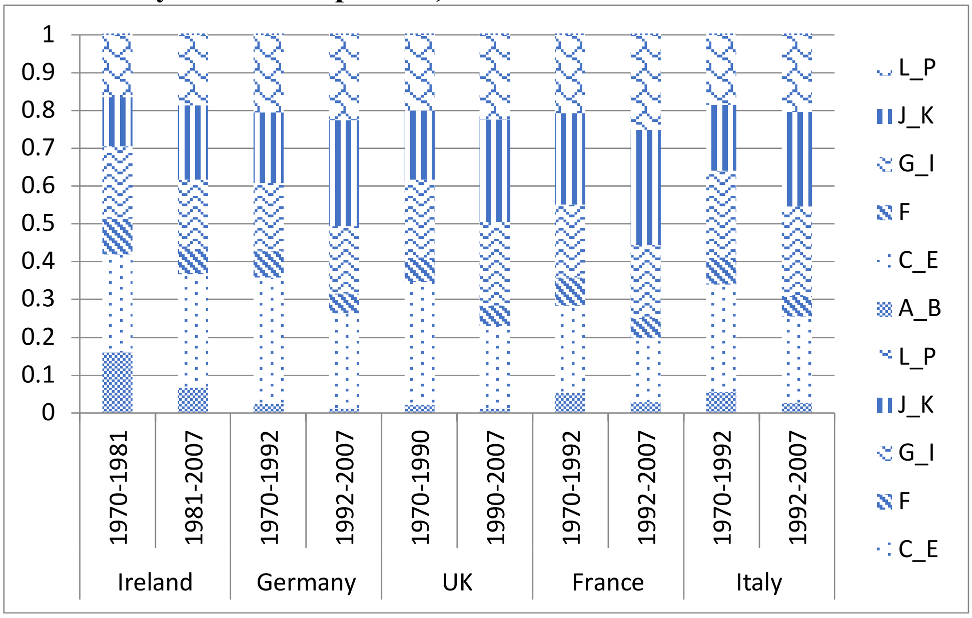
Figure 3.8: Actual and counterfactual quarterly Productivity Series – 1990s Recession



Another possible explanation of the varying responses across countries may be economic structure. Martin (2010) notes that one of the central elements of resilience post shock is restructuring involving structural change. Figure 3.9 displays the average contribution of each sector to an economy's GDP pre and post recession. It can be observed that there are some similarities in how countries' industrial structure evolved following the recessionary shock. For instance, most countries, with the exception of Ireland, observed a decrease in the contribution of industry to GDP following a recession. This decrease in industry appears to have corresponded to an increased contribution to GDP from Financial intermediation, real estate, renting and business activities and also from other service activities. In the case of Ireland the recession also resulted in a reduced contribution from Agriculture, hunting, forestry and fishing.

The UK experienced the largest change in average sectoral contribution to GDP following the recession, followed by Ireland, Germany, France and Italy. Given that the UK and Ireland appear to be the most resilient to the recessions studied and they also experienced the largest reallocation of sectoral contribution to GDP this may suggest that structural change does play a role in countries' responses to recessionary shocks. This is a concept which is returned to, discussed, and analysed in more detail in Chapter 4 of this dissertation.

Figure 3.9: Sectoral Contribution to GDP – Pre and Post Recession (displays the average sectoral contribution to GDP for each of the countries in the sample for the pre and post recessionary shock time periods)



Notes: 1 Where A_B indicates Agriculture, hunting, forestry and fishing, C_E indicates Industry, including energy, F indicates Construction, G_I indicates Wholesale and retail trade, repairs, hotels and restaurants and transport, J_K indicates Financial intermediation, real estate, renting and business activities and L_P indicates Other service activities

2 Source: OECD (2011a)

3.9 Impulse-response analysis

The impulse-response analysis is based on orthogonalized impulse response functions (OIRFs) which measure endogenous variables' responses to a hypothetical one unit (one standard error) shock to one specific endogenous variable occurring at one instant in time. Orthogonalization eliminates contemporaneous correlation and it is possible to therefore 'shock' one variable without 'shocking' others, thus allowing a causal interpretation. To achieve this the model invokes a recursive structure corresponding to the ordering of the Cholesky decomposition of the cross-equation covariance matrix (Enders, 2010). However, because the identifying restrictions are arbitrary, with different Cholesky decomposition orderings possible, there are different possible outcomes, although in this case the outcomes are robust to different orderings.

In order to identify the responsiveness of countries to shocks originating from within and outside the country, IRFs are derived which show the impact of (i) internal shocks, (ii) shocks from other EU countries and (iii) shocks from the US. Shocks originating in both GDP and employment can be considered, but in line with the Verdoorn law motivation, the analysis here is limited to the impact of shocks to GDP on productivity. The use of IRFs allows for an analysis of whether impulses from foreign countries are stronger or weaker than local impulses.

Secondly, it is possible to assess the relative permanency of the response of productivity to GDP shocks.

3.10 Impact of a Shock to GDP on Productivity

The response of countries' productivity to a hypothetical negative one standard error shock in GDP can be observed in Figure 3.10. The broad conclusions are as follows. First, there is evidence that the effects of a shock, irrespective of source, are always negative in the short run. Secondly, domestic shocks mainly have a permanent negative effect. Thirdly, in the long run the negative effects of shocks emanating from neighbouring European economies tend to dissipate. Finally, shocks with origins in the US generally have a permanent negative effect. Of course these are generalizations, and looking in detail it is possible to immediately see that there is substantial variation in how countries respond to shocks in terms of response magnitudes, sensitivity to internal and external shocks, the persistence or transience of these shock effects and also whether the shocks have positive or negative long-run effects on productivity.

Starting with Ireland, Figure 3.10 indicates that GDP shocks, regardless of their origin, clearly have permanent negative effects on Irish productivity, an interpretation generally reinforced by the alternative (less preferred) model outcomes which have been presented earlier to show robustness as Figures 3.5 through 3.7. Domestic GDP shocks have the largest negative effect on Irish productivity. The spillover effect of a shock to US GDP produces a less intense negative response, and while remaining negative, the long-run response is only just negative although the alternative models (Figure 3.5) generally support the view of a negative long-run response. Shocks originating in the EU-14 also have a permanent long run negative effect on Irish productivity, though the initial response is slightly positive. However, Figure 3.6 shows that the alternative models exhibit some ambiguity relating to the response in the long-run. The evidence suggests that Ireland may be more sensitive to GDP shocks originating in the domestic economy followed by other EU countries and finally the US economy. Although due to variations in the alternative model specifications there is less confidence in the EU shock interpretation.

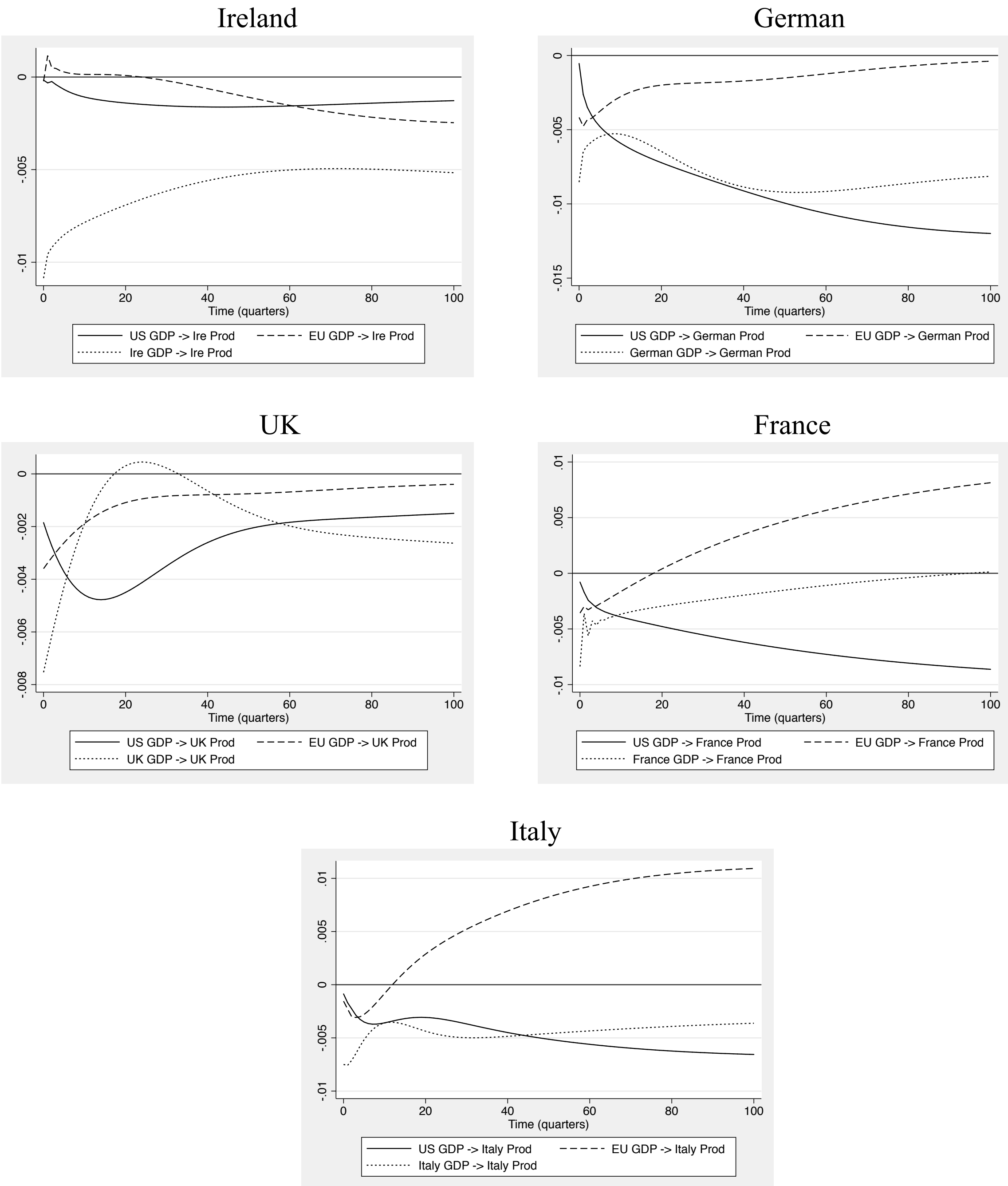
Turning to Germany, Figure 3.10 shows that while domestic GDP shocks and GDP shocks originating in the US have permanent negative effects on productivity, the relative magnitude is reversed compared with Ireland. Shocks from the US have a deeper negative effect than domestic shocks suggesting that, unlike Ireland, Germany is evidently more susceptible to outside shocks as opposed to domestic shocks. This is interesting, because one would suppose that Ireland was much more susceptible to external shocks, and the large German economy was more insulated. However, while Figure 3.5 reinforces the view that a US GDP shock has a permanent negative effect on German productivity, the preferred model is definitely more pessimistic than almost all the alternative models considered, while the prediction of the preferred model of the Irish productivity response is in the middle of all the alternatives considered, so the deeper response in Germany may not be so profound as Figure 3.10 indicates. Interestingly, the response of German productivity to a negative GDP shock in the EU14 is mainly transient with no long-run impact. Like some other countries, Germany is relatively immune to negative external shocks originating from the EU, with no apparent long-run impact on productivity. This prediction is fairly central to the range of reasonably clustered outcomes from the alternative specifications shown in Figure 3.6.

As in the case of Ireland, for the UK the preferred simulations show that domestic shocks have a larger negative effect than US or EU shocks, although again the prediction is towards the bottom of the range of outcomes in Figure 3.6. US shocks also evidently have a persistent but smaller negative effect on productivity. Figure 3.10 shows that in the long-run shocks originating in the EU14, while initially negative, once again mainly dissipate so that the long-run consequence for productivity is negligible. Figure 3.6 shows that some alterative specifications produce the same outcome, but some (less preferred) models predict a more positive long-run response.

A negative shock to US GDP also has a large permanent effect on the French economy, relative to a domestic or EU GDP shocks, clearly reducing productivity in the long-run. Somewhat in contrast, a negative GDP shock in the neighbouring EU economies produces positive long-run consequences for French productivity, which is an outcome that is not confined to the preferred specification (see the alternative projections in Figure 3.5). However, a negative domestic shock to France's GDP is tending towards no long-term negative consequences for productivity, an interpretation supported by almost all outcomes in Figure 3.6. The possibly transient nature of the impact of a domestic GDP shock is unusual compared with outcomes for the other countries in the sample.

Italy is similar to France in that shocks originating from the US have the largest negative effects on Italian productivity. However, the consequences of a shock to domestic GDP are also evidently negative in the long-run, tracing a similar path to the US impulse. Italy, like other countries, suffers no long term negative effects from EU shocks, indeed like France it actually experiencing a permanent increase in productivity. These conclusions are supported by the alternative specifications presented previously.

Figure 3.10: IRF – Countries' Productivity Responses to a Hypothetical Negative one Standard Error Shock to GDP



The reasons for the differentiated responses are, possibly, very much related to the industrial structure of each country and to the size and diversity of economies. Industrial structure may be important as some economies are more cyclically sensitive than others, typically those dominated by manufacturing may be more prone to the vagaries of the economic cycle. It also appears that larger economies, such as Germany, the UK, France and Italy bounce back and productivity is enhanced in the long-run when subject to a negative impulse from the surrounding 14 EU economies, as though within the EU-14 negative output shocks decimate domestic productive capacity and the larger economies gain in the long-run, capturing neighbours' markets post-recession whenever domestic productive capacity is reduced. This would be consistent with the increasing returns to scale story embodied within the Verdoorn law theory which provides a theoretical context for this empirical analysis. The static version of Verdoorn's law suggests increasing levels of productivity as output increases. Therefore, as domestic economies suffer from a negative shock this should have an adverse effect on productivity. In Dixon and Thirwall's (1975) model, which incorporates income in other countries, the varying responses of economies to shocks in other countries may be due to varying dependence on price and income in other countries as well as the extent of trade between these countries.

Regarding the counter-intuitive responses of Germany and Ireland to shocks originating domestically and in the US this may be due to the underlying characteristics of these economies. For instance an important consideration may be the degree of flexibility in an economy in terms of its ability to respond and adapt to the loss of export markets and domestic productive capacity. Some economies, perhaps overspecialized in sectors that are vulnerable, may find it difficult to change to other types of production that are more resilient to shocks. Moreover adapting to external shocks may have been easier in economies with smaller, more flexible production units and labour markets than those more dominated by large inflexible enterprises with a large amount of sunk capital dedicated to supplying specialised vulnerable markets. Ireland can be thought of as an economy which has overspecialised in various industries thought the period studied, most notably construction throughout the late 1990s and up to 2007. This may have made Ireland more susceptible to domestic shocks than to international shocks. Avellaneda and Hardiman (2010) note that Germany, as the largest exporting economy in Europe, may be especially exposed to external demand for its goods and services. If one were to consider the US as a barometer of the global economy, a negative output shock originating in the US could signal falling demand for German exports in the global economy. Given the overriding importance of exports to the German economy this sensitivity to US shocks may represent a lack of resilience in Germany to shocks in its export markets.

While all European countries may be expected to suffer from falls in the demand for their exports the variation in responses to shocks may be the effect of variegated connectivity across economies, partly as a result of different hierarchical ownership and control patterns for productive capital. For example, decisions made by multinational US companies to cut output and employment both domestically and internationally may impact different economies in different ways as their export markets fall away and may have had global repercussions for productive capacity and employment levels in subsidiary plants wherever they are located within the EU economies. Therefore, while a shock from the US may impact on Germany through a reduction in demand for their exports, a shock to the US may impact Ireland through its effects on US multinational companies operating in Ireland. These differing connectivity patterns may explain the sensitivity of Germany to US shocks while Ireland appears more susceptible to domestic shocks.

However, as an added a word of caution, the analysis, which is predicated on average impulse-response reactions over the entire quarterly series going back to 1960Q1, masks the dynamical structural changes that are probably occurring in each country in response to earlier shocks. Thus vulnerability in some sectors to negative shocks, and positive growth in other sectors in response to positive shocks, is very likely to be changing the structural composition of each country over time, and thus also changing the country's resilience to economic shocks.

3.11 Conclusions

This Chapter analyses how selected EU economies' productivity growth paths have been affected by previous recessions and uses this to cast light on how the post-2007 economic downturn experienced across the EU and other developed economies may impact on their subsequent productivity. The Chapter firstly looks at the post-recession path of productivity relative to counterfactuals based on pre-recession trends. Secondly, it analyses the responsiveness of economies to hypothetical domestic and external GDP shocks, addressing the question of which of domestic, US or neighbouring EU economies are more influential in terms of the responses they invoke, and, whether some economies are more exposed than others to negative spillover effects.

Five European countries are analysed; Ireland, Germany, the UK, France and Italy. Quarterly GDP and employment levels from 1960q1 to 2011q1 are utilised. A series of five preferred VEC models are estimated which include each of these countries' GDP and employment, US GDP and employment and an aggregate of the EU15 countries' (excluding the individual country considered) GDP and employment. From the resulting models a series of dynamic forecasts and impulse response functions are obtained showing the impact of GDP shocks on productivity.

Comparing post-recession outcomes with counterfactual series suggests varying responses to recession. Evidence suggests that the recessions experienced by Germany, France and Italy in the 1990s resulted in these countries' productivity shifting to a lower growth path. However, UK and Irish productivity recovered from the recessionary shocks they experienced, with the UK even performing above expectation. This suggests a strong heterogeneity in the response of European countries to recessionary shocks.

Subsequent analysis using IRFs allows a more detailed analysis of varied outcomes which depend on the source of the shock and the country affected, although the short-run impact of a shock to GDP from any source is invariably negative for productivity. One common element among the countries is that shocks originating from the US have a permanent negative effect. In the case of all countries bar Ireland (which for much of the period was tied closely to the UK economy), this negative response to US shocks is greater than to shocks originating in the EU. This suggests that the EU countries considered appear to suffer more from shocks originating in the US than shocks originating in their European neighbours (recall that the data covers the period 1960 to 2011, so what is observed are 'average' responses for this whole period). The relative importance of domestic and external shocks also varies across countries. While Ireland and the UK are most vulnerable to domestic shocks, Germany, France and Italy are more responsive to shocks from the US. These results suggest that the ability of countries to rebound from shocks is predicated upon the origin of the shock experienced and the specific country. The results also suggest that two countries, which experience the same types of shock, may have substantially different long run outcomes resulting from the shock.

From the perspective of Verdoorn's law, or more specifically the Dixon and Thirlwall's (1975) theory, it would appear that what is important for productivity growth is the growth of output, which is fundamentally determined by export growth. The latter depends on both domestic (export) price inflation, which itself depends on wage growth relative to productivity growth and on the mark-up on labour costs that one would associate with imperfectly competitive market structures. Export growth also depends on competitor price inflation, and on real income growth in export markets. So there are a range of variables that one might consider that will differ across domestic economies, with different labour markets, and these domestic economies will themselves have different export markets each of which has its own specific inflation and real income growth rates. An important message from this theoretical model is the importance of interdependence between economies, notably via trade, but also the heterogeneity across economies relating particularly to their labour market structures and export orientation.

To sum up, the implications of the analysis in light of the 2008 crisis are that, if previous trends are followed, the shock will have a permanent negative effect on the productivity growth path of most EU economies. It is possible that structural change may help countries recover from the crisis, but the scope for structural adjustment in the economies studied, which are now largely service based economies, may be limited.

What has been shown in this Chapter is that on average there appear to be differences in economies' resilience to shocks which are a fairly long-lasting feature, as is apparent from the time series that are available here. The next Chapter focuses to a greater extent on the 2008 economic shock and its impact on US regions (specifically US metropolitan statistics areas) and focuses on the issue of structural change which is highlighted in this Chapter as a possible explanatory factor in how economies respond to crises.

Chapter 4: Metropolitan Resilience to the 2008 Economic Crisis

4.1 Introduction

This Chapter builds on the work of Martin et al. (2016), Fingleton et al. (2012), Fingleton et al. (2015), and Martin (2012), who analyse the impact of recessionary shocks to UK or EU regions, by applying a dynamic spatial panel model (DSPM) estimator, following Baltagi et al. (2014). This allows for the construction of a counterfactual employment series for Metropolitan Statistical Areas (MSAs) of the United States, which then provides a yardstick for assessing the depth of the MSA-specific shock impact and the extent of subsequent recovery in each MSA. The underlying theoretical basis for the DSPM specification is Verdoorn's law (Verdoorn, 1949), which is a cornerstone of Kaldorian and post-Keynesian economics, and which has been applied to enhance the understanding of persistent regional and national economic disparities (León-Ledesma, 2000; León-Ledesma, 1999; McCombie and Roberts, 2007; Dixon and Thirlwall, 1975). In the DSPM specification, the level of employment in each MSA depends on MSA-specific output levels. In addition, employment depends on its temporal and spatial lags. The temporal lag can be thought of as an outcome of market failure, whereby there is non-instantaneous adjustment to economic change, so that the level of employment in an MSA partially depends on the level in the previous period, the assumption being that the economy has some form of memory. The spatial lag follows from earlier extensions of Verdoorn's law which also consider contemporaneous spatial spillovers across locations to be important (Fingleton and McCombie, 1998; Pons-Novell and Viladecans-Marsal, 1999; Bernat, 1996). The level of employment also undoubtedly depends on unobserved factors, and important among these is inter-MSA heterogeneity. I attempt to capture these through the presence of (spatially interdependent) individual-specific random effects in the model.

The DSPM specification leads to a prediction equation which generates counterfactual employment series based on an assumption that output growth across all MSAs is equal to national output growth. From 2008 to 2014 the growth path of each MSA is assumed to follow the national output growth rate in order to generate a counterfactual of how the MSA would have responded had it followed the national average. Further details on the generation of this counterfactual are discussed in Section 4.6.2. In summary each MSA, from 2008 onwards, is assumed to have grown each year at the national growth rate. This generates a counterfactual output series which shows how each MSA would have responded if they had followed the national average. Using this, I measure the resilience of each MSA by comparing its predicted employment with the actual level over the post-shock period from 2008 to 2014. These resilience measures are treated as the dependent variable in regression models which are used to test the hypothesis of interest, that MSA resilience depends on the industrial structure of the MSA.

The hypothesis that resilience to economic shocks is shaped by, and shapes, industrial structure, broadly defined, has been considered elsewhere in the literature (Glaeser, 2005; Glaeser et al., 2014; Martin, 2012; Combes, 2000; Quigley, 1998; Doran and Fingleton, 2014; Holm and Østergaard, 2015; Fingleton and Palombi, 2013). For example Capasso et al. (2014) highlight the importance of industry structure in explaining the evolution of regions' growth paths over time, while Holm and Østergaard (2015) emphasise the importance of regional industrial structure in explaining a region's susceptibility to shocks and its ability to better recover following shocks. Likewise the differentiated impact of industry structure on resilience has been discussed by Martin et al. (2016) as a possible explanatory factor for regional divergence, with a region's ability to resist and recover from shocks impacting its long run growth path.

There are some novel aspects to this Chapter which are highlighted here. First, the modelling approach, involving both dynamic and spatial interaction, is relatively unusual and a clear advance on static spatial panel approaches which do not take account of time-dependency in spatio-temporal series. Secondly, and somewhat unusually, the DSPM estimation takes account of the potential endogeneity of the regressor, output, with respect to employment. Thirdly, the focus is essentially on city-region (i.e. MSA) resilience, in contrast to the more usual region- or country-specific estimates of resilience found in the literature. Fourthly, the analysis seeks to avoid omitted variables bias by introducing covariates, and allows for endogeneity in the regression analysis, in an attempt to obtain consistent causal effects of industrial structure on resilience.

The remainder of this Chapter is structured as follows. Section 4.2 provides an overview of the industrial structure hypothesis and how this relates to regional resilience. The data used are discussed in Section 4.3. The Verdoorn's law model and estimation strategy is outlined in Section 4.4. Section 4.5 gives the estimates. The forecasting methodology utilised is discussed in Section 4.6. Section 4.7 describes the resilience indices. Section 4.8 gives the regression analysis and interpretation. The final section, 4.9, concludes.

4.2 Resilience and the industrial structure hypothesis

Martin et al. (2016) note that in economic geography resilience describes regions' reactions to, and recovery from, negative economic shocks, based on a concept which has been widely used in the engineering and ecological sciences and which has been increasingly adopted in economic geography [see Cross et al. (2010), Grinfeld et al. (2009), Christopherson et al. (2010), Simmie and Martin (2010), and Palaskas et al. (2015) among others]. Martin (2010) suggested three conceptualisations of resilience; (i) engineering, (ii) ecological, and (iii) adaptive resilience (my preferred conceptualisation for this Chapter). As each of these has been discussed in Chapter 2 a brief summary, of how these concepts relate to this Chapter, is presented here. Engineering resilience relates to an economy's ability to regain equilibrium after a shock (Martin, 2010; Fingleton et al., 2012), the assumption being the existence of self-correcting forces typified by Friedman's (1993; 1964) plucking model. Ecological resilience differs in that it assumes that systems are characterised by multiple equilibria. In ecological resilience, shocks push the system beyond its recovery threshold to a new domain rather than allowing it to return to the same equilibrium path. This is similar to the concept of hysteresis whereby a shock permanently affects the subsequent growth path of an economy (Romer, 2001). Essentially the memory of the shock is left behind in the economy even after the shock has faded away. Finally, the preferred concept, adaptive resilience, relates to the capacity of a regional economy to adapt its structure in response to external shocks (Martin et al., 2016; Nyström, 2017). Martin et al. (2016) also identify four dimensions of resilience; risk, resistance, reorientation, and recovery, noting that these four dimensions are influenced by a myriad of factors including, but not limited to, economic structure. In this Chapter I focus on the effect on resistance and recovery of an MSA's economic structure controlling for other factors.

The focus in this Chapter is on the question of whether the response of US MSAs to the 2008 economic crisis can be affected, at least in part, by differences in industrial structure. The adaptive resilience concept supposes that the relationship between shock-impact and industrial structure is complex and two-way, so that a shock-effect depends on industrial structure, but also industrial structure may change as a consequence of a shock. Given this potentially endogenous relationship, I attempt to tease out the causal effect of industrial structure in the remainder of the Chapter.

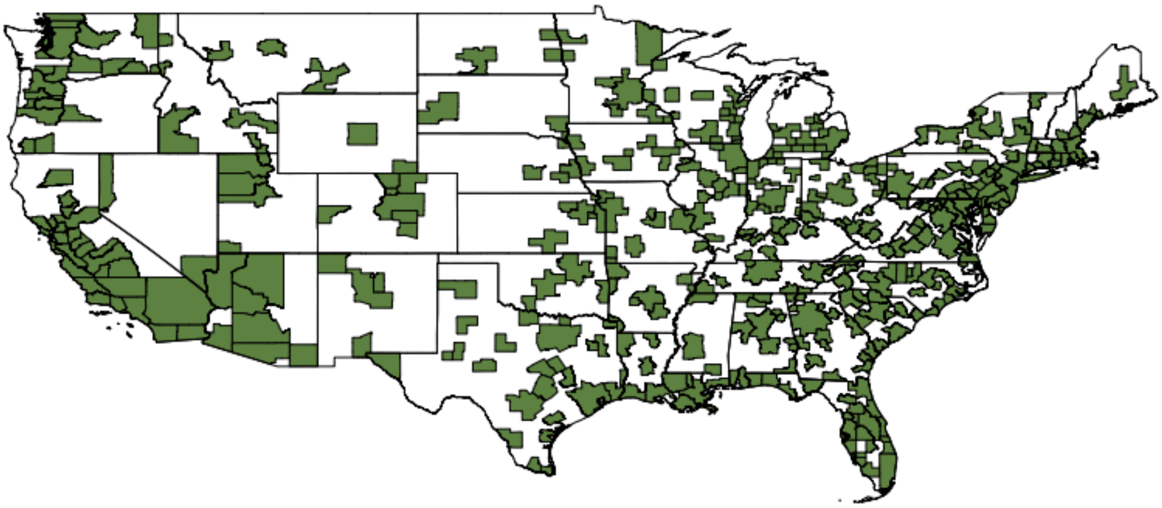
4.3 Data

The analysis is based on data for 377 US MSAs[13], as defined for use by Federal statistical agencies involved in collecting, tabulating, and publishing Federal statistics. The MSAs considered are mapped in Figure 4.1 and each contains a core urban area of 50,000 or more population plus any adjacent counties with a high degree of social and economic integration

[13] These comprise the majority of MSAs in the US, and exclude Alaska and Hawaii.

(as measured by commuting to work) with the urban core (United States Census Bureau, 2012). MSAs are by their nature not necessarily contiguous to other MSAs, with some clustered in relative geographic proximity to others and some relatively isolated.

Figure 4.1: Map of MSAs



Employment and GDP data for 2001 to 2014 come from the Bureau of Economic Analysis (BEA) regional economic accounts (Bureau of Economic Analysis, 2016); in the analysis MSA GDP is the market value of all final goods and services produced within an MSA in each year. The BEA MSA employment series utilized comprises estimates of the number of jobs, both full time and part time, by place of work. Full time equilivants are not available.

When considering the determinants of resistance and recover in Section 4.8 I employ data from the American Community Survey on (i) the number of individuals employed in 12 broad sectors, (ii) the number of individuals over the age of 24 with a third level education, and (iii) the population density of each MSA. The data are obtained through the American FactFinder service for the years 2005-2014 for MSAs (data prior to 2005 is not available for these variables).

4.4 Model Specification

4.4.1 Theoretical Framework

The empirical analysis rests on a fundamental theoretical assumption, that of increasing returns to scale. Increasing returns has found much favour within regional economics and economic geography as a basis for regional and urban disparities. From a post-Keynesian economics perspective increasing returns are embodied within the so-called Verdoorn Law (Verdoorn, 1949) which, in its so-called dynamic form, gives the exponential growth of labour productivity (p) as a positive function of the exponential growth of output (q), thus

$$p = a + bq \tag{4.1}$$

This equation forms an integral part of Dixon and Thirlwall's (1978; 1975) model of circular causation (used as the underpinning of Chapter 3) and is very much in the demand oriented tradition of economic growth analysis involving increasing returns to scale, with productivity growing in response to output growth, as implied by the typically estimated value of $b \approx 0.5$ (Fingleton and McCombie, 1998). Taken as a stand-alone equation, defining labour productivity growth as output growth minus employment growth (e) presents a minor problem for OLS estimation, in that output growth occurs on both sides of the equation and imparts a degree of spurious correlation, but as pointed out by Kaldor (1975) this can easily be circumvented by re-specifying the equation as

$$e = -a + (1-b)q \tag{4.2}$$

which can be written in terms of log levels as $\ln E = -a + (1-b)\ln Q$, which is the static Verdoorn Law (McCombie, 1983). As originally specified, Verdoorn's Law was applied to the manufacturing sector, but I retain the spirit of this model in the analysis which is in terms of the overall urban economy. León-Ledesma (2000) observes that when considering sectors other than manufacturing increasing returns are observed. As noted by León-Ledesma (2000) "in modern economies, it may be possible to identify some activities, especially in the services sector, that could also be subject to increasing returns. Activities intensive in technology and information-intensive capital (such as hardware and software), can also be considered to be crucial" (pp 61). As well as manufacturing, 'some degree of increasing returns can also be found for the service sector". This is further supported by Dall'erba et al. (2009) who note that while "the law was originally designed for the analysis of productivity in the manufacturing sector, we believe that it is even more appropriate to apply it to the services industry. In the past decades, the share of service sectors across the economies has got larger and this has been contextual with rapid growth of economies" (pp 336). They also note that evidence of increasing returns in producer services in a Verdoorn type context is highlighted by Faini (1984). Piras et al. (2012) test their specification of Verdoorn's law using data on the whole economy and the service economy for a sample of EU regions. Chapter 3 of this PhD [published as Doran and Fingleton (2014)] also uses aggregate output and employment rather than the manufacturing sector alone, likewise McCombie et al. (2017).

As shown by Thirlwall and McCombie (1994), Fingleton (2001a; 2001b), Dall'erba et al. (2009), Le Gallo and Páez (2013), and Britto and McCombie (2015), among others, various other specifications exist, and most relevant from the perspective of the current Chapter is the static Verdoorn Law written as a regression equation, hence,

$$\ln y_t = \alpha + \beta \ln x_t + \varepsilon_t; \quad t = 1,...,T \tag{4.3}$$

In equation (4.3), y_t is an N by 1 vector of employment levels in N MSAs at time *t*, ln denotes the natural log, and x_t is an N by 1 vector of output levels[14] , α is a constant term and β is a scalar coefficient. Other unobserved factors are captured by the error term ε_t, and some of these become explicit in the extended model. In the full model specification, described below, I propose that there is an element of memory in the system, so that the level of employment at time *t* is partly dependent on the level at *t*-1, in other words employment is not simply an instantaneous response to current levels of the drivers of employment. Other specifications introduce additional variables, for example Fingleton and McCombie (1998) include national dummy variables in their model of regional productivity growth across EU regions in order to capture international heterogeneity.

4.4.2 Spatial and temporal Lags

Extending the model by including a contemporaneous spatial lag as well as a temporal lag of the dependent variable gives:

$$\ln y_t = \alpha + \rho_1 W_N \ln y_t + \gamma \ln y_{t-1} + \beta \ln x_t + \varepsilon_t \tag{4.4}$$

The temporal lag is denoted by the N x 1 vector $\ln y_{t-1}$ and the spatial lag is an N x 1 vector $W_N \ln y_t$ resulting from the matrix product of the N x N 'connectivity' matrix W_N and the N

[14] The potential endogeneity of output with respect to employment is allowed for in the estimation methodology.

x 1 vector of log employment levels at time t denoted by $\ln y_t$, with coefficients γ and ρ_1 respectively.

With regard to the spatial lag, connectivity between MSAs is assumed to be a diminishing function of distance, so that

$$W^*_{Nij} = \left(1 - \frac{d_{ij}}{\max(d\ )}\right)^{\pi} \tag{4.5}$$

In which d_{ij} is the great circle distance between MSA i and MSA j, $\max(d)$ is the maximum great circle distance in the N by N matrix of distances d and $\pi = 1$. With $\pi = 1$ this is known as the Bartlett kernel [see Phillips et al. (2003)]. The resulting matrix W^*_N is standardised following the approach of Ord (1975). Accordingly, with the diagonal matrix D taking values equal to the row sums of W^*_N thus

$$D = diag\left(\left(\sum_{j=1}^{N} W^*_{Nij}\right)\right)$$

$$W_N = D^{-0.5} W^*_N D^{-0.5} \tag{4.6}$$

The matrix W_N is symmetrical with $W_{Nij} = W_{Nji}$, which retains absolute rather than relative distance between MSAs as the basis of connectivity, with maximum eigenvalue equal to 1.0, which facilitates easy interpretation of ρ_1. The continuous range for which $(I_N - \rho_1 W_N)$ is nonsingular is $1/\min(eig) < \rho_1 < 1/\max(eig) = 1$, and ρ_1 falling within this range is one of the conditions necessary for a stable, stationary model. Given $\rho_1 \neq 0$, MSA employment levels are mutually and contemporaneously interdependent, with interdependence based on geographical distance.

A justification for the inclusion of a spatial autoregressive term in Verdoorn's law estimations is provided by Fingleton and McCombie (1998). They note that when modelling spatially proximate regions at a sub-national level there is the potential for significant spatial spillovers. Alexiadis and Tsagdis (2006) further support this assertion by noting that "a complete specification of a model of regional growth should incorporate the effects of spatial dependence" (pp. 159). Without the inclusion of a spatial autoregressive parameter the model essentially ignores cross-regional spillovers. It is common to assume in existing literature on Verdoorn's law that productivity growth in region *i* depends on causal factors in region *i* and region *j*, depending upon the distance between region *i* and region *j*. It is unlikely that administrative boundaries will prevent spillover effects from region *j* to region *i* and, therefore, this necessitates the inclusion of a spatial autoregressive processes in the model so as to avoid misspecification bias and to correctly account for these potential spolliver effects.

With regard to the dynamic element of the model, with $\gamma \neq 0$ there is memory in the system, so that the level of employment in an MSA is partly dependent on its level in the previous period. The mechanism operating here could be one in which the temporal lag is capturing the effect of omitted lagged values of the right hand side variables[15]. It is possible to imagine these omitted lagged effects reflecting market imperfections, with the effect of change being spread over more than one period.

4.4.3 Spatially autoregressive Disturbances

A second potential source of spatial interdependence involves the error term ε_t. For simplicity an autoregressive error process defined as follows is again assumed

$$\begin{aligned}
&\varepsilon_{it} = \rho_2 \sum_{k=1}^{N} m_{Nik}\varepsilon_{kt} + u_{it} \\
&\varepsilon_t = (I - \rho_2 M_N)^{-1} u_t \\
&u_{it} = \mu_i + v_{it} \\
&M_N = \text{ an } N \text{ x } N \text{ matrix of known spatial weights } (=W_N) \\
&\mu_i \sim iid(0, \sigma_\mu^2) \text{ the individual-specific time-invariant effect} \\
&v_{it} \sim iid(0, \sigma_v^2) \text{ the remainder effect} \\
&\text{cov}(\mu_i, v_{it}) = 0
\end{aligned} \qquad (4.7)$$

Notice here that the autoregressive error process is governed by ρ_2 which has the same stability conditions as ρ_1, and by the weights matrix M_N, which here is identical[16] to and thus has the

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[15] Something similar to this can be seen in a general time-series context, namely the Koyck transformation (Watson, 2003; Koyck, 1954).

[16] This identity is not a requirement of the modelling approach.

same properties as W_N. If one assumes $\rho_2 = 0$then there is no spillover involving the errors and $\varepsilon_{it} = \mu_i + v_{it}$, and the error term then depends solely on the two error components, one time-invariant component $\mu_i$which is a set of independent draws from an $iid(0,\sigma_\mu^2)$ distribution. This term captures unobserved sources of inter-MSA heterogeneity. The component v_{ij}, which is assumed to be independent of $\mu_i$and distributed as $iid(0,\sigma_v^2)$, picks up the remaining unobservable effects that vary across both MSA and across time.

A justification for the inclusion of this spatial error process can be found in Alexiadis and Tsagdis (2006) who explicitly set out the framework for why the spatial error process should be incorporated into Verdoorn's law estimations. They note that the inclusion of spatial error processes allow for a random shock on a region's growth rate to disperse beyond that region's borders and affect the growth rate of other, surrounding regions. They highlight that failure to include a spatial error process may result in a misspecification bias.

4.5 Empirical Estimation

4.5.1 GMM-SL-SAR-RE Estimation

An estimation method for dynamic spatial panel data with random effects is given by Baltagi et al. (2014). The significant advantages of this estimator is that it allows the incorporation of a large number of regions in the analysis. In comparison, vector autoregressive (VAR) and vector error correction (VEC) modelling as applied by Papanyan (2010), Fingleton et al. (2012) and Chapter 3 [published as Doran and Fingleton (2014)] becomes highly impractical once one extends beyond about a dozen regions and would certainly be prohibitive given 377 MSAs. Therefore, while appropriate in the context of Chapter 3 the use of VEC models is not possible or appropriate in this Chapter.

This 'Generalized Method of Moments-Spatial Lag-Spatial Autoregressive-Random Error' or GMM-SL-SAR-RE estimator detailed in Baltagi et al. (2014) is based on Arellano and Bond (1991), but contains additional moments to take full account of the spatial dimension of the model. It is important to mention one difference between the estimator in Baltagi et al. (2014) and the application here. In the former, the regressor(s) are assumed to be exogenous, with the exception of the endogenous lags. These then become instruments facilitating consistent estimation. However it is unclear whether output can realistically be treated as exogenous to employment, as is evident in the exchange between Kaldor (1975) and Rowthorn (1975b; 1975a). In this Chapter it is assumed that the regressor, $\ln x$, is also an endogenous variable.

Thus in the estimation, $\ln x$ is treated symmetrically with regressand $\ln y$. The standard approach with an endogenous variable as an instrument is that it should be lagged by two periods[17] . The moments equations assume independence of the levels of the instruments and the differenced errors $\Delta v_t = v_t - v_{t-1}$, and so with an endogenous instrument such as $\ln y_t$, assuming $E(\Delta v_{it}, \Delta v_{it-2}) = 0$, this yields $\text{cov}(\ln y_{t-2,} \Delta v_t) = 0$. Therefore in the moments conditions in the estimator, while the spatial lags of the regressand and regressors are maintained as instruments, as in Baltagi et al. (2014), a lag the regressor $\ln x$ and its spatial lag are also included in the same way as the endogenous regressand and its spatial lag, thus the instrument set for individual i and time t becomes

$$\left(\ln y_{i1},...,\ln y_{it-2}, W_N \ln y_{i1},...,W_N \ln y_{it-2}, \ln x_{i1},...,\ln x_{it-2}, W_N \ln x_{i1},...,W_N \ln x_{it-2}\right) \tag{4.8}$$

4.5.2 Estimates

Applying the GMM-SL-SAR-RE estimator outlined above the estimates given in Table 4.1 are obtained. The table shows that the coefficients are all significant and display the anticipated sign, with the values of ρ_1, $\rho_2$and γ falling with the stable bounds given in Baltagi et al. (2014)[18].

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[17] An accessible summary of this is given in Bond (2002).

[18] The conditions for spatial stationarity are given as $e_{\min}^{-1} < \rho_1 < e_{\max}^{-1}$ and $\tilde{e}_{\min}^{-1} < \rho_2 < \tilde{e}_{\max}^{-1}$ where e= a vector of real characteristic roots of W and $\tilde{e}$= a vector of real characteristic roots of M. Dynamic stability is given by $|\gamma| < 1$, $|\gamma| < 1 - \rho_1 e_{\max}, \rho_1 > 0$ and $|\gamma| < 1 - \rho_1 e_{\min}, \rho_1 < 0$ where in this case e does not exclude complex eigenvalues.

Table 4.1: Parameter Estimates

VARIABLES	PARAMATERS	(4)
$\ln y_{t-1}$	γ	0.4782***
		(0.0078)
$W_N \ln y_t$	ρ_1	0.2731***
		(0.0124)
$\ln x_t$	β	0.2167***
		(0.0058)
	ρ_2	0.4464
	σ^2_μ	1.5638
	σ^2_υ	0.2499

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The estimated ρ_1 is highly significant[19], with a one-tailed p-value less than 0.001. The estimated ρ_2 is also significantly different from 0. For inference regarding ρ_2, the reference distribution is obtained as a result of 100 Monte Carlo simulations in which the residuals are sampled with replacement and thus randomly allocated spatially. This has a mean equal to -0.0445 and standard deviation equal to 0.2266, so the t-ratio is 2.17 with a two-tailed p-value equal to 0.03, indicating that estimated falls outside the sampling distribution consistent with a null hypothesis that $\rho_2 = 0$. Also there is a considerable amount of individual (MSA) heterogeneity as evident from the estimated variance $\hat{\sigma}^2_\mu$ which is large relative to the variance of the remainder component $\hat{\sigma}^2_v$.

The positive association between output and employment is consistent with the theoretical model presented previously, and indicates that, controlling for endogeneity, there exists a

[19] Given the assumption of endogeneity, the estimates of standard errors that are obtained are larger than those obtained assuming exogeneity. In the latter case, the two-step spatial lag estimate of 0.214 is highly significant with standard error = 0.0079.

positive causal impact of output with regards to employment. The positive spatial lag parameter (ρ_1) suggests that there are simultaneous positive spatial dependencies between MSA employment levels having controlled for significant positive temporal dependence as indicated by the estimated γ.

The estimates in Table 4.1 suggest that the constant elasticity of employment with respect to output is quite small, as indicated by $\hat{\beta}$, when compared to the typical value of the Verdoorn coefficient $b \approx 0.5$. However, the impact of output on employment as given by $\hat{\beta}$ is quite misleading, for it fails to take account of the spatial and temporal interactions present in the model.

It is now standard practice to acknowledge that the effect of a variable should equal the true derivative of $\ln y$ with respect to $\ln x$, which in the presence of significant spatial lag and dynamic effects is not simply the estimate $\hat{\beta}$ [Le Sage and Pace (2009) and Elhorst (2014)]. There are both short and long run effects. The short run effects at a specific point in time t are the derivatives

$$\begin{bmatrix} \frac{\partial \ln y_1}{\partial \ln x_1} & \cdots & \frac{\partial \ln y_1}{\partial \ln x_N} \\ \vdots & \ddots & \vdots \\ \frac{\partial \ln y_N}{\partial \ln x_1} & \cdots & \frac{\partial \ln y_N}{\partial \ln x_N} \end{bmatrix}_t = \left(\boldsymbol{I}_N - \rho_1 \boldsymbol{W}_N\right)^{-1} \begin{bmatrix} \beta_1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \beta_1 \end{bmatrix} \tag{4.9}$$

And the long run effects are given by

$$\begin{bmatrix} \frac{\partial \ln y_1}{\partial \ln x_1} & \cdots & \frac{\partial \ln y_1}{\partial \ln x_N} \\ \vdots & \ddots & \vdots \\ \frac{\partial \ln y_N}{\partial \ln x_1} & \cdots & \frac{\partial \ln y_N}{\partial \ln x_N} \end{bmatrix} = \left((1-\gamma)\boldsymbol{I}_N - \rho_1 \boldsymbol{W}_N\right)^{-1} \begin{bmatrix} \beta_1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \beta_1 \end{bmatrix} \tag{4.10}$$

The total short run effect is the effect on $\ln y$ at time t of a one unit change in $\ln x$ (or equivalently a 1% change in x) in each of N regions (cities) at time t, inclusive of both direct and indirect effects. For the long run effect the derivatives give the total effect on $\ln y$ at time T (as T goes to infinity) of a one unit change in $\ln x$ in each of N regions which remains through all times to T. Given the size of these matrices of derivatives, one takes the mean of the main diagonal of the matrix of partial derivatives for the direct effects, and the mean of the off-diagonal cells for the indirect effects. The sum of the two means is the total effect. Table 4.2 gives the results.

Table 4.2: Short and long run effects (two-step estimates)

	Short run		Long run
Direct	0.2169		0.4162
Indirect	0.0797		0.4472
Total	0.2966		0.8634

Table 4.2 indicates that the direct short run effect (0.2169) is slightly larger than $\hat{\beta} = 0.2168$, because the direct effect also includes feedback effects due to effects passing through other MSAs and back to the original MSA[20]. The short run indirect effect comes from the off-diagonal cells of the matrices of derivatives, and thus captures the spillover effect on employment in an MSA of a change to output in other MSAs. Adding the direct and indirect effects gives a total short run effect of 0.2966. Interestingly, the short run total effect is positive and less than one, not unlike the traditional Verdoorn coefficient $b \approx 0.5$, suggesting that productivity depends on output in line with the increasing returns hypothesis. The total long run effect resulting from a persistent increase in output and taking into account spillovers, is an elasticity[21] of 0.8634. This is closer to the value 1.0 consonant with constant returns to scale, but nevertheless the evidence here is that in the very long run, there remains some overall productivity gain as output increases.

4.6 Prediction and Generating a Counterfactual Employment Series

4.6.1 Methodology

The prediction methodology involves using the parameter estimates given in Table 4.1, which relate to the model set out as equation (4.4), in order to simulate counterfactual employment levels across the 377 MSAs. Equation (4.4) is repeated here, but as a recurrent equation in matrix format, as equation (4.11),

$$\ln y_t = G_N^{-1}\left[\gamma \ln y_{t-1} + \ln x_t \beta + B_N^{-1} u_t\right] \tag{4.11}$$

[20] See Elhorst (2014).

[21] This is equal to 0.8607 assuming exogeneity.

In which $G_N = (I_N - \rho_1 W_N)$ and $B_N = (I_N - \rho_2 M_N)$.

Following Chamberlain (1984), Sevestre and Trognon (1996) and Baltagi et al. (2014), the linear predictor is given by equation (4.12).

$$E[\ln y_t] = G_N^{-1}\left(\gamma E[\ln y_{t-1}] + \ln x_t \beta + B_N^{-1} E[\mu]\right) \tag{4.12}$$

$$\ln \hat{y}_t = \hat{G}_N^{-1}\left(\hat{\gamma} \ln \hat{y}_{t-1} + \ln \tilde{x}_t \hat{\beta} + \hat{B}_N^{-1} \hat{\mu}\right) \tag{4.13}$$

Equation (4.12) is the same as equation (4.11) but with expectations E[·], and this leads to equation (4.13) which gives the estimated expectations of (log) employment ($\ln y_t$) based on counterfactual levels of (log) output $(\ln \tilde{x}_t)$ and estimated parameters $(\hat{\gamma}, \hat{\beta}, \hat{\rho}_1, \hat{\rho}_2)$. The estimated expectations of the individual effects $\hat{\mu}$ are obtained from the residuals averaged over time, as described below.

In order to operationalise the prediction equation (4.13), estimates of the time-invariant individual effects μ are required. The approach adopted, as suggested by Fingleton (2014), is based on the residuals averaged over time, so that given

$$\ln y_t = \gamma \ln y_{t-1} + \rho_1 W_N \ln y_t + \ln x_t \beta + \varepsilon_t \tag{4.14}$$

then

$$\varepsilon_t = \ln y_t - \left(\gamma \ln y_{t-1} + \rho_1 W_N \ln y_t + \ln x_t \beta\right) \tag{4.15}$$

Also since $\varepsilon_t = B_N^{-1} u_t$ in which $u_t = \mu + v_t$, then

$$B_N^{-1} u_t = \ln y_t - \gamma \ln y_{t-1} - \rho_1 W_N \ln y_t - \ln x_t \beta \tag{4.16}$$

so that

$$\hat{\mu}^{(t)} = \hat{B}_N \left[\hat{G}_N \ln y_t - \hat{\gamma} \ln y_{t-1} - \ln x_t \hat{\beta} \right] - v_t \tag{4.17}$$

Assuming that $v_t \sim N\left(0, \hat{\sigma}_v^2\right)$ and drawing at random from this distribution, I take the mean over time of the $\hat{\mu}^{(t)}$'s to give the time-invariant quantity $\hat{\mu}$.

4.6.2 Generating the Counterfactual Series

Given equation (4.13), the counterfactual employment series ($\ln \hat{y}_t$) depends on the counterfactual output series ($\tilde{x}_t$). The 2008 economic crisis is treated as a common shock across all MSAs (though each MSA will have reacted differently), the counterfactual output series is based on the observed national change in output over the period 2008 to 2014, an assumption that is consistent with Martin et al. (2016). The underlying assumption made here is that output in a particular MSA would contract at the national rate during a recession and expand at the national rate during a recovery were it not for differences in industrial structure. This can be represented as:

$$\tilde{x}_{it+1} = (1 + g_{Nt+1})\tilde{x}_{it}$$

Where $\tilde{x}_{it+1}$ denotes counterfactual output for period t+1 for MSA i, g_{Nt+1} is the national growth rate of GDP from t to t+1, and $\tilde{x}_{it}$ is the value of output in time period t for region i. Note that $\tilde{x}_{it+1}$ depends on $x_{it}(t = 2007)$, the actual level of output in 2007. Subsequently, for all other $t > 2007$ $\tilde{x}_{it+1}$ depends on $\tilde{x}_{it}$. This gives a counterfactual level of output for each MSA assuming that the MSA output grew through the crisis at a rate identical to the national GDP growth rate. This is similar to the approach used by Martin et al. (2016), but this approach differs in that here the counterfactual is used, not to generate resilience indices per se, but to instead feed into the employment prediction equation (4.13).

4.7 MSA Resilience to the 2007 Economic Crisis

4.7.1 Measuring Elements of Resilience

I focus on two elements of resilience; resistance and recovery (Martin et al., 2016; Martin, 2010; Palaskas et al., 2015). Resistance is the ability of a regional economy to resist the initial impact of the crisis; recovery is the ability to recover following the shock (Han and Goetz, 2013).

Following, broadly, Han and Goetz (2013) and Martin et al. (2016), resistance and recovery are defined here by equations (4.18) and (4.19) respectively.

$$Resis_i = \frac{(\Delta y_i^c) - (\Delta \hat{y}_i^c)}{E_i^{2007}} \tag{4.18}$$

$$Recov_i = \frac{(\Delta y_i^r) - (\Delta \hat{y}_i^r)}{E_i^{2007}} \tag{4.19}$$

In (4.18), Δy_i^c is the change in employment in region i during the contraction period of the economic crisis, and in (4.19) Δy_i^r is employment change in region i during the post-crisis recovery period. In contrast to these actual employment changes, $\Delta \hat{y}_i^c$ is the counterfactual employment change during contraction, and $\Delta \hat{y}_i^r$ is the counterfactual change during recovery. Differences between actual and counterfactual are scaled by 2007 employment level E_i^{2007}. For both $Resis$ and $Recov$, a zero value indicates that employment changed in line with the counterfactual (based on the national change), a negative value shows relatively weak resistance/recovery and a positive value indicates stronger resistance/recovery relative to the national performance.

4.7.2 Testing the industrial structure hypothesis

To explain inter-MSA variation in $Resis$ and $Recov$, three industry structure variables are calculated; a Krugman dissimilarity index (4.20), a Herfindal index (4.21), and a Lilien index (4.22) of structural change, each of which is based on MSA employment across 13 different sectors, data provided by the American Community Survey[22].

$$D_{i,2007} = \sum_j \left| \left(\frac{y_{ij,2007}}{y_{i,2007}} \right) - \left(\frac{y_{Nj,2007}}{y_{N,2007}} \right) \right| \tag{4.20}$$

[22] Data on employment in MSAs by sector are only available from 2005 to 2014 so when constructing the indices I are restricted to this time period. Also, data are only available from the American Community Survey on sectoral employment for 340 of the 377 MSAs. Therefore, the empirical analysis in this section is constrained to an analysis of these 340 MSAs.

$$Her_{i,2007} = \sum_j \left(\frac{y_{ij,2007}}{y_{i,2007}}\right)^2 \qquad (4.21)$$

$$Lilien_{i,t} = \left[\sum_j \left(\frac{y_{ijt}}{y_{it}}\right)\left(\Delta log y_{ijt} - \Delta log y_{it}\right)^2\right]^{1/2} \qquad (4.22)$$

In equations (4.20), and (4.21) , i refers to MSA i in 2007. Also $y_{ij,2007}$ is MSA i's industry j employment level, $y_{i,2007}$ is total employment, $y_{Nj,2007}$ is total industry j employment in all MSAs, and $y_{N,2007}$ is total employment in all MSAs.

The Krugman index $D_{i,2007}$, measuring industrial structure dissimilarity, ranges from zero to two, with zero indicating that MSA i's industrial structure is identical to the national industrial structure and two indicating maximum dissimilarity (Goschin et al., 2009; Egeraat et al., 2016). The Herfindal index $Her_{i,2007}$ measures concentration in a particular industry. The higher the index, the more specialised is an MSA (Egeraat et al., 2016). The $Lilien_{i,t}$ index measures shifts in industrial employment over a given time period (Goschin et al., 2009; Martin et al., 2016). For this two time periods are defined, the recession (2008-2009) and the recovery (2009-2014).

Given that the indices $D_{i,2007}$ and $Her_{i,2007}$ measure specialisation just prior to the onset of the crisis, the hypothesis is that an MSA's specialization pre-crisis had an effect on its in-crisis resistance and post-crisis recovery. For the $Lilien_{it}$ index, which measures within-crisis (2007-2009) and post-crisis (2009-2014), this explores whether contemporaneous structural change had an effect on an MSA's resistance and recovery.

Subsequent analysis treats $Resis$ and $Recov$, referred to collectively as $R_i, i = 1,...n.$, as the dependent variables in regression models in which the Krugman, Herfindal and Lilien indices are the causal variables of principal interest. However it is also necessary to control for a number of covariates so as to eliminate omitted variable bias. For the Krugman, and Herfindal indices, since they are based on 2007 data, it can reasonably be assumed they are exogenous, and thus cause subsequent changes in R_i, in which case OLS estimation should give unbiased estimates. However, endogeneity is built in *ab initio* into the Lilien index since it is calculated using data from the within-crisis and post-crisis periods respectively, so there is a possibility of resistance and recovery both being affected by, and affecting, structural change. This two-way interaction between structure and employment response is to be anticipated given the earlier discussion of adaptive resilience. To allow for potential endogeneity instrumental variables are applied.

Four instrumental variables are employed. Firstly, a spatial lag of the $Lilien_{i,t}$ variable is included. Secondly Bartlett's three group method is employed. In this, given an endogenous variable of dimension n, its instrument is formed by dividing the variable into three categories. The $n/3$ smallest values are set to -1, the $n/3$ largest are set to 1 and the $n/3$ middle values are set to zero (Johnson, 1984; Kennedy, 2008). The assumption is that while the resulting instrument will be correlated with the endogenous variable, it will be independent of the error term, as required for consistent estimation[23]. A third instrument is provided by the spatial lag of Bartlett's three groups. The fourth instrument used is the synthetic instrument proposed by Le Gallo and Paez (2013). This is based on a contiguity matrix, but since MSAs are on the whole non-contiguous, I treat an MSA's three nearest neighbours to be contiguous with the MSA. I follow Le Gallo and Paez (2013) in creating a synthetic instrument for the Lilien index by first obtaining the eigenvectors of the contiguity matrix. Then eignvectors are regressed on the Lilien index and the significant eigenvectors are retained and summed to create an exogenous instrument (each significant eignvector is weighted according to the estimated regression coefficient). Utilising these instruments means that it is possible to treat the regression coefficient relating to the Lilien index, when estimated by IV, as estimates of the change in R_i caused by a unit change in this explanatory variable.

Additional regressors [see also Han and Goetz, (2013)] are introduced to avoid omitted variable bias, bias which may come about if the industrial structure indices also capture the impact of correlated variables not included explicitly in a regression specification. Consequently I control

[23] The method was initially designed to address measurement error in a regressor but has been found useful, given the paucity of external instrumental variables, to control for other sources of endogeneity (Fingleton, 2003; Artis et al., 2012; Le Gallo and Paez, 2013). However, as noted by Le Gallo and Páez (2013) "the properties of this type of instrument are investigated in Fingleton and Le Gallo (2008a; 2008b; 2009). By construction, this instrument is correlated with the endogenous variable". Therefore, the use of Bartlett's three group method does not remove the problem but reduces it.

for population density, educational attainment, sectoral composition, and the Region[24] of the US in which the MSA is located to give the model

$$R_i = \beta_0 + \beta_1 D_{i,2007} + \beta_2 Her_{i,2007} + \beta_3 Lilien_{it} + covariates + \varepsilon_i \qquad (4.23)$$

In (4.23), R_i denotes either $Resis_i$ or $Recov_i$ for MSA i, the βs are the regression coefficients, $D_{i,2007}$ is the Krugman dissimilarity index for 2007, $Her_{i,2007}$ is the Herfindal concentration index, and $Lilien_{it}$ denotes structural change for the time periods t =2007-2009 for $Resis_i$ and t = 2009-2014 for $Recov_i$. The error term ε_i represents additional unobserved effects, distributed as $iid(0,\sigma^2)$ in which σ^2 denotes constant error variance. Equation (4.23) is estimated via instrumental variables (IV). In contrast to $Lilien_{it}$, population density, educational attainment (the proportion of those aged over 24 with a third level degree), sectoral composition and region relate to the year 2007, and so are treated as exogenous.

Table 4.5 gives the IV estimates of equation (4.23). To save space in the main body of this document I omit the parameter estimates of the 22 covariates (see Appendix Tables A4.1 and A4.2 for these), which are of limited interest, but I do show the overall significance of the covariates by adding them sequentially in blocks, namely demographics (population density and educational attainment), sectors (12 sector variables), and regions (8 region dummy variables), and find they are all jointly significant at the 95% level (at least) for both $Resis_i$ and $Recov_i$. To support these inferences, I show instrument relevance (i.e. the extent of correlation of the IVs with $Lilien_{it}$) and instrument exogeneity (i.e. their lack of correlation with the errors). Following Stock et al. (2002) instrument relevance is indicated via F statistics greater than 10. Given overidentification, because I have four instruments, instrument exogeneity for the group is shown to exist using Hansen's (1982) J statistic[25]. In the Appendix I test each instrumental variable separately to identify individual relevance, showing that the

[24] Regional dummies based on the US Census Bureau Regions and Divisions which indicate whether an MSA is in the broadly defined regions of New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, or Pacific.

[25] The null hypothesis of the test is that the instruments are uncorrelated with the error term, while the alternative is that at least one of the instruments is correlated with the error term. In this case, as both p-values are greater than 0.1, the null hypothesis cannot be rejected.

most relevant instrument is Bartlett's three group method followed by the Le Gallo and Paez (2013) synthetic instrument.

Table 4.5 indicates that the Krugman index and the Herfindahl index both have a negative effect on resistance, indicating that specialization increases susceptibility to shocks. In contrast post-crisis, specialisation appears to positively aid recoverability. Also the significant positive effect of the Lilien index suggests that shifts in industrial employment following a shock have a beneficial effect on post-shock recovery. This may reflect MSAs reorienting themselves away from impacted sectors to sectors which were not impacted by the crisis.

With regard to the control variables, the estimates indicate that MSAs with a higher percentage of the population with Bachelor degrees, or higher, are better able to resist and recover following the crisis. This points to the importance of an educated workforce, *ceteris paribus*, in improving an MSA's resilience. Salient among several significant sectoral composition and regional dummy effects, I find that MSAs with a higher proportion of construction employment were less able to resist the crisis, and MSAs more specialised in manufacturing were both less able to resist and also less able to recover.

The robustness of the Table 4.5 inferences is predicated on error distribution assumptions. Figure 4.2 shows approximately normality for both $Resis$ and $Recov$ regression residuals, but Figure 4.3 highlights potentially influential outliers, although when excluded, as in the Table 4.6 estimates, the results are broadly consistent with Table 4.5. The key industrial structure variables remain significant and appropriately signed.

To allow for the possible presence of error dependence among the residuals, I also estimate the model with the same specification as the Table 4.5 model but also with an additional spatial autoregressive error term. Following Arraiz et al. (2010) and Drukker et al. (2013), via the use of instrumental variables and GMM, I obtain similar estimates to those of Table 4.5 and 4.6, with no evidence of significant residual autocorrelation.

As a further robustness test, with the results presented in Appendix Table A4.3, I also re-estimate the recovery equation in Table 4.5 with the resistance index included as an additional explanatory variable. This is done as it is possible that the resistance of regions may impact their ability to recover. It may be that regions which were relatively resistant to the crisis may recovery more strongly or that regions which were most negatively affected during the resistance phase may experience a stronger bounce back during recovery. Alternatively, it may also be that those regions which experience the strongest negative effect during the resistance phase may be the regions which experience the strongest degree of re-orientation of their industry structure, thus necessitating the inclusion of this resistance index in addition to the industry structure variables included in the model. However, when the resistance index in included in the recovery equation the sign and significant of the industry variables (the key variables of interest) remain unchanged and the variable itself is insignificant. Indeed the magnitude of the other variables of interest in the model are also relatively unchanged. This suggests that the model is robust to alternative specifications which include the resistance index within the estimation of the recovery equation. The full results of this estimation are presented in Appendix 4.3.

To summarize, the regression estimates show that a more specialised MSA is less resistant to shocks than a diverse MSA, and that, post-crisis, specialisation appears to positively impact an MSA's recoverability. Also, the significant positive impact of structural change suggests that the reorientation of industrial structure following a shock aids post-shock recoverability.

Table 4.5: Industry Structure Controls and Resistance and Recovery

VARIABLES	Resistance	Recovery
Lilen 2007-09	-0.278	
	(0.325)	
Lilen 2009-14		0.495*
		(0.278)
Krugman D-Index	-0.0770**	0.0865**
	(0.0308)	(0.0407)
Herfindahl Index	-0.00344**	0.00508***
	(0.00165)	(0.00171)
22 additional variables plus constant	l.i.	l.i.
Observations	341	341
R-squared	0.338	0.398
F-test (Demographics)	5.99**	10.95***
F-test (Industry)	32.45***	91.44***
F-test (Region)	57.41***	31.49***
Hansen's J Statistic (p-value)	0.7751	0.1226
F Statistics of First Stage IVs	73.5939	48.9425

l.i. denotes of limited interest
Note 1: Robust standard errors in parentheses
Note 2: *** p<0.01, ** p<0.05, * p<0.1
Note 3: Hansen's (1982) J statistic chi-squared test is reported. A statistically significant test statistic always indicates that the instruments may not be valid.
Note 4: Following Stock et al. (2002) instrument relevance is indicated via F statistics greater than 10.

Figure 4.2: Residuals of IV Regression Model

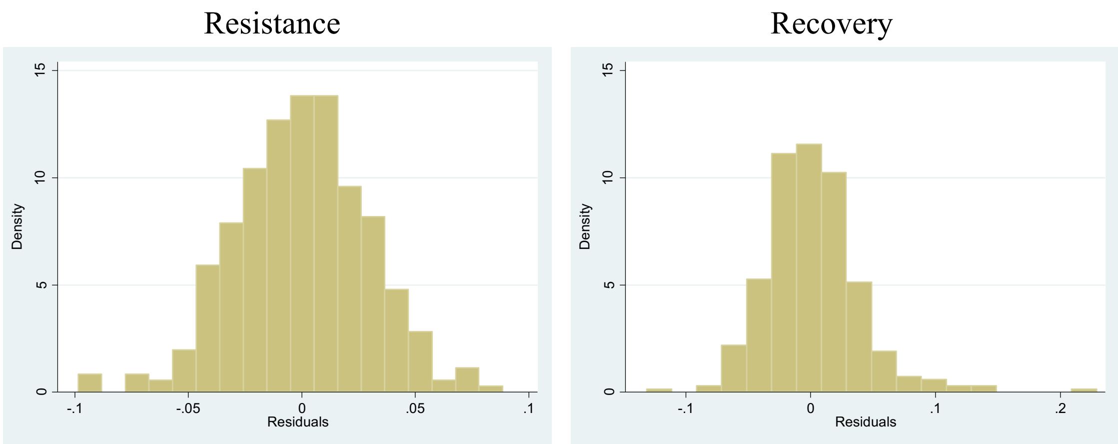


Figure 4.3: Box Plot of residuals to identify outliers

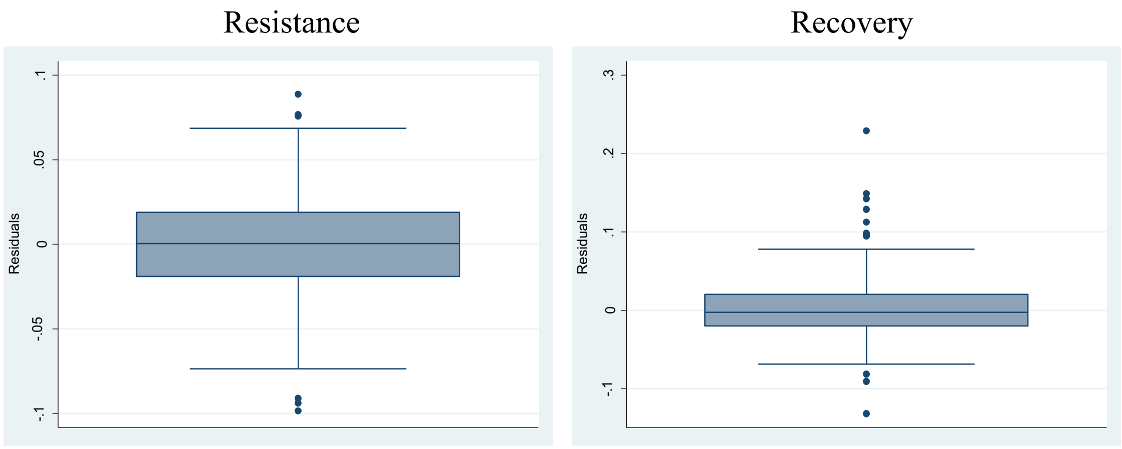


Table 4.6: IV Regression of Resistance and Recovery (with outliers trimmed)

VARIABLES	Resistance	Recovery
Lilen 2007-09	-0.383	
	(0.314)	
Lilen 2009-14		0.474*
		(0.255)
Krugman D-Index	-0.0650**	0.0960**
	(0.0297)	(0.0400)
Herfindahl Index	-0.00388**	0.00444***
	(0.00161)	(0.00162)
22 additional variables plus constant	l.i.	l.i.
Observations	336	331
R-squared	0.3504	0.4102
F-test (Demographics)	8.93**	17.64***
F-test (Industry)	34.25***	111.80***
F-test (Region)	58.27***	42.08***
Hansen's J Statistic (p-value)	0.9203	0.1483
F Statistics of First Stage IVs	72.2237	47.1242

l.i. denotes of limited interest
Note 1: Robust standard errors in parentheses
Note 2: *** p<0.01, ** p<0.05, * p<0.1
Note 3: Hansen's (1982) J statistic chi-squared test is reported. A statistically significant test statistic always indicates that the instruments may not be valid.
Note 4: Following Stock et al. (2002) instrument relevance is indicated via F statistics greater than 10.

4.8 Conclusions

This Chapter studies the effect of economic structure on the resilience of US MSAs to the 2007 economic crisis, and in doing so is one of a growing but small number of studies which analyse resilience at a city, rather than country or regional, level [for an example of a city levels analysis see Wrigley and Dolega (2011)]. In doing so I find that MSAs which were more specialised were more adversely affected by the crisis and less able to resist it. But during the recovery phase post-crisis I find evidence that being specialised positively affected recovery. In addition, structural change during the recovery period also had a positive effect on recovery.

These interpretations are however provisional and are open to revision as longer series become available for analysis. In addition it would be useful to look retrospectively at earlier recessions to see if more evidence could be gained regarding the determinants of resilience, taking account also of the type, strength and duration of that shock. Such past example would be major events such as the 1861–63 Cotton Famine, which had a major adverse impact on the towns of the Lancashire cotton district, the great stock market crash of 1929, and indeed the two World wars of 1914 and 1939, each having its own particular consequences for local, regional, national and global economies.

Chapter 5: Individual Level Wage Resilience to the 2008 Economic Crisis

5.1 Introduction

There has been considerable attention paid to the impact of shocks on both regional and national economies, with a number of alternative approaches adopted. These include case studies, the generation of indices, time series analysis and causal economic models, with the focus being on national, regional or city economies (Ormerod, 2010; Foster, 2007; Fingleton et al., 2012). The typology of resilience studies is discussed in detail in Martin and Sunley (2014), however, to date there has been little if any work on resilience which uses the individual as the unit of analysis. In this Chapter I focus on the impact of the 2008 economic crisis on individual wages in the US.

This Chapter is motivated by the recent interest in the concept of the resilience, and specifically the resilience of wages, to shocks at regional levels (Fingleton and Palombi, 2013) as well as by the recent application of regional wage models to micro-data series (Fingleton and Longhi, 2013; Hering and Poncet, 2010). This Chapter combines these two strands of the literature on wages (resilience and regional wage models) to analyse the resilience of individual level wages to economic shocks.

The starting point of the Chapter is a model of wages at the individual level, while also incorporating determinants of wages measured at the aggregate (areal) level, over the period 2005 to 2007. Specifically, I estimate a model of individual wages, incorporating individual specific characteristics [*à la* Mincer (1974)] and areal factors [market potential and employment density which, under New Economic Geography (NEG) and Urban Economic (UE) theory respectively, should also determine wage levels]. This model is estimated using data from the American Community Survey 2005 to 2007 which is an annual survey conducted by the US Census Bureau and is the largest individual survey they conduct with the exception of the census (as noted in the previous Chapter, this data is only available from 2005 onwards). These individual level data are combined with the Public Use Microdata Area (PUMA) data, which are at the lowest level of spatial disaggregation available[26]. The acronym PUMA is used throughout the Chapter to refer to data at this level of aggregation. The focus on the individual level helps allay possible self-selection problems associated with aggregate regional level analysis, such that high wages, which typically occur in cities, may simply be attributable to

[26] There are about 2,100 PUMAs compared with approximately 3,100 counties and county equivalents in the USA.

highly productive and qualified mobile individuals choosing to work in cities, rather than any inherent benefits imparted by a city location per se. Thus, working at the individual level it should be possible to moderate the wage-premium commonly associated with city locations, by controlling for individual level variables that also have an impact on wages, thus taking account of self-selection.

Having estimated the wage equations, the Chapter then combines the estimated model parameters with projected values of the variables driving wage levels through the period of the recession, with projected values obtained on the basis of assumptions about the trajectory of the drivers under a no-recession counterfactual. Given wage levels thus obtained under the counterfactual, the Chapter explores how the recession has affected individual wage levels differently, according to gender, education, social and economic status and age, seeking to determine which, if any, individual characteristics convey resilience, and examines the significance of market potential and employment density.

The structure of the Chapter is as follows. Section 5.2 provides a brief review of the related resilience literature (which was discussed in detail in Chapter 3), putting the current Chapter in context. Section 5.3 outlines the theoretical background to the analysis including Mincer's (1974) wage equation, which is specific to the individual, and the PUMA-level indicators; market potential derived from NEG theory and employment density derived from UE theory. The empirical approach employed, together with how the counterfactual estimates for resilience are obtained, are outlined in Section 5.4. Section 5.5 describes the data used in the Chapter. Section 5.6 gives model estimates, Section 5.7 describes geographical patterns of resilience, Section 5.8 discusses resilience at the individual level and Section 5.9 concludes.

5.2 Resilience to Shocks

The responses of national and regional economies to economic shocks has long been a focus of analysis with increased interest in the topic of resilience following the 2008 economic crisis (Martin, 2012; Friedman, 1964; Romer, 2001; Fingleton et al., 2012). The focus of the recent resilience literature has been on the impact of shocks, be they economic or some other form, on the growth path of regions and nations (Simmie and Martin, 2010). Indeed the central question is often whether temporary shocks result in a permanent or temporary effect[27] on either GDP or employment within a region (Cross et al., 2009; Grinfeld et al., 2009).

Analysis of the effects of economic shocks has been enhanced by consideration of the observed growth path of the economy through recession in relation to what would have otherwise happened, and various modelling strategies have been adopted in order to create the necessary counterfactual series. In Chapter 3 [published as Doran and Fingleton (2018)] I obtain counterfactual productivity predictions for EU countries on the basis of vector error correction models. Fingleton et al. (2014) develop counterfactuals for employment levels and growth across EU regions based on spatial panel models. Similarly, Fingleton and Palombi (2013) use spatial panel models to measure resilience in the context of counterfactual wage series, in their case wages paid in British cities in the Victorian era. They note that shocks appear to have a permanent effect on wage levels, but that industrial structure and other factors may convey resilience to city economies. In this Chapter I also focus on the resilience of wages, but rather than using city or regional averages I am fortunate to have wage data and covariates at the individual level. This microlevel analysis is the main contribution of the Chapter, since to my knowledge all previous geographically-oriented empirical work on resilience has been at an aggregate level and thus does not consider potentially resilience inducing individual-level factors.

When considering resilience to shocks Martin (2012) notes that there are four elements to resilience (i) resistance, (ii) recovery, (iii) re-orientation and (iv) renewal. While each of these four elements of resilience are important, given the time frame of this Chapter I am focusing on the resistance of wages to the 2008 economic crisis and the extent to which wages recovered towards pre-2008 levels by 2011 (the most recent data available at the time this Chapter was written).

5.3 The Determinants of Individual Wages

The empirical analysis of the impact of the 2008 economic shock is based on a model of the determinants of individual wages which naturally divide into two groups, firstly individual specific factors and secondly PUMA-level factors. In order to identify individual specific factors I appeal to Mincer's (1974) wage equation, which has a long established literature

[27] This temporary versus permanent debate relates closely to the concept of hysteresis, as discussed for example by Romer (2001) and Blanchard and Summers (1987).

describing the positive impact of human capital on wages (Heckman et al., 2003). At the regional level, I appeal to New Economic Geography (NEG) and Urban Economics (UE) theory, which suggest that regions or cities with high levels of market potential or employment density will tend to have higher levels of wages. Each of these respective models are fully detailed and derived in Ciccone and Hall (1996) and Fujita et al. (1999) and has been discussed in detail in Chapter 2.

5.3.1 Mincer's Wage Equation

As noted by Lemieux (2006) the most widely used form of the seminal Mincer (1958; 1974) wage equation relates log earnings to years of education and experience[28]. More precisely, the model captures the impact of human capital investment on income returns, with schooling an equilibrium outcome as a result of investing in education in order to maximise the present value of income. The experience element of the model captures the subsequent development of human capital post-schooling. This type of specification has become so well established that it has been referred to as a "cornerstone of empirical economics" (Heckman et al. (2003: pp 1). However, as noted in Lemieux (2006), it has now become standard to not just include schooling and experience in the wage equation, but also a variety of other individual specific factors which may impact on wages (Fingleton and Longhi, 2013).

In additional to individual factors the approach adapted in this Chapter is to build an empirical model that captures two important regional-level influences on wages. This is consistent with Fingleton and Longhi (2013) and Hering and Poncet (2010). One is market potential, which provides an indication of a region's centrality with respect to supply of and demand for the region's goods and services. The benefits of locating where there is good market access means that firms are able to offer higher nominal wages to workers in certain locations, thus providing part of the explanation of why wage levels vary spatially. The rationale for this is NEG theory, although I do not explicitly summarise this here as it is widely available in the standard literature (Fujita et al, 1999) and has been outlined in detail in Chapter 2. The basic relationship coming from this theory, which is one of a set of simultaneous equations associated with the short-run equilibrium prior to labour mobility with respect to real wage differentials, is

[28] The exact functional form for these independent variables is discussed extensively in Heckman et al. (2003).

$$\ln w_i = \frac{1}{\sigma} \ln P_i \qquad (5.1)$$

Where w_i is nominal wage at location i, P_i denotes market potential at i, and σ is a scalar parameter.

However, NEG theory on its own has had only limited success in explaining the granularity of localised wage differences (Fingleton, 2011), and therefore the model is enhanced to try to pick up specific city-oriented rather than region-oriented effects. For this component of the model I appeal to Urban Economics theory, but I do not set this out explicitly instead I simply make use of the main result coming from this branch of economics that wages are a function of employment density. In other words there are specific advantages accruing to dense cities because of the complex variety of services available locally in cities that enhance productivity proportional to city density, leading to a reduced form involving employment density, with consequences for wage levels. The detailed theoretical and empirical rationale for this relationship between wages and density can be found in the literature, most notably Cicconne and Hall (1996), Abdel-Rahman and Fujita (1990), and Rivera-Batiz (1988) and has been discussed and outlined in Chapter 2. For the purposes of this Chapter I simply make use of the reduced form in loglinear terms, which is

$$\ln(w) = \gamma + \phi \ln(E) \qquad (5.2)$$

In which E denotes employment per square mile (or km) and γ and ϕ are scalar parameters.

5.4 Empirical Approach

5.4.1 Model Specification and Estimation Approach

The approach used in this Chapter combines the two separate explanations of wage variation (coming from NEG and UE theory) at the aggregate PUMA level as a single, hybrid model. Typically such models have been designed to allow a decision to be made regarding the relative veracity of these two rival non-nested models (Fingleton, 2006), but here I strive to maximise explanatory power so as to create optimal counterfactual predictions by incorporating effects consistent with both theories, each of which has something to contribute to the understanding of wage variations at the aggregate level. I could opt to reduce the model to one or other theory-consistent specification if inferential rules allow but, as shown below, in this case both theories carry significant information with regard to the determinants of wage levels.

Therefore, the econometric model is specified based on a Mincer's style wage equation incorporating variables at the individual level augmented by the PUMA-level indicators of market potential and employment density. The Mincerian element of the econometric specification relates individual wages to individual specific characteristics such as education, gender and sector of employment. The regional variables capture the impact of the individual's location on his or her level of wages. The model combining individual and areal effects is given in equation (5.3),

$$\ln w_{it} = \alpha + X_{it}\beta + \frac{1}{\sigma}\ln P_{rt} + \phi \ln E_{rt} + \mu_s + \mu_t + \mu_{it} \tag{5.3}$$

In which $\ln w_{it}$ is the log of wages of individual *i* in time period *t*, α is a constant term, X_{it} is a matrix of variables representing the characteristics of individual *i* including age, age^2, education, marital status and gender, among others and β is the associated vector of coefficients. $\ln P_{rt}$ and $\ln E_{rt}$ are vectors containing measures of market potential and employment density for PUMA *r* in time period *t* and σ and ϕ are the associated coefficients. Additionally sets of dummy variables capturing unobserved variation across States and across time are included. Thus μ_s is a vector of state fixed effects where *s*=1…*K* states[29] and μ_t is a matrix of year fixed effects where *t*=2005 to 2007. Also μ_{it} is the individual specific error term for person *i* in time period *t*. This approach is similar to that of Dalmazzo and de Blasio (2007b; 2007a), Di Addario and Patacchini (2008) and Bratti and Leombruni (2009). Note that, consistent with this literature, as I do not have true panel data I do not have individual level fixed effects. As noted by Canton (2009) it is likely that μ_{it} is correlated within areas as area-specific elements may be impacting on all the people within that area. Therefore, to allow for intra-PUMA correlation I cluster the errors according to PUMA which generates appropriate standard errors[30].

[29] These take the form of a series of dummy variables representing state 2 to *K* (with State 1 is the base state).

[30] With positive intra-PUMA dependence, not allowing for this will result in smaller standard errors than otherwise and hence larger t-ratios, leading to a higher than nominal proportion of Type I errors.

When estimating equation (5.3) potential problems that could arise given the possibility of high levels of multicollinearity and which might result from endogeneity must be considered. When considering multicollinearity I calculate the variance inflation factor (VIF) and ensure the value is below 10 for all variables present in the model (Kutner et al., 2004). This allows for confidence in the estimates and inferences and ensures that they are not affected by bias induced through unduly excessive collinearity among the explanatory variables.

I also control for endogeneity in the estimation of equation (5.3), which could occur if there is simultaneity or omitted variable(s) causing the error term to be correlated with the explanatory variables. Simultaneity may occur if high wages increase market potential (since wages will determine income which is a determinant of market potential), and there may be sorting of highly skilled, high income workers into network-rich (Venables, 2011) and high amenity urban locations. Also shock-induced worker migration to high wage locations will tend to reinforce the centrality of cities and city regions so that there is reverse causality involving wages and both market potential and employment density. In an attempt to counter these possible sources of endogeneity, and given the difficulties of finding instruments that are highly correlated with the endogenous variables and yet at the same time independent of the errors, I resort to the use of internal instruments via the application of Bartlett's three group method (initially introduced in the context of endogeneity caused by measurement error) in order to provide instruments for market potential and employment density. Bartlett's (1949) three group method simply divides the endogenous variable into three categories based on the size of the variable. The n/3 smallest are set to -1, the n/3 largest are set to 1 and the n/3 middle values are set to zero (Johnson, 1984; Kennedy, 2008). The process was initially designed to address measurement error but can be applied in the context of endogenous regressors (Fingleton, 2003; Artis et al., 2012; Le Gallo and Paez, 2013). On a note of caution, Fingleton and Le Gallo (2007) show that three-group instruments are typically pseudo-instruments rather than true instruments, in that if they are based on an endogenous variable an element of correlation with the errors will be retained, and so while they will tend to reduce endogeneity-induced bias, they may not eliminate it totally. It turns out that the positive link between wages and employment density, and between wages and market potential, remains in force given the application of instrumental variables, and controlling for the individual level factors. Such a finding is not inconsistent with previous literature.

5.4.2 Generating Counterfactual Wage Series

Counterfactual values for wages of individual *i* are generated using the following equation:

$$\ln \hat{w}_{i2011} = \hat{\alpha} + X_{i2011}\hat{\beta} + \frac{1}{\hat{\sigma}} \ln P_{r2011} + \hat{\phi} \ln E_{r2011} + \hat{\mu}_s + \hat{\mu}_{2007} \tag{5.4}$$

In (4), $\hat{\bullet}$ indicates estimates resulting from fitting equation (5.3) for data covering the period 2005-2007. As is evident in (5.4), I predict wage levels for the year 2011 using the assumed 2011 values for the individual variables denoted by X_{it} and projected 2011 values for log market potential ($\ln P_{rt}$) and log employment density ($\ln E_{rt}$). I also use the estimated state level dummy coefficients to control for state specific effects. Additionally, using the year 2007 dummy controls for the time trend, thus eliminating inflation over the period 2007-11.

Given counterfactual wages, it is now possible to assess the resilience of individuals to the crisis based on the difference between $\ln w_{i2011}$ (the actual 2011 wages) and $\ln \hat{w}_{i2011}$.[31] This then allows for the examination of possible differences in resilience across areas or with respect to individuals' characteristics, such as gender, age and education in order to see whether individual characteristics convey resilience.

5.4.3 Generating Counterfactual Independent Variables

In order to generate counterfactual forecasts for individual resilience it is necessary to acquire a series of counterfactual input series, *X*, *P* and *E*, for the model. Obtaining these input series is relatively straightforward for the individual level variables *X* as it is possible to simply utilise the 2011 indicators for education, gender etc. A necessary assumption, due to the pseudo panel nature of the data which does not allow for the tracking of individuals across time, is that these X variables have not been affected by the economic crisis, in other words the observed individual variables are assumed to be the same as what one would observe under the no-crisis counterfactual. While ideally, if true panel data had been available and it were possible to track the same individuals over time it would be possible to assess whether there had been changes in individual conditions over the crisis period. For instance, it would be possible to assess whether people had left or joined a union or had gone back to education. If it were possible to do this then a more robust analysis of changes over time could be accomplished. It is possible that to some extent these independent variables may be endogenous to the shock, in that the impact of the shock may have resulted in individuals changing their behaviour (e.g. education, union membership, etc.) and therefore these variables may, to a certain extent be endogenous.

[31] Note that I adjust the actual wage levels to 2007 price levels.

Again, true panel data could overcome this issue as the pre-crisis values of these variables could be taken ensuring their exogeneity. However, in the case of this paper, as is emphasised earlier, true panel data is not available and I rely on a pseudo-panel. While this has its limitations, and may result in the model suffering from the afore mentioned potential endogeneity, it is not possible to control for this effect with a pseudo-panel. Therefore, in this instance an assumption must be made that the variables are exogenous and that the shock will not have resulted in individuals changing their behaviour. Given the time frame between the crisis and the resilience analysis is only three years this may alleviate this potential endogeneity bias as individuals can not reasonably be expected to have significantly changed their educational qualifications etc. within this short period of time. However, it is necessary to bear this limitation in mind when considering the discussion of the empirical results.

The main issue arises when considering the PUMA-level variables; market potential and employment density. Both of these have changed substantially over the crisis period. Therefore, it is necessary to generate a no-recession counterfactual for these two variables. One way to do this is to simply carry forward the levels of employment density and market potential from 2007. This would essentially assume that these variables would not have changed between 2007 and 2011. However, this assumption may be unrealistic so I generate a no-recession counterfactual for employment density and market potential resulting from applying the average annual rate of growth of these variables from 2005 to 2007, compounded to 2011. This assumes that growth would have continued at pre-crisis levels had the 2008 economic crisis not occurred.

5.4.4 Measures of Resilience

In order to analyse the resilience of individuals I construct a measure of resilience, namely proportional resilience. In fact there are two interrelated resilience measures. The first is absolute resilience which is simply the difference between actual and counterfactual wages (R_A) at the end of the period of analysis (2011). The second, proportional resilience (R_P) is absolute resilience scaled by actual wages (in 2011), as shown by equation (5.5),

$$R_P = \frac{R_A}{\text{Actual Wages}_{2011}} \tag{5.5}$$

Proportional resilience thus scales absolute resilience such that a given wage difference will have a bigger proportional impact on the poor than on the rich. This approach is preferred to absolute resilience because it is possible that a higher income will by itself impart resilience to a shock and in controlling for the effect of wage level it is possible to obtain a more appropriate measure of resilience. Negative values indicate that an individual has wages below the counterfactual wage level and the more negative the value the less resilient an individual is to the shock.

It is possible to calculate proportional resilience for each individual in the sample and this resilience indicator by individual then becomes the dependent variable in a subsequent model, where I endeavour to measure the impact of variables such as the age or the educational attainment of individuals on this individual-level resilience measure. Likewise it is possible to measure PUMA-level proportional resilience by simply averaging the proportional resilience of all individuals resident in a given PUMA. This gives approximately 2,100 such incidences of proportional resilience, one for each area. The result is a set of PUMA-level proportional resilience measures and this is the dependent variable in the PUMA-level model.

5.4.5 Factors Determining Resilience

Once the resilience indexes are calculated the proportional resilience measure can be used, at the level of the individual or at the area (PUMA) level, as a variable to be explained. Initially, at the PUMA-level, PUMA-level factors are considered such as industry structure and aggregate educational attainment measures as explanatory factors for PUMA level resilience. This allows for a determination of whether the industrial structure of the economy can convey resilience to an area while also controlling for educational levels in the area as well as age structure. This is captured in equation (5.6)

$$R_{P\,rt} = \alpha + Z_{rt}\beta + \frac{1}{\sigma}\ln P_{rt} + \phi \ln E_{rt} + \mu_s + \mu_{rt} \tag{5.6}$$

where $R_{P\,rt}$ is the proportional resilience of PUMA r in time period t and Z_{rt} is a matrix of PUMA-level variables controlling for the proportion of employees in a range of sectors (listed in Table 5.3), the proportion of individuals over the age of 20 by educational category, and the proportion of individuals in each age category in the PUMA. Also in equation (5.6), proportional resilience by PUMA depends on log market potential ($\ln P_{rt}$), log employment density ($\ln E_{rt}$), state fixed effects (μ_S) and unmodelled residual effects (μ_{rt}). The terms α, σ and ϕ are scalar parameters to be estimated and β is a vector of coefficients to be estimated.

At the individual level I use individual-specific proportional resilience as the dependent variable as in equation (5.7)

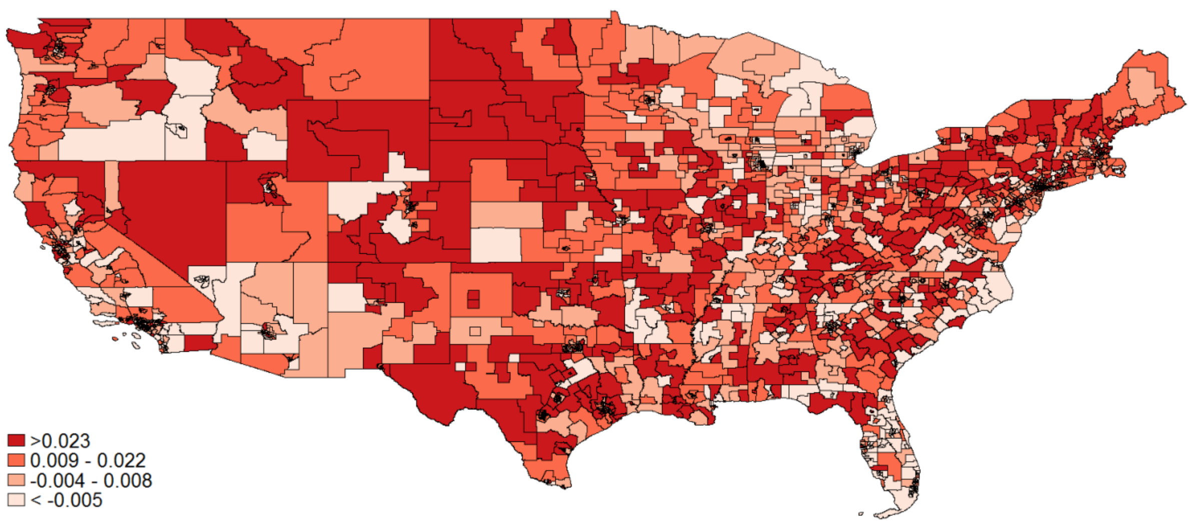
$$R_{P_{it}} = \alpha + X_{it}\beta + \frac{1}{\sigma}\ln P_{rt} + \phi \ln E_{rt} + \mu_s + \mu_{it} \tag{5.7}$$

in which $R_{P_{it}}$ is the proportional resilience of person *i* in time period *t* where *t* is 2011 and the matrix X contains individual-specific variables. This is similar to equation (5.3) except that rather than explaining wages here I am attempting to explain resilience.

5.5 Data

In this Chapter I am interested in exploring the impact of the 2008 economic crisis on individual level wages in the US. To contextualise this analysis Figure 5.1 shows the change in the log of wages per employee from 2007 to 2011 at the PUMA level of aggregation. It is possible to see that while some PUMAs (with dark shading) have experienced positive growth in average wage levels, others (with lighter shading) have experienced decreases in average wages. In this Chapter I ask what would wages have looked like had the crisis not occurred and compare the observed wages in 2011 with counterfactual predictions obtained under a no-recession counterfactual. Essentially I am concerned with examining whether, by 2011, wages had been depressed by the crisis to a level below their counterfactual level or whether they had proven resilient (i.e. actual wages had rebounded to their counterfactual level or had not been impacted by the crisis). If they have been resilient, I ask what factors contributed to that resilience.

Figure 5.1: Change in Log Wages per Employee 2007-2011



The data used are derived from The Integrated Public Use Microdata Series (IPUMS-USA); specifically the data are from the American Community Surveys (hereafter ACS) of 2005-2011 which is an on-going statistical survey by the U.S. Census Bureau, delivered to approximately 250,000 addresses monthly (or 3 million per year). It has the advantage of providing snapshots at frequent and regular intervals of socio-economic phenomena that were only previously available in the decennial census, and is the largest survey other than the decennial census that the Census Bureau administers. The ACS is a repeated cross sectional survey, and therefore it is not a panel dataset but a pseudo-panel as it surveys different individuals[32] in each wave. However, the questions are consistent across years allowing the data to be pooled in a manner similar to Dalmazzo and de Blasio (2007b; 2007a) and Canton (2009) who construct pseudo-panels for various repeated cross-sectional surveys. Table 5.1 summarises the variables and gives descriptive statistics of the ACS. This shows that the average wage across years varies between \$45,000 and \$48,000 while the average age of survey respondents is just over 45 years. The sample is predominantly male with a roughly 60/40 split, and the majority of individuals surveyed are married. The ethnic composition is mixed but the majority of people are white. Most have at least a Grade 12 education, while approximately 35% have at least 4 years college education.

The ACS microfiles also contain the Public Use Microdata Areas (PUMA) data. PUMAs (as in Figure 5.1) are non-overlapping regions which partition each state into areas each containing about 100,000 residents, and were first made available in ACS micro files in 2005[33]. The presence of geographical identifiers in the dataset allows for the incorporation of measures of market potential and employment density into the model specification. In total, given about 2,100 PUMAs in the US, there are about 2,100 measures of market potential and employment density alongside approximately 650,000 individual observations annually.

The information required for the generation of the market potential variables is obtained from 'The American Factfinder' and is derived from ACS estimates of employment at the PUMA level. Specifically, I acquire data on sectoral employment in each PUMA[34] as well as income

[32] Note that the sample size each year is approximately 650,000 people. These are people in the ACS who are in employment in the year in question.

[33] ACS files from 2000-2004 did not include the PUMA variables.

[34] Where the industries available are (i) Agriculture, forestry, fishing and hunting, and mining; (ii) Construction; (iii) Manufacturing; (iv) Wholesale trade; (v) Retail trade; (vi) Transportation

and this enables the calculation of market potential in a way that is broadly consistent with NEG theory. The starting point is equation (5.8),

$$P_i = \sum_{r=1}^{R} Y_r (G_r^M)^{\sigma-1} \overline{T}_{ir}^{\,1-\sigma} \qquad (5.8)$$

in which P_i denotes market potential in area *i*, and I sum across a set of *R* areas to obtain this. The variable Y_r is the level of income in area *r*, G_r^M is the price index for the *M* sector[35] in area *r*, and $\overline{T}_{ir}$ is the transport cost between areas *i* and *r*. Also, following from established literature the elasticity of substitution is set to be σ= 6.25, an assumption based on the summary of empirical estimates presented in Head and Mayer (2003). This value is also used in Fingleton (2011). Note that this is the same σ as in equations (5.1, 5.3 and 5.4) but in these equations it is an estimate based on empirical data. Note that strictly this equation relates to *M* sector wages, but I simplify by setting the price index equal to 1 across all areas, so that market potential then relates simply to income levels and transport costs, and this more informal specification can then be related to wages overall.

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and warehousing, and utilities; (vii) Information; (viii) Finance and insurance, and real estate and rental and leasing; (iix) Professional, scientific, and management, and administrative and waste management services; (ix) Educational services, and health care and social assistance; (x) Arts, entertainment, and recreation, and accommodation and food services; (xi) Other services, except public administration; and (xii) Public administration. I use these to define the M and C sectors.

[35] In NEG theory, the economy is divided in the *M* sector under a monopolistic competition market structure, and the competitive sector (*C*).

Table 5.1: Descriptive Statistics of American Community Survey

Variable	2005	2006	2007	2011
Wage ($)	45,017	45,992	48,308	48,580
	(50,502)	(52,152)	(55,657)	(55,414)
Age (years)	45.13	45.05	45.32	45.96
	(12.54)	(12.78)	(12.85)	(13.39)
Gender (%)				
Male	0.61	0.60	0.59	0.57
Female	0.39	0.40	0.41	0.43
Marital Status (%)				
Married, spouse present	58.29	56.95	57.02	53.54
Married, spouse absent	1.75	1.84	1.87	2.00
Separated	2.68	2.69	2.62	2.75
Divorced	15.90	15.88	15.78	15.97
Widowed	3.43	3.35	3.31	3.45
Never married/single	17.95	19.30	19.40	22.30
Race (%)				
White	82.17	81.24	81.13	80.02
African American	8.41	8.74	8.83	9.78
American Indian or Alaska Native	0.69	0.68	0.68	0.83
Chinese	0.95	1.01	0.99	1.20
Japanese	0.30	0.30	0.30	0.28
Other Asian or Pacific Islander	2.52	2.68	2.80	3.18
Other Race	3.77	4.08	3.93	2.91
Two major races	1.10	1.18	1.25	1.64
Three or more major races	0.08	0.09	0.09	0.15
Education (%)				
No Schooling	0.33	0.37	0.33	0.71
Nursery School to Grade 4	0.36	0.37	0.33	0.37
Grade 5, 6, 7 or 8	1.99	2.05	2.01	1.77
Grade 9	1.15	1.16	1.13	0.96
Grade 10	1.42	1.40	1.34	1.13
Grade 11	1.61	1.57	1.49	1.39
Grade 12	33.78	33.76	33.12	31.72
1 year of college	15.36	15.55	15.39	16.66
2 years of college	8.73	8.78	8.87	9.19
4 years of college	21.52	21.46	21.97	21.57
5+ years of college	13.74	13.54	14.00	14.55

Source: ACS 2005, 2006, 2007 and 2011.

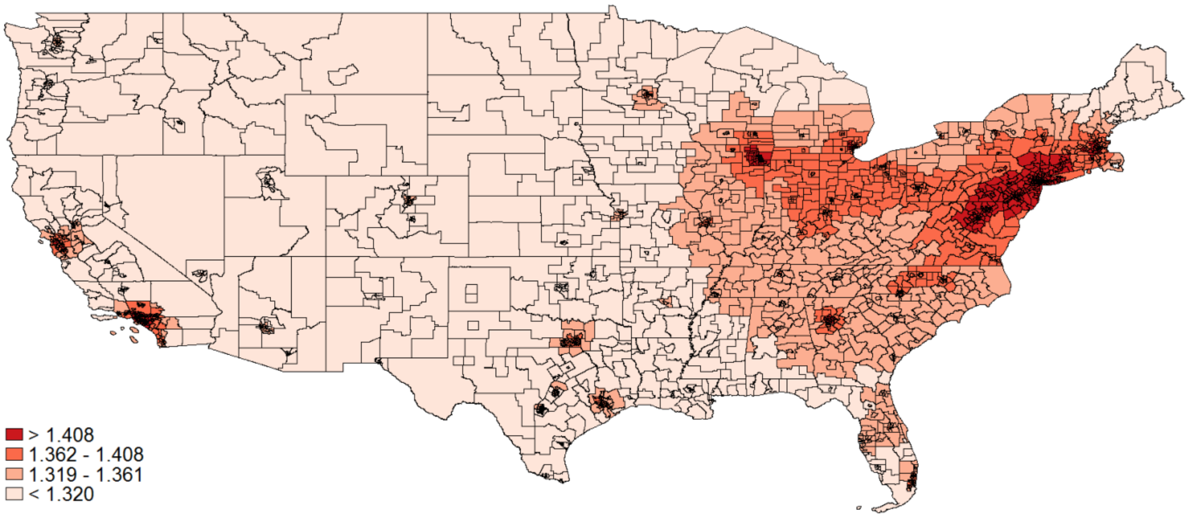
Note 1: Standard deviations are given in brackets for select variables.

When defining trade costs in equation (5.8) I use the distance between PUMAs, thus $\overline{T}_{ir} = e^{\tau \ln D_{ir}}$ where D_{ir} is the straight line distance between the main towns of area *i* and area *r* respectively and the τ parameter defines the rate at which trade costs increase with distance. Ideally, this would be estimated using trade data as in Redding and Venables (2004), however, at the PUMA level this is not possible as no statistics for trade are available. Therefore, following the published literature I assume a value for τ equal to 0.1 (Fingleton, 2006). This assumption produces plausible levels of market potential which accord with the *a priori* notions, as described in Figure 5.2. Varying the assumed value of τ within a reasonable range does not distort the resulting geographical pattern too greatly, so I are reasonably confident that the market potential variable is a robust and reasonable measure.

The market potential map presented in Figure 5.2 shows the highest concentration (darker shading) is on the East coast of the US with two pockets of high market potential on the West coast, centred around major urban concentrations.[36] Low market potential prevails across the central and Western states, with obvious exceptions for large urban concentrations.

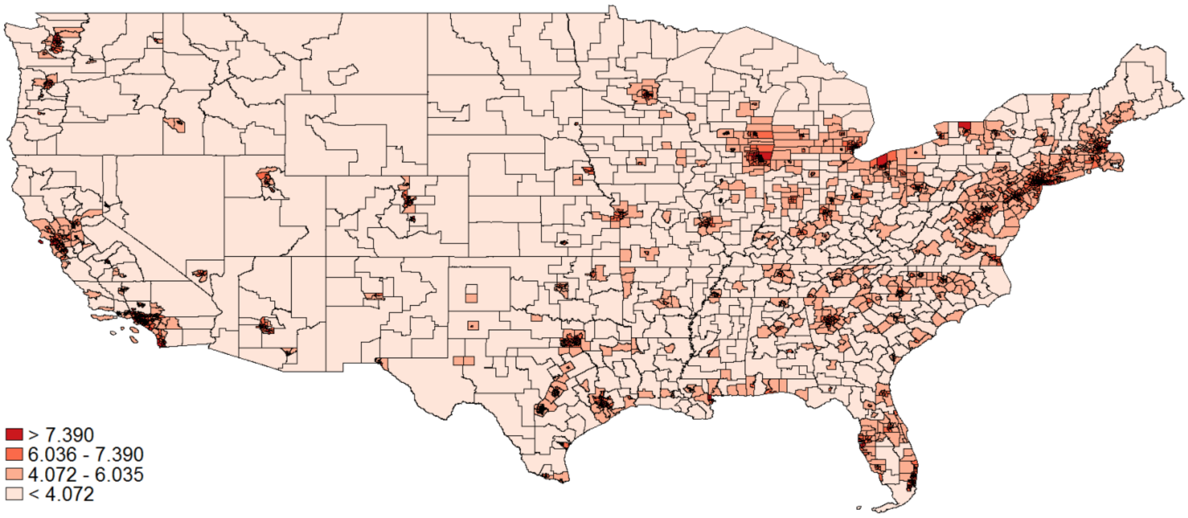
[36] These are centred around Los Angeles and Seattle.

Figure 5.2: Log of Market Potential 2007



In contrast to the NEG motivated market potential variable, the link to UE theory is simply via employment density, defined as employment per square kilometre. Figure 5.3 presents the 2007 employment density map again using the geographical framework of the PUMAs. Quite naturally employment density is also highest around the core urban areas of the US, as depicted on the map by the regions with darkest shading.

Figure 5.3: Log of Employment Density in 2007



5.6 Model Estimates

Table 5.2 gives the estimates[37] of equation (5.3), which relates individual level wages to individual and areal factors. This is the workhorse equation which is the basis of the counterfactual wage levels. The table shows that both the areal variables are significant and positive, thus indicating that wages are higher in areas with higher employment density and market potential. This finding is consistent with the individual level analysis of Fingleton and Longhi (2013).

When considering the individual level variables, there is evidence of a quadratic relationship between age and wages, with the positive coefficient on age and the negative coefficient on age-squared, indicating that wages increase with age up to a point, and then fall. There is also evidence that females tend to have lower wage levels than males, and being married has a positive effect. When considering ethnicity, 'White' (the default category) and 'Japanese' individuals earn the highest wages while 'Chinese' ethnicity is associated with the lowest wages. It can also be noted that individuals who work more weeks during the year achieve higher wage levels. Moreover, I find that individuals with higher levels of education earn higher wages, and this is a systematic effect, as evidenced by an increase in the magnitude of the coefficient as education increases. Also it can be seen that sector of employment has an effect on wage levels, with mining, utilities, and finance related sectors being associated with high wages, and service occupations such as food services associated with lower wage levels. These service activities are predominantly to be found in urban locations, so while urban locations per se would seem to be associated with higher wages, some typical urban occupations are in low wage sectors.[38]

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[37] Given the size of the data set, this estimation takes approximately 3 hours when carried out using Stata 11 running on an Intel Core i5 processor with 64MB of Ram at 3.30 gigahertz.

[38] The reference sector for industries is agriculture, forestry and fishing.

Table 5.2: Factors affecting wage levels

Variable	Coef.	Std. Err.
Constant	-11.1393***	(0.3649)
Age	0.0890***	(0.0003)
Age2	-0.0010***	(0.0000)
Sex	-0.3246***	(0.0012)
Marital Status		
Married, spouse absent	-0.0905***	(0.0038)
Separated	-0.1361***	(0.0032)
Divorced	-0.0437***	(0.0015)
Widowed	-0.1027***	(0.0031)
Never married/single	-0.1453***	(0.0015)
Ethnicity		
African American	-0.1497***	(0.0019)
American Indian or Alaska Native	-0.0695***	(0.0062)
Chinese	-0.2008***	(0.0052)
Japanese	-0.0204***	(0.0095)
Other Asian or Pacific Islander	-0.1340***	(0.0032)
Other Race	-0.1705***	(0.0028)
Two major races	-0.0920***	(0.0047)
Three or more major races	-0.0861***	(0.0172)
Education		
Nursery School to Grade 4	-0.0570***	(0.0123)
Grade 5, 6, 7 or 8	0.0444***	(0.0095)
Grade 9	0.1208***	(0.0100)
Grade 10	0.1829***	(0.0099)
Grade 11	0.2115***	(0.0097)
Grade 12	0.3810***	(0.0089)
1 year of college	0.5008***	(0.0089)
2 years of college	0.6044***	(0.0090)
4 years of college	0.8576***	(0.0089)
5+ years of college	1.1286***	(0.0090)
Industry		
Mining	0.6301***	(0.0086)
Utilities	0.4810***	(0.0065)
Construction	0.3107***	(0.0050)
Manufacturing	0.3473***	(0.0048)
Wholesale Trade	0.3054***	(0.0053)
Retail Trade	0.0355***	(0.0049)
Transportation and Warehousing	0.2919***	(0.0052)
Information and Communications	0.3130***	(0.0056)
Finance, Insurance, Real Estate, and Rental and Leasing	0.3764***	(0.0050)
Professional, Scientific, Management, Administrative, and Waste Management Services	0.2562***	(0.0049)
Educational, Health and Social Services	0.1125***	(0.0048)

Arts, Entertainment, Recreation, Accommodations, and Food Services	-0.1416***	(0.0051)
Other Services (Except Public Administration)	-0.1074***	(0.0053)
Public Administration	0.2947***	(0.0051)
Year		
2006	0.0109***	(0.0013)
2007	-0.0177***	(0.0021)
Weeks Worked		
14-26	0.8410***	(0.0045)
27-39	1.3458***	(0.0042)
40-47	1.6710***	(0.0039)
48-49	1.8941***	(0.0040)
50-52	2.0409***	(0.0034)
PUMA-level Variables		
ln(Employment Density)	0.0125***	(0.0006)
ln(Market Potential)	1.6574***	(0.0352)
R2		0.4716
Obs.		1,988,212

Note 1: State level dummies are included in the model but not presented here in order to save space.
2: Estimates based on ACS 2005-2007 for those employed.
3: ***, ** and * indicate significance at the 99, 95 and 90 percent level.

5.7 Geographical Patterns of Resilience

To calculate the proportional resilience indicator, I apply the Table 5.2 estimates as in equation (5.4), assuming that employment density and market potential in 2011 continued to grow at their 2005 to 2007 average annual growth rates over the period 2008 to 2011 as though there had been no economic crisis during this period. Focusing on the PUMA level of geographical aggregation (State-level analysis is rather uninformative with no pattern evident), I observe that the proportional resilience indicators are consistently negative. However, there is substantial geographical heterogeneity. For the entire US, the Z value for the Moran's I statistic[39] for PUMA proportional resilience is 190.304 with an associated p-value of less than 0.0001. This suggests that while there is heterogeneity in PUMA resilience there is an overall positive statistically significant spatial pattern to proportional resilience. This suggests that resilient regions are likely to be located near to other resilient regions and less resilient regions are also likely to be spatially clustered. As an example of regional heterogeneity Figure 5.4 can be considered, which presents a series of maps of proportional resilience for PUMAs in States containing major city regions (notably New York, Houston, Los Angeles, Philadelphia and

[39] Using a row standardised matrix containing the inverse of the distance in kilometres from the 'centre point' of each region.

Chicago). Darker shading denotes more resilience, since it is associated with the least negative values. It is possible to compare these city regions, which comprise small densely populated PUMAs, with more rural, less densely populated PUMAs. Looking closely at the maps it is evident that a significant number of small inner urban areas have proven relatively less resilient to the crisis, possessing lower levels of proportional resilience.

This apparently low inner urban area resilience is also evident when looking at the entire country using aggregate (PUMA level) data which shows how proportional resilience relates to employment density and market potential. Thus, in Table 5.3 I provide estimates of equation (5.6) based on PUMA-level (not individual) data and controlling for industry structure and educational level[40], I find that market potential has a positive link to proportional resilience but employment density has a negative association. The fact that high employment density, which is typically an inner urban phenomenon, has a negative association is indicative of low inner urban area resilience. It is also noted that areas with higher proportions of individuals with higher levels of education are more resilient than areas with higher proportions of less-educated individuals. Industry structure also appears as a significant driver of resilience. I attempt to capture the nonlinear relation between age and resilience observed in the individual level analysis by a series of dummy variables, and this has some consonance with the individual level analysis (see Table 5.4), in that at the extremes of the (working) age range the coefficients tend to be large and negative, and more moderate or even positive in the middle age range. However, the pattern is suggestive of a more complex relationship between age and resilience than might be suggested by a simple quadratic function. Table 5.3 also shows that PUMAs with high concentrations of employment in construction are relatively less resilient while PUMAs with high concentrations of employment in Finance are relatively more resilient, so although the provenance of the crisis was the financial sector, the construction industry evidently took the brunt of the impact. I jointly test for the significance of each of the categories of variables using F-tests. The test results at the foot of Table 5.3 show that jointly the education coefficients are significantly different from zero, suggesting that they play an important role in explaining differences in regional resilience. The F-tests for industry, age and market potential with employment density are also significant.

[40] Note that I also considered ethnicity in this regression initially, however, this resulted in an excessive variance of inflation factor indicating multicollinearity. Therefore, I have chosen to drop ethnicity from the area level estimation.

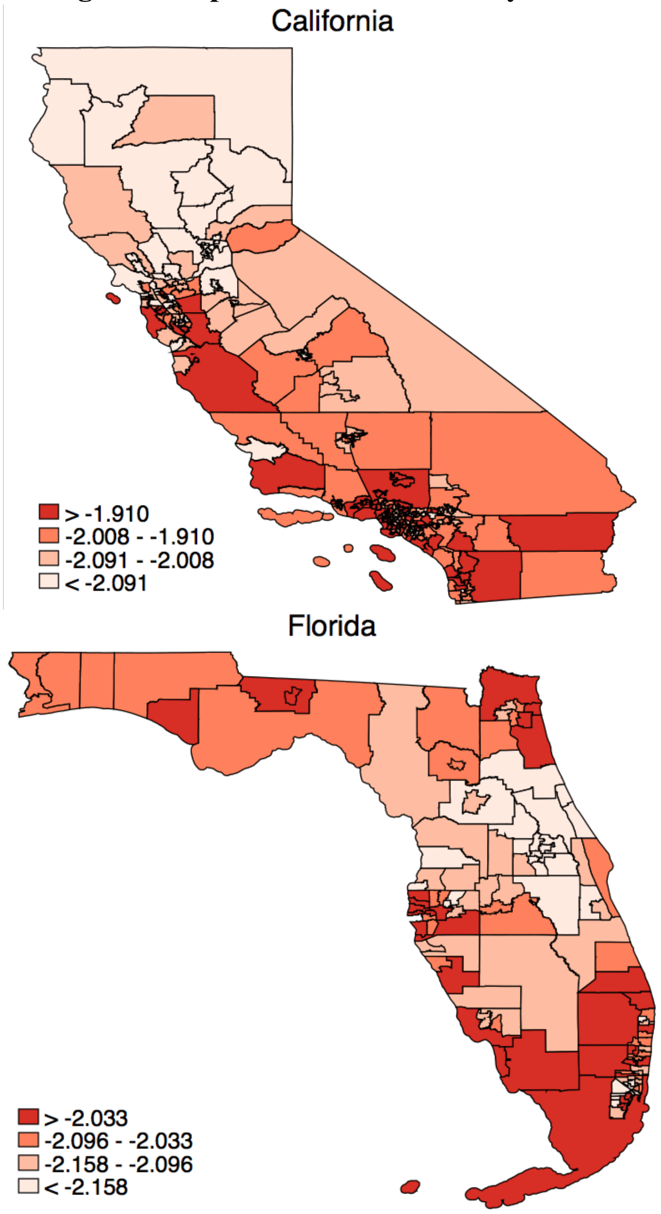
Table 5.3: Factors Affecting PUMA Resilience

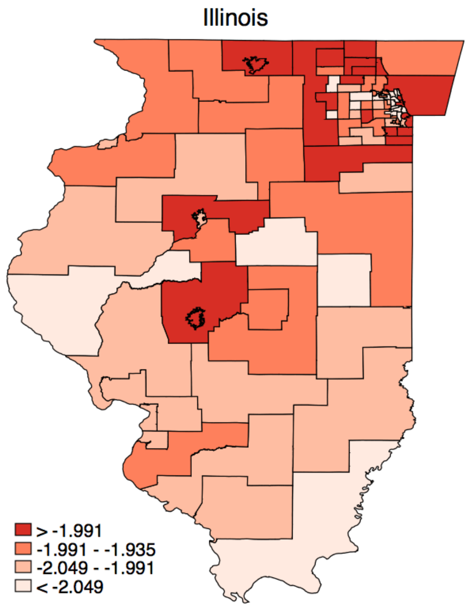
Variable	Coef.	Std. Err.
Constant	-0.3715***	0.0370
Age		
5-9	0.0742	0.0604
10-14	0.0653	0.0551
15-19	-0.2316***	0.0453
20-24	-0.1410***	0.0415
25-34	-0.1530***	0.0416
35-44	-0.0052	0.0421
45-54	0.0767*	0.0410
55-59	-0.0579	0.0517
60-64	-0.0866	0.0575
65-74	-0.1783***	0.0563
75-84	0.0380	0.0532
>85	-0.2087***	0.0725
Gender	0.0063	0.0242
Education		
9th to 12th Grade	-0.0116	0.0199
High School Graduate	0.0326***	0.0114
Some College (did not graduate)	0.0337**	0.0134
Associate Degree	0.0468**	0.0203
Bachelor's Degree	0.0257*	0.0153
Graduate or Professional Degree	0.0571***	0.0158
Industry		
Construction	-0.0808***	0.0178
Manufacturing	-0.0413***	0.0160
Wholesale	-0.0231	0.0379
Retail	-0.0058	0.0219
Transportation	-0.0356	0.0243
Information	-0.0085	0.0341
Finance	0.0671***	0.0236
Professional	-0.0114	0.0257
Educational	-0.0308*	0.0189
Entertainment	-0.0395**	0.0200
Other Services (excluding public administration)	-0.0300	0.0316
Public Administration	-0.0244	0.0200
Employment Density	-0.0048***	0.0006
Market Potential	0.1750***	0.0112
R2		0.5505
No of Obs		2064
Chi2		2345
Prob>Chi2		0.0000
F-tests		
Education		50.1 [0.0000]
Age		379.81 [0.0000]

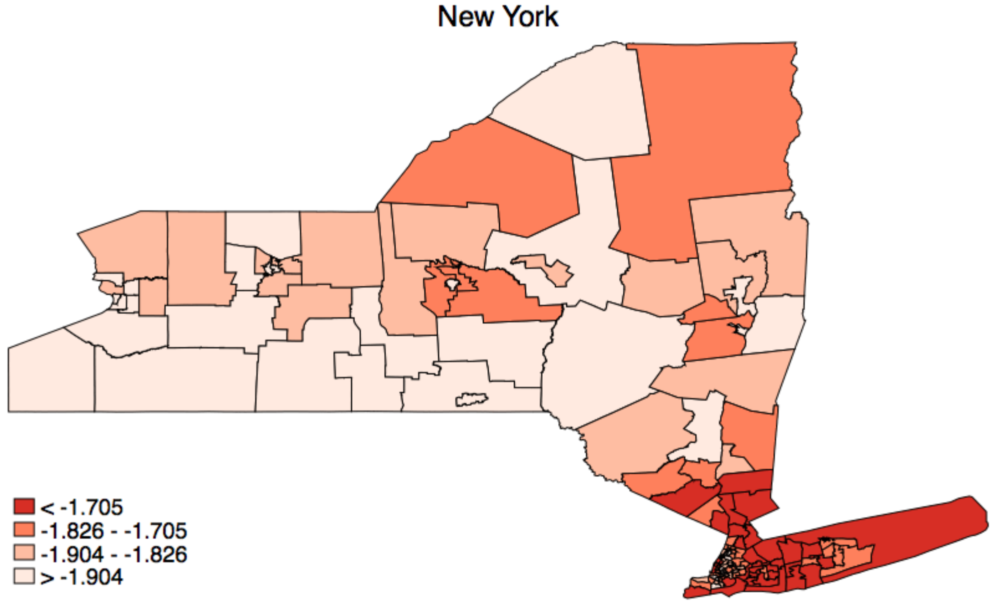
Industry	75.24
	[0.0000]
PUMA Market Potential and Employment Density	256.05
	[0.0000]

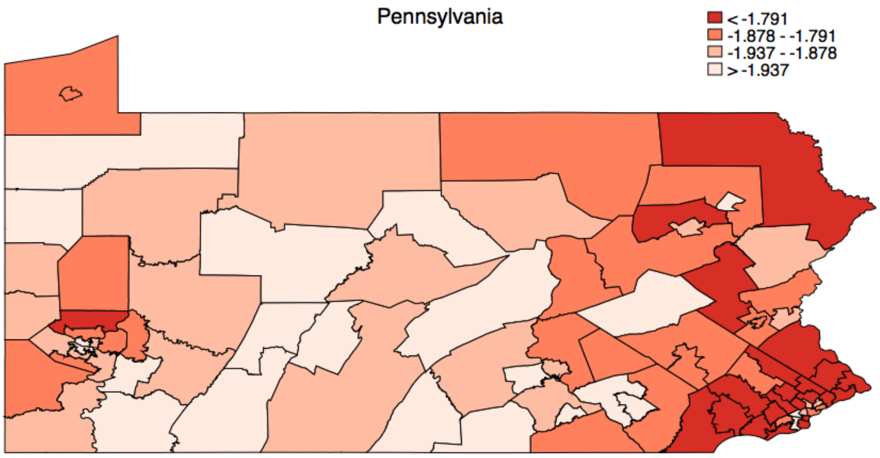
Note 1: State level dummies are included in the model but not presented here in order to save space.
2: ***, ** and * indicate significance at the 99, 95 and 90 percent level.
3: standard errors are in parentheses, p-values for F-tests are in square brackets.

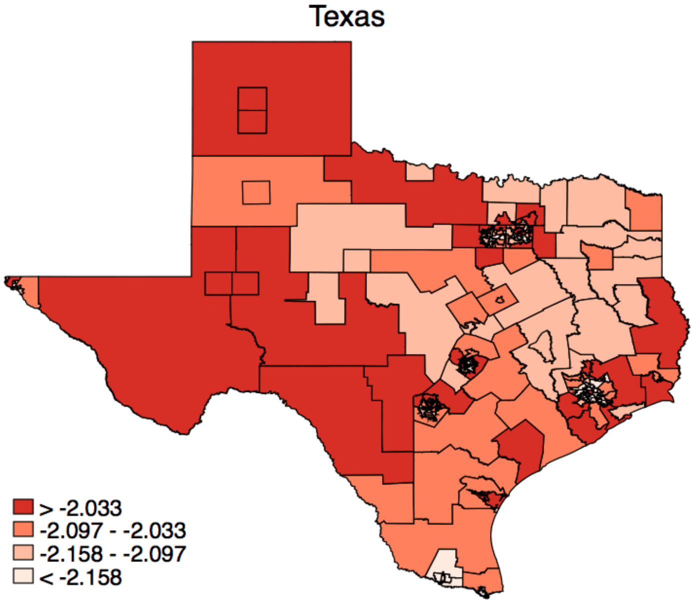
Fig 5.4: Proportional Resilience by States




Illinois
> -1.991
-1.991 - -1.935
-2.049 - -1.991
< -2.049


New York
< -1.705
-1.826 - -1.705
-1.904 - -1.826
> -1.904





5.8 Resilience at the Individual Level

With regard to resilience at the individual level, this is based on equation (5.7) which has proportional resilience as the dependent variable and education, age, ethnicity, gender and industry are the independent variables. The resulting estimates are given in Table 5.4.

Table 5.4 shows a significant influence of educational attainment on individual proportional resilience, with those with a college education being more resilient than those without. Clearly there is a bonus associated with striving to achieve more than one year of college education, since the extra effort and sacrifice involved is rewarded in terms a substantially higher proportional resilience. Overall, highly educated respondents earned the highest wages (see Table 5.2) and this alone would have contributed to a higher level of proportional resilience.

With regard to gender, the equation (5.7) estimates do not detect any significant difference between males and females. In the case of age, I again assume that a quadratic relationship between age and resilience is a reasonable approximation, forming the inverted U-shaped relationship typical of many Mincerian wage models, with the youngest and oldest individuals being the least resilient and middle aged individuals being the most resilient.[41] Table 5.4 also highlights differences according to ethnicity and sector, with mining standing out as being a resilient occupation, and various services and retail jobs featuring among the least resilient. Perhaps the most striking feature of the Table 5.4 estimates is the lack of significance attributable to employment density, which hitherto had suggested low inner urban area resilience. Thus, with the most fully developed model, given as equation (5.7), which takes account of both individual attributes and areal variables, among the latter it is market potential alone which turns out to be positively linked to resilience. Inner urban areas, having controlled for a variety of individual variables, do not appear, *per se*, to be causes of lack of resilience. That is not to say that I do not observe a lack of resilience in inner urban areas with high employment density, but the causes seem to be related to the attributes of individuals rather than the characteristics of the areas themselves.

Table 5.4 also presents F-tests of the variables to assess joint significance. It can be noted that all the categories are significant at the 99% level, suggesting that education, industrial occupation etc. all play a role in explaining individual level resilience.

[41] This is shown as the coefficient on age is positive while the coefficient on age^2 is negative indicating a non-linear, inverse U-shaped relationship.

Table 5.4: Factors Affecting Individual Resilience

Variable	Coef.	Std. Err.
Constant	-0.5852***	0.0794
Age	0.0027***	0.0001
Age2	-0.0001***	0.0001
Sex	-0.0001	0.0003
Marital Status		
Married, spouse absent	-0.0029***	0.0009
Separated	-0.0009	0.0008
Divorced	-0.0026***	0.0004
Widowed	0.0012	0.0007
Never married/single	-0.0087***	0.0004
Ethnicity		
African American	-0.0009**	0.0004
American Indian or Alaska Native	0.0032**	0.0014
Chinese	0.0026**	0.0011
Japanese	-0.0043*	0.0024
Other Asian or Pacific Islander	-0.0003	0.0007
Other Race	0.0032***	0.0008
Two major races	-0.0065***	0.0010
Three or more major races	-0.0022	0.0032
Education		
Nursery School to Grade 4	0.0127***	0.0026
Grade 5, 6, 7 or 8	0.0039**	0.0018
Grade 9	0.0007	0.0020
Grade 10	0.0042**	0.0019
Grade 11	0.0065***	0.0018
Grade 12	0.0073***	0.0015
1 year of college	0.0051***	0.0015
2 years of college	0.0138***	0.0016
4 years of college	0.0170***	0.0015
5+ years of college	0.0216***	0.0015
Industry		
Mining	0.0095***	0.0019
Utilities	0.0013	0.0015
Construction	-0.0017	0.0012
Manufacturing	-0.0035***	0.0011
Wholesale Trade	-0.0061***	0.0013
Retail Trade	-0.0139***	0.0011
Transportation and Warehousing	-0.0075***	0.0012
Information and Communications	-0.0093***	0.0014
Finance, Insurance, Real Estate, and Rental and Leasing	-0.0075***	0.0012
Professional, Scientific, Management, Administrative, and Waste Management Services	-0.0091***	0.0011
Educational, Health and Social Services	-0.0135***	0.0011

Arts, Entertainment, Recreation, Accommodations, and Food Services	-0.0140***	0.0012
Other Services (Except Public Administration)	-0.0162**	0.0012
Public Administration	-0.0025**	0.0012
Weeks Worked		
14-26	0.0628***	0.0011
27-39	0.0783***	0.0010
40-47	0.0955***	0.0010
48-49	0.0944***	0.0013
50-52	0.1183***	0.0008
PUMA-level Variables		
ln(Employment Density)	0.0002	0.0001
ln(Market Potential)	0.0188***	0.0071
R2		0.0763
Obs.		671,472
Chi2		55917
Prob>Chi2		0.0000
F-tests		
Marital Status		629.4
		[0.0000]
Age		2671.95
		[0.0000]
Race		82.91
		[0.0000]
Education		2058.4
		[0.0000]
Industry		1454.64
		[0.0000]
Weeks Worked		26834.21
		[0.0000]
PUMA Market Potential and Employment Density		34.87
		[0.0000]

Note 1: State level dummies are included in the model but not presented here in order to save space.
2: ***, ** and * indicate significance at the 99, 95 and 90 percent level.
3: standard errors are in parentheses, p-values for F-tests are in square brackets.

5.9 Conclusions

In this Chapter I analyse the resilience of individual level wages with respect to the 2008 economic crisis, using the American Community Survey 2005-2007 and 2011. I estimate a model of wages [drawing on Mincer (1974) type wage equations] augmented with regional indicators of market potential and employment density for the period 2005 to 2007 and use the coefficients derived from this model to generate a counterfactual of what wages could have been in 2011 had the 2008 economic crisis not occurred. I then generate a measure of resilience based on the difference between the actual and counterfactual wage series. Following this I analyse the geographical patterns of resilience across US PUMAs. The Chapter also considers individual characteristics, namely age, education, ethnicity, occupation etc. as determinants of resilience.

The findings indicate that as a result of the 2008 economic crisis, wages fell relative to what one would anticipate under a no-crisis counterfactual, but the extent of the fall depends on individual characteristics, and it also appears to be related to where individuals lived, with those in inner city high density locations *seemingly* experiencing an effect due to their location, as suggested by Figure 5.4. These maps suggest that there is a large degree of heterogeneity in the geographical distribution of resilience across the US. Those living in areas with higher levels of employment density (typical urban concentrations), which possess higher wages during the 2005-2007 period, are evidently less resilient to the 2008 economic shock than people located in lowers levels of employment density, as shown by Table 5.4. Importantly, I note that, when one looks overall at the relationship between employment density and proportional resilience, having controlled for individual characteristics, this negative relationship does not persist. Thus, while high employment density is correlated with low proportional resilience, this is attributable to the characteristics of the individuals rather than to inherent location-specific characteristics. In contrast for market potential it is noted that there is a positive effect on PUMA level resilience and this effect persists having controlled for individual level characteristics. Thus, living in a location with good market and supplier access imparts resilience in addition to the effects on resilience of having a college education, or being of a certain age, ethnicity or employed in a certain industrial sector.

A limitation of this research is the restricted time period for which data is available, so of course the results are conditional on the data that are available. Ideally one would like to have more data pre-2005 and data beyond 2011, but this is not available. Since the impact of the crisis was on-going beyond 2011, it is evident that the data set does not include the full boom-bust cycle, so it would be interesting to study additional data as that becomes available. *Pro tem*, the analysis is of resilience up to 2011 (which is predominately a resistance story rather than a recovery story), but this may not be the final story. Also it might be argued that because the model of wages is based on a period when the US economy was growing rapidly and the level of the counterfactual wages may be inflated as a consequence. However, this would be the same for everyone, and simply have the effect of reducing the level of absolute resilience for everyone by the same amount, so that differences between individuals would remain the same.

Finally, it is worth noting that this Chapter focuses on the resilience of wages (i.e. those employed) and does not consider the probability of employment. Therefore, while educational attainment may be important for resilience in wages it is also likely to be positively associated with the probability of employment. Given the burgeoning employment crisis in many Western economies, this additional employment-oriented dimension is another important and rather unexplored consideration for individual-level resilience-based studies in the future. Indeed in the next Chapter I consider the impact of the 2008 economic crisis on employment outcomes for individuals across European regions.

Chapter 6: Individual Level Employment Resilience to the 2008 Economic Crisis

6.1 Introduction

Recently there has been considerable attention paid to the impact of shocks to both regional and national economies. These studies typically focus on cities, regions or nations as the unit of analysis (Fingleton and Palombi, 2013; Hill et al., 2008; Martin, 2012; Ormerod, 2010; Fingleton et al., 2015) and use a variety of different approaches such as case studies, indices, time series models and structural economic models (Martin and Sunley, 2014). However, to date there has been relatively little analysis of resilience in the regional context which uses the individual as the unit of analysis. This Chapter provides insights into how individual specific characteristics and regional variations can help explain the resilience of employment outcomes during an economic crisis. This Chapter focuses on the crisis as it was experienced in 2010, following crisis impacts going forward from 2008.

This Chapter differs from the previous Chapter in that it considers employment outcomes as opposed to wage levels. The focus here was to provide a comparison of the impact of the crisis on individuals in the US versus to EU. However, as similar data is not available for both areas, it was not possible to consider wages in the European context. Using the European Social Survey, wage data is only available in deciles and not in euro values. Therefore, in order to complete the analysis it was necessary to focus on employment outcomes as opposed to wages. The added contribution is to provide the first analysis of individual level resilience for European countries and to do so for a selection of pan-European regions. In doing so this Chapter is amongst the first empirical evaluations of regional employment resilience from an individual perspective. It builds on the previous Chapter by providing an analysis of individuals across European regions while also focusing on employment outcomes, as opposed to wages.

Using data from the European Social Survey (ESS), a model of employment outcomes for individuals over the period 2002 to 2008 is estimated. Data are available for this period from four waves of the ESS carried out in 2002, 2004, 2006 and 2008. The model explains individual-level employment outcomes using individual specific variables together with a regional economic variable (namely unemployment rates in the NUTS1[42] region in which the individual is located). The estimated model parameters allow for the generation of predicted outcomes for individuals in 2010 which are based on the economic conditions prevalent across NUTS1 regions at this point in the recession cycle. These are compared to the predictions based on the levels of explanatory variables as they would have been had the 2008 recession not

[42] NUTS translates as Nomenclature of Territorial Units for Statistics.

occurred. These predictions are referred to as the no-recession counterfactual. Given these two sets of predictions, one based on realised values of the explanatory variables over the period from 2008 and the other a no-recession counterfactual set of predictions, measures of employment resilience are generated based on the difference between the predictions. This allows for an evaluation of the effect on resilience of individual characteristics such as education and age, and the effect of regional unemployment rates.

The remainder of this Chapter is structured as follows. Section 6.2 provides a brief overview of the concept of regional resilience. Section 6.3 provides a review of studies which have considered the drivers, both individual and regional, of employment outcomes. Section 6.4 outlines the modelling approach and discusses the generation of the counterfactual employment outcomes and resilience index. Section 6.5 describes the data used in this analysis and Section 6.6 presents the model estimates. Section 6.7 considers the impact of individual characteristics on the resilience of employment outcomes. Finally, Section 6.8 concludes.

6.2 Regional Resilience

The concept of regional resilience has received increasing attention since the 2008 economic crisis (Martin, 2012; Fingleton and Palombi, 2013; Simmie and Martin, 2010; Martin and Sunley, 2014) but resilience per se can be related to economic models developed by Friedman (1964; 1993) and has an earlier provenance going back to the concept of hysteresis, as discussed for example in Romer (2001). This Chapter specifically focuses on the resilience of employment to economic shocks. As noted previously, and to emphasise in the context of the current Chapter, at an aggregate regional level Blanchard and Summers (1987) (in the context of unemployment) note that the concept of hysteresis can refer to “the development of alternative theories of unemployment embodying the idea that the equilibrium unemployment rate depends on the history of the actual unemployment rate. Such theories may be labelled hysteresis theories after the term in the physical sciences referring to situations where equilibrium is path-dependent” (pp 290). Thus a negative shock leading to permanently higher unemployment may occur if the long term unemployed lose skills and miss out on job training, so that they ultimately become unemployable. In contrast, the employed continue to benefit from learning-by-doing. This viewpoint of hysteresis in unemployment is supported by Jaeger and Parkinson Jaeger and Parkinson (1994) and Jacobson et al. (1997).

In a European regional context there has been much discussion as to the negative impact of economic shocks from 2008 on employment. For example Fingleton et al. (2012) analyse the response of employment in UK regions to the crisis and suggest that output shocks can have a persistent negative effect on employment. Cellini and Torrisi (2014), using a similar approach, note that regional resilience in output can vary dramatically across regions and can help explain long run differences in the growth paths of regional economies. Fingleton et al. (2015), using a dynamic spatial panel model analyse the impact of shocks on the Eurozone, concluding that there was substantial heterogeneity in the responses of regional economies to the 2008 economic crisis. Davies (2011) provides an analysis of the resilience of employment to economic shocks using EU regional data and the impact that policy can play in stimulating resilience. Bailey and Berkeley (2014) provide an analysis of the impact of the 2008 economic crisis on the West Midlands region of the UK and contextualises the response of this region to the crisis using Martin's (2012) four dimensions of resilience. At a national level, in Chapter 3 [published as Doran and Fingleton (2014)] I find that output shocks have a negative effect on employment[43] that is persistent.

A number of alternative methodologies have been employed in the analysis of resilience. Chapter 2 provides a typology of these resilience studies, based upon, and extending, the typology presented in Martin and Sunley (2014). These alternative methods are briefly defined as follows. The case study approach is essentially descriptive in nature and focuses on one or a small number of regions. Typically a regional specific shock is studied such as the decline of a particular industry (Bailey and Berkeley, 2014). When more regions are considered a common approach is the construction of resilience indices. These provide insight into the severity of shocks as well as the extent of recovery. They are based around the identification of a particular time period when a shock occurs and are sensitive to the exact specification of this period (Martin, 2012), and usually capture the extent of decline followed by the speed of recovery. Time series analysis, often in the form of vector autoregressive or vector error correction models, is typically employed for regional resilience studies which focus on a relatively small number of regions but over a long time period (usually utilising quarterly data). An advantage of these models is their statistical robustness, however, they are limited to small numbers of regions (or else the methodology becomes unwieldy) and also necessitate a long time period for analysis (Fingleton et al., 2012). Fourthly, an analysis based on formal economic models utilising spatial panel econometric techniques can be utilised. The types of regional economic models utilised vary from those based on the Wage Curve (Fingleton and

[43] In Chapter 3 [published as Doran and Fingleton (2014)] the analysis focuses on productivity but discusses the impact of output shocks on the two facets of productivity; output and employment.

Palombi, 2013) to the wide family of models whose provenance is the Dixit-Stiglitz theory of imperfect competition such as the Verdoorn's Law underpinnings of Chapter 4 [published as Doran and Fingleton (2018)]. The final type of analysis is relatively new and is based on merging individual level data with regional data to analyse the impact of economic shocks on individuals. The approach adopted by this Chapter is to use the final typology, of merging individual and regional data, by building on the work of the previous Chapter [published as Doran and Fingleton (2015)]. A similar methodology is used to analyse employment outcomes. Analysis at the individual level is still relatively rare but it advantageously allows one to capture effects which might otherwise be difficult to model, and the necessary individual level data are increasingly accessible. Also, increasingly, techniques to exploit such data are being developed and becoming more readily available. The present Chapter is set in the context of these recent developments.

To summarise, the Chapter analyses the resilience of employment to economic shocks, not at an aggregate regional level, but at the level of the individual. It focuses on the response of individuals to the 2008 economic crisis, controlling for individual specific factors such as age, education etc. while also incorporating regional (NUTS 1 level) economic indicators which may also affect individual employment probabilities.

6.3 Determinants of Employment

The model specification adopted in this Chapter is based on the extensive literature which considers the determinants of (un)employment outcomes, both at the level of individuals and of regions. At the individual level, prominent among factors which have been found to be important are age, education, gender and family composition (Baum and Mitchell, 2008). Thus, individuals with higher levels of educational attainment are more likely to be employed than those with lower levels while those from a disadvantaged background are less likely to be employed. Ethnicity and whether or not a person is an immigrant are also evidently factors affecting employment outcomes (Wang and Lysenko, 2014), but some other factors, such as gender, are more ambiguous with mixed results coming from the literature (Baum and Mitchell, 2010).

In line with the approach adopted in this Chapter, recently there has been a suggestion in the literature of the importance of controlling for regional factors when considering individual's employment outcomes. Baum and Mitchell (2010) note that employment outcomes have typically been analysed either using micro data to assess the importance of individual level characteristics on the likelihood of employment/unemployment, or at an aggregate regional level focussing on regional employment levels. However, they suggest that it is the combination of both individual and regional level data which could be the most informative and that a two-level approach which considers both elements is needed[44]. Their approach is to model individual employment outcomes as a function of educational attainment, age and other socio-demographic factors as well as regional employment conditions such as the proportion of people who are employed. Further application of this mixed-level approach is given in Baum et al. (2008), Baum and Mitchell (2008; 2011) and in Wang and Lysenko (2014) who, in a different context, also note that an individual's employment outcome is dependent upon his or her individual skills and experience but also upon the characteristics of the labour market within which the individual is embedded. They note that factors such as economic structure and average educational attainment of the labour force (as well as individual characteristics) impact upon individuals' performance.

6.4 Empirical Model

6.4.1 Modelling Individual Employment Outcomes

The starting point of this Chapter is a model of the probability of employment as set out in equation (6.1):

$$E_{it} = F\left[\alpha_0 + X_{it}\beta + \lambda U_{rt} + \rho W_r U_t + \mu_r + \mu_t\right]; \forall r, i, t \tag{6.1}$$

In which E_{it} is the probability of employment for individual i at time period t and F denotes the cumulative normal distribution function which maps the linear predictor into the 0/1 space. The constant term is denoted by α_0, and U_{rt} is the unemployment rate in region r in time period t and λ is the associated coefficient. The inclusion of regional unemployment rates as an explanatory variable in determining individual level employment outcomes is consistent with Baum et al. (2008). While alternatives such as regional GDP may also be used, in this case the inclusion of both regional unemployment and regional GDP is not possible due to the high levels of multicollinearity which exists between these two indicators. Therefore, as labour

[44] Note that when there are variables at different levels of aggregation, such as regional and individual, there is a possibility that the estimated standard errors are biased, as pointed out by Moulton (1990). In order to correct for this bias the error terms are clustered by region. This is discussed in more detail in Section 6.4.

outcomes are being considered (in the form of employed or not at individual level) a measure of the regional labour market was deemed most suitable for inclusion when both GDP and unemployment could not be incorporated in the same model due to the afore mentioned endogeneity and therefore regional unemployment was included. At the individual level X_{it} denotes individual specific characteristics including, among other factors, the age, gender and educational attainment of individual *i* at time *t*, and β is the associated vector of coefficients. The inclusion of these variables is consistent with Baum and Mitchell (2008) and Wang and Lysenko (2014) who likewise relate individuals' employment outcomes to their age, gender, and educational attainment. The term $W_r U_t$ denotes the weighted average of unemployment rates 'near' to region *r*, with the associated coefficient ρ. This controls for potential spillovers in labour market effects across regions. W_r is the *r*'th row of the spatial weights matrix W which is an n by n contiguity matrix, where n is the number of regions, so that cells are allotted the value 1 when a (row and column) pair of regions share a border and zero otherwise. This is subsequently row standardised so that rows of W sum to 1. The 1 by n row vector W_r is then post-multiplied by n by 1 vector U_t yielding a spatial lag of U_{rt}, $\forall r,t$. This Chapter also accounts for unobservable time-invariant factors via the regional specific fixed effects μ_r, and unobservable factors through time via the year-specific fixed effects μ_t. Estimation is by maximum likelihood, but I also invoke instrumental variable Probit models as mentioned subsequently.

The four waves of the European Social Survey question different individuals in each wave, and so is not a true panel data set-up (similar to the data used in Chapter 5), but rather a pseudo panel. This means that it is not possible to include individual fixed effects in the model, which would control for time-invariant individual unobservable heterogeneity[45], as the same individuals are not observed over time. A similar situation is faced by Dalmazzo and De Blasio (2007b; 2007a), Di Addario and Patacchini (2008) and Bratti and Leombruni (2009) who also use pseudo-panels. However, it is possible to capture unobservable effects at the regional level via the presence of fixed NUTS1-level effects (denoted by μ_r) and fixed effects for each time period through the inclusion of μ_t. Region and time fixed effects control for differences in the expected employment outcomes of individuals across regions and time which are not captured

[45] This would be an ideal situation because then this Chapter would be accounting for much inter-individual variation and reducing bias due to omitted variables.

by the other independent variables. Accordingly, the estimation of equation (6.1) containing individual and regional level variables, together with the regional fixed effects, implies, as is standard in the panel data literature (Rauch, 1993; Wooldridge, 2002) that there are no omitted (time-invariant) variables at the regional level which could induce omitted variable bias.

Another issue, as demonstrated by Moulton (1990), regarding the inclusion of micro level data with aggregated regional level data, is that there are potential implications for the standard errors of the estimated model. Moulton (1990) notes that even the slightest level of (positive) correlation within groups in the error term can cause serious downward bias in the estimated standard errors and therefore upward bias in t ratios leading to Type I error occurring at a rate higher than the nominal 5%. This is also noted in recent work by Canton (2009) and Baum and Mitchell (2010). They point out that it is likely that observations will be correlated within regions as region specific elements may be impacting on all the people within that region. Therefore, since (positive) intra-region correlation within the regression model is expected, the standard modification for intra-group dependence which produces larger than otherwise standard errors (and adjusts the variance-covariance matrix), and avoids upwardly biased t-ratios, is used. The final estimation procedure for equation (6.1) is a probit model where the error terms are clustered.

An additional consideration is the potential for bias due to endogeneity. As it turns out, this is evidently not an issue, as the Wald test does not reject the null hypothesis of exogeneity (Stata, 2009). However generally in this kind of analysis there is reason to suspect that endogeneity bias might be present, as discussed in the following paragraph, and therefore as a precaution some ancillary estimates using an instrumental variable probit model are presented[46]. However the outcomes (Table 6.5) are very similar to the standard probit model, which is used as the basis for projecting the counterfactual series, as the Wald test suggests that it is legitimate to treat the unemployment rate as exogenous.

Endogeneity bias could occur if there are one or more omitted variables causing the error term to be correlated with the regressors included in the model, as would be the case if included and omitted variables were correlated. This is a consideration because in the case of this Chapter the size and significance of the regional unemployment variable could possibly be biased by the existence of an omitted variable(s) correlated with the regional unemployment rate. I have tried to avoid omitting variables by the presence of the regional fixed effects and also by the

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[46] The model is estimated in Stata 11 and uses the ivprobit command.

inclusion of the spatial lag term $W_r U_{rt}$ and, as it turns out, this is not an issue for the current estimation but it is useful to rehearse the arguments. Typically an important source of endogeneity is the existence of sorting, which has been suggested as a potentially real phenomenon in the economic geography literature, for example one could see sorting into high amenity or network-rich, urban locations (Venables, 2011), and one can also envisage sorting based on regional labour market conditions. Sorting is a phenomenon well known, for example, in the educational economics literature. An instance would be where one is trying to analyse the effect of class size on pupil performance, but parents opt to place high ability pupils non-randomly into smaller classes, so that small class pupils perform better because they have more ability, which is omitted from the analysis, and not because small class size per se has an effect. In this case, ability is an omitted variable which is correlated with class size and causes omitted variable bias in the class size parameter. Therefore, in the context of the analysis, a low unemployment rate in a region may stimulate the sorting of highly educated, mobile individuals into the region. Although the basis of the analysis is a detailed empirical model capturing individual and regional effects on the probability of employment, and so hopefully capturing the main determinants of employment and resilience in the models, I nevertheless take a cautionary approach, mindful of the possibility of a sorting effect. In other words sorting due to omitted variables could theoretically be an issue because it is not possible to control for individual unobservables via fixed or indeed random effects (which is not possible given the data). Accordingly, in the ancillary instrumental variable probit model estimation summarised in Table 6.5 I have endeavoured to control for endogeneity due to omitted variables using instruments while also including regional fixed effects to control for omitted variables at the regional level.

It is difficult to identify suitable instruments for inclusion in the model, and I therefore adopt Bartlett's three group method (initially introduced in the context of endogeneity caused by measurement error) as an instrument for the unemployment rate. Bsrtlett's (1949) three group method was proposed as a more efficient instrumental approach than the Wald method. It divides the endogenous variable into three categories based on the size of the variable. The n/3 smallest are set to -1, the n/3 largest are set to 1 and the n/3 middle values are set to zero (Johnson, 1984; Kennedy, 2008). The process was initially designed to address measurement error but can be applied in the context of endogenous regressors (Fingleton, 2003; Artis et al., 2012; Le Gallo and Paez, 2013). While it appears to be a feasible and easy to implement solution, I remain cautious, since Fingleton and Le Gallo (2007) show that three-group instruments which are based on an endogenous variable will retain an unwanted element of correlation with the residuals, thus perhaps reducing endogeneity-induced bias, but maybe not totally eliminating it. Therefore I also include an additional set of instruments based on the synthetic instruments approach developed in Le Gallo and Paez (2013). They outline a five step procedure which produces a synthetic instrument for each endogenous variable. I briefly outline their approach here but refer interested readers to the full explanation in Le Gallo and Paez (2013). It starts by defining a contiguity matrix, in the case of this Chapter a matrix of inter-NUTS1 regional contiguity, and obtaining the eigenvectors of this matrix. Then each eign-vector is regressed on the endogenous variable and the significant eigenvectors are retained and summed to create an exogenous instrument (each significant eign-vector is weighted according to the regression coefficient obtained by regressing the eign-vector on the endogenous variable). This is done separately for each time period, with the set of instruments then concatenated to create a single instrument covering all periods.

Therefore, in total I estimate two models based on equation (6.1). The first is estimated using a standard probit model, and the second controls for possible endogeneity via an instrumental variable probit model. However, the test of endogeneity and the estimates obtained point to the standard probit model as an appropriate vehicle for analysis.

6.4.2 Generating a Counterfactual Employment Outcome

Normally, as in Doran and Fingleton (2014) (see Chapter 3) who consider deviations in actual GDP from a counterfactual of GDP, the observed outcome in the post-estimation period would be compared with what is predicted under the counterfactual. In the current modelling set-up however, there is a binary response variable and no observed post-estimation employment outcomes, and to work around this shortfall the Chapter simply uses predicted employment probabilities under two scenarios, one is that the economic shock did not occur (the counterfactual), and the other is that it did occur. Therefore, the analysis is based on differences at the individual level between the probability of employment estimated under the economic conditions that actually prevailed and under counterfactual economic conditions. This enables an assessment of the impact of individual-level and region-level factors on resilience to the crisis as it unfolded over the period 2008-2010.

The starting point therefore is to generate the predicted probability of an individual being in employment based on the individual's characteristics and on the observed, actual, unemployment rate in, and contiguous to, the individual's region of employment. This is given as:

$$\hat{E}_{i2010} = F\left[\hat{\alpha}_0 + X_{i2010}\hat{\beta} + \hat{\lambda}U_{r2010} + \hat{\rho}W_r U_{2010} + \hat{\mu}_r + \hat{\mu}_{2006}\right]; \forall i, r \qquad (6.2)$$

Where $\hat{\bullet}$ indicates an estimated value. The coefficient estimates are those obtained from equation (6.1) using data from 2002, 2004, 2006 and 2008. Unobservable time-invariant factors are accounted for via the estimated regional specific fixed effects $\hat{\mu}_r$, and temporal variation is controlled for by the presence of the year-specific fixed effect for (arbitrarily) 2006 denoted by $\hat{\mu}_{2006}$. Since the aim is to estimate the employment probability of each individual $\hat{E}_{i2010}; \forall i$, under recession conditions, equation (6.2) uses the actual 2010 values of the regional unemployment variable $U_{r2010}; \forall r$.

The predicted probabilities under the no recession counterfactual are given by equation (6.3)

$$\bar{E}_{i2010} = F\left[\hat{\alpha}_0 + X_{i2010}\hat{\beta} + \hat{\lambda}\bar{U}_{r2010} + \hat{\rho}W_r \bar{U}_{2010} + \hat{\mu}_r + \hat{\mu}_{2006}\right] \qquad (6.3)$$

in which all the values are identical to equation (6.2) except for $\bar{U}_{r2010}$ which is the counterfactual unemployment rate for region r had the 2008 economic crisis not occurred, and $\bar{U}_{2010}$ is the corresponding n by 1 vector. The mechanisms used to obtain the counterfactual input series are described in Section 6.4.3. The predicted probability $\hat{E}_{i2010}$ differs from $\bar{E}_{i2010}$ since these probabilities corresponding respectively to the actual observed economic conditions in the NUTS region in which individual *i* is employed and the economic conditions under the counterfactual which assumes that the economic crisis did not occur.

In equations (6.2) and (6.3), the individual specific factors, given as X_{i2010}, are simply the observed 2010 indicators for education, gender etc. Observed rather than simulated indicators are employed due to data limitations which do not allow for this analysis to track individuals across time. This is discussed in more detail in the following paragraph. An argument is made that it is not expected these variables will have been affected by the economic crisis. Therefore, the sole driver of the difference between equation (6.2) and (6.3) is the regional indicator which changes according to the assumptions made about the economic crisis.

While the limitation of holding the X_{i2010} values constant is a necessary one resulting from data limitations and the inability to track individuals across time to see if there was any change in the independent variable an argument can be made that some of these variables, if not all, would be unaffected by the crisis. The assumption that the individual level variables are not affected by the recession is a theoretical one. While variables such as gender and age will not have been impacted by the recession others such as education or union membership might have been. It is therefore these variables which require a more cautious interpretation in the empirical analysis. It is assumed that given the onset of the crisis in 2008, by 2010 an individual will not have had sufficient time to have dramatically changed his/her educational attainment. I highlight again that ideally individuals could be tracked through time to ascertain whether this is in fact the case, however, due to the data used on this Chapter this is not possible. However, while the crisis may have forced some unemployed individuals back into education, in the two year period considered by this Chapter is not likely to have had a major impact. For instance it is unlikely in the two year period an individual will have moved from post-secondary education to having completed tertiary education. Union membership is somewhat more problematic as people can quickly join or leave a union. Indeed when discussing the data in Table 6.1 it can be noted that a slight drop in the proportion of individuals who are union members between 2008 and 2010. However, union membership has been falling from 2002 and the fall from 2008 to 2010 is in line with the downward trend observed across the studies time period. As the fall in membership is not out of line with what would be anticipated based on trend, it is assumed that union membership has also been unaffected by the recession. Again, this is a strong assumption, which in future research using true panel data, could be tested. Unfortunately this form of data is not available for this Chapter.

6.4.3 Generating the Counterfactual Input Series

When considering the counterfactual input series for unemployment the problem at hand is to generate the counterfactual unemployment rate which may have been observed had the 2008 economic crisis not occurred. In order to check the robustness of the preferred approach, in fact three alternative counterfactuals are generated. Therefore, while the autoregressive model outlined below, based on the approach used in Fingleton and Palombi (2013), is the preferred method of generating the counterfactual unemployment rate the results of two alternative approaches to obtaining the counterfactual are also discussed below.

The preferred counterfactual series for unemployment rates in the NUTS1 regions are based on a panel autoregressive model in first differences fitted to data provided by Eurostat Regio, which includes region specific effects as shown in equation (6.4):

$$\Delta U_{rt} = \gamma_r + \sum_{j=1}^{2} \pi_j \Delta U_{rt-j} + v_{rt}; \forall r, t \tag{6.4}$$

In (6.4), ΔU_{rt} is the (differenced) log unemployment rate for region *r* in time period *t*, and ΔU_{rt-j} denotes lagged values for region *r* with lag *j* equal to 1 to 2. Also γ_r is the time invariant fixed effect for region *r* and v_{rt} is the error term for region *r* and time *t*.[47] Equation (6.4) is estimated for unemployment using annual data for 2001 to 2008 and used to generate the forecasted values for the unemployment rate in 2008 to 2010 using dynamic forecasting. This gives an estimate of what the unemployment rate in each region would have been had the 2008 economic crisis not occurred. These counterfactual predictions of the regional unemployment rates are used as the values for $\overline{U}_{r2010}$ in equation (6.3) when generating the no recession counterfactual $\overline{E}_{i2010}$.

The second counterfactual series is generated based on average annual growth rates in the time period leading up to the 2008 crisis. These are obtained by initially calculating the average annual change in the unemployment rate over the 2001 to 2008 period[48]. Then it is assumed that this average annual rate of change would have continued into the future over the crisis period. Specifically, beginning with the 2008 rate of unemployment and applying the average annual growth rate over the 2001 to 2008 period, it is possible to generate the 2009 counterfactual unemployment rate. The same is done for 2010, using this counterfactual 2009 unemployment rate and the average annual 2001-2008 growth rate.

The third and final counterfactual unemployment rate is based on the assumption that if the 2008 crisis had not occurred the *status quo* would have been maintained. In this case it is simply assumed that the unemployment rate that would have been observed in 2010 had the crisis not occurred would be the same as the 2008 unemployment rate.

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[47] Note that since ΔU_{rt} is the first difference of log unemployment, it equates to exponential rates of growth.

[48] The average annual growth rate is calculated as $g = \left(1/T\right) * \ln\left(U_{t+T}/U_t\right)$

The merits and limitations of these three alternative approaches to generating counterfactual regional unemployment rates are discussed in Section 6.5.3. The results of the analysis using these three alternatives are presented in Table 6.3. As the substantive results remain unchanged regardless of the type of counterfactual employed (as will be seen in Table 6.3) I am confident in the robustness of this analysis to reasonable alternative specifications of the counterfactual unemployment rate.

6.4.4 Generating a Resilience Index

The measure of resilience used in this Chapter is what is called absolute resilience, which is simply equal to the difference between an individual's 'observed' probability of employment $\hat{E}_{it}$ and the individual's probability of employment coming from the no recession counterfactual $\bar{E}_{it}$, as shown by equation (6.5). Provided it is negative, the larger the difference, the less resilient the individual.

$$r_{it} = \hat{E}_{it} - \bar{E}_{it} \tag{6.5}$$

6.4.5 The Determinants of Employment Resilience

Given the resilience measure (6.5), attention now focuses on assessing the effect of individual and region-level factors on inter-individual resilience, thus

$$r_{it} = \alpha_0 + X_{it}\beta + \lambda U_{rt} + \rho W_r U_t + \mu_r + \mu_{it}; \forall i, t = 2010 \tag{6.6}$$

Apart from r_{it}, the terms X_{it}, U_{rt} and $W_r U_t$ are identical to those in equation (6.1), but equation (6.6) is estimated via OLS, given that in this case there is no restriction on the feasible range of the dependent variable and it is again assumed that the regressors are exogenous. Also in this case, considering equation (6.6) as a generalised linear model, the link function *F* is the identity and so can be omitted. For the purposes of inference, I assume that the errors μ_{it} are not independently distributed but (positively) correlated within clusters (regions). Allowing for this leads to corrected standard errors and eliminates upward bias in t-ratios, and this allows a more appropriate analysis of the effect of the individual level and regional level variables on the resilience of individuals. Note also that within-cluster correlation is also allowed for in inference involving the probit models.

6.5 Data

6.5.1 The European Social Survey

The data used in this analysis is derived from the European Social Survey (ESS). This survey gathers information from individuals aged 16 plus resident in European countries about a variety of issues ranging from the political opinions to their individual socio-economic characteristics. This Chapter is specifically concerned with data relating to the socio-economic characteristics as well as the regional identifiers within the data. The surveys were carried out in 2002, 2004, 2006, 2008, 2010 and 2012 but the 2012 survey data has only been released for selected countries (at the time this analysis was conducted) and therefore cannot be used in this analysis. Accordingly, the Chapter does not consider all European countries covered in the ESS, instead focusing on the 13 countries which were covered in each wave from 2002 to 2010 of the survey, namely Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, Ireland, the Netherlands, Norway, Portugal, Sweden and the United Kingdom.

Table 6.1 summarises the survey data of relevance to this study, showing that across the years the proportion of sampled individuals who are employed varies around 64% to 65% with the exception of 2010 where there was a drop of nearly 4 percentage points (which can be attributed to the economic crisis). Table 6.2 contains some indication of the varying interest in the survey across countries. Ireland, with about 4 million people, submitted more returns than the UK, with about 70 million. Thus the proportions in Table 6.1 are not true indications of the proportions in Europe as a whole. Nevertheless the survey as a whole amounts to about 25,000 individuals each year, or about 125,000 individuals overall, which is a large sample by most standards. Regarding the representativeness of the ESS, the sampling frame is the entire population of each country aged 16 and over. Random probability sampling is used to avoid bias. Each individual year of the ESS has a corresponding report on the representativeness of the sampling method. As an example, the ESS 2010 results are compared with the European wide Labour Force Survey (LFS) in Koch et al. (2014) to assess its representativeness of the countries surveyed.

Table 6.1: Descriptive Statistics by Year

Variable	2002	2004	2006	2008	2010
Employed	65.38%	64.16%	64.81%	64.21%	61.53%
Age Category					
16-24	11.58%	11.63%	10.93%	10.84%	11.96%
25-34	15.76%	15.33%	15.04%	14.78%	13.92%
35-44	19.86%	19.01%	18.46%	17.87%	16.84%
45-54	16.75%	16.52%	16.63%	16.95%	17.36%
55-65	15.34%	15.92%	16.39%	16.10%	16.36%
>65	20.09%	20.91%	21.95%	22.77%	22.80%
Education					
Less than lower secondary education	17.29%	18.98%	18.17%	17.81%	17.71%
Lower secondary education completed	20.02%	19.75%	18.28%	17.93%	18.43%
Upper secondary education completed	35.72%	33.35%	32.92%	32.29%	30.35%
Post-secondary non-tertiary education completed	1.88%	2.20%	2.86%	2.70%	4.52%
Tertiary education completed	24.91%	25.27%	27.76%	29.24%	28.62%
Individual Specific Factors					
Union Membership	27.17%	25.40%	24.13%	23.27%	22.44%
Female	52.05%	53.45%	53.21%	52.58%	52.39%
Number of People in Household	2.69	2.67	2.61	2.58	2.60

Source: (ESS Round 1: European Social Survey Round 1 Data, 2002; ESS Round 2: European Social Survey Round 2 Data, 2004; ESS Round 3: European Social Survey Round 3 Data, 2006; ESS Round 4: European Social Survey Round 4 Data, 2008; ESS Round 5: European Social Survey Round 5 Data, 2010)

Table 6.2 shows the number of respondents in each country and the number of NUTS1 regions per country.

Table 6.2: Sample Size by Country

Country	Number of Observations					Number of NUTS1 Regions
	2002	2004	2006	2008	2010	
Belgium	1,871	1,760	1,779	1,737	1,689	3
Denmark	1,506	1,474	1,505	1,595	1,556	1
Finland	1,968	1,994	1,870	2,172	1,846	1
France	1,498	1,798	1,973	2,058	1,707	8
Germany	2,905	2,851	2,900	2,740	3,001	16
Ireland	2,045	2,282	1,795	1,757	2,556	1
Netherlands	2,351	1,871	1,886	1,766	1,815	4
Norway	2,036	1,744	1,731	1,534	1,526	1
Portugal	1,494	2,044	2,211	2,359	2,144	1
Spain	1,713	1,658	1,872	2,560	1,882	7
Sweden	1,977	1,922	1,911	1,807	1,486	3
Switzerland	1,990	2,131	1,796	1,811	1,497	1
UK	2,043	1,771	2,379	2,337	2,340	12

6.6 The NUTS1 Regions

Note that the administration of the survey in each country is based on differing degrees of geographic disaggregation. Countries that are part of the NUTS nomenclature have a regional variable that is possible to map to the NUTS system. Some countries use NUTS 1, but others NUTS 2 or 3. The data are therefore collected at different geographical levels for each country. The level of disaggregation used also varies within countries across years. Unfortunately, as noted by Rozanska-Putek et al. (2009) this means that finding a common geographical level when combining the ESS across countries and time is problematic. Indeed they note that the lowest level of disaggregation possible is at the NUTS1 level, which is the highest, sub-national, level of regional classification used by the European Union. Ideally, lower levels of geographical disaggregation would be used but this is not possible when combining the ESS across countries. Therefore, this Chapter uses NUTS1 regions in the analysis with Table 6.3 detailing the names of NUTS1 regions in each country considered.

In an analysis of the impact of the changing economic environment over the period of the 2008 economic crisis on the likelihood of an individual being employed (controlling for their individual level characteristics), it is reasonable to suppose that higher rates of unemployment at the NUTS1 regional level will have a negative effect on the likelihood of an individual being employed, since he or she will be faced with a crowded labour market characterised by a relatively high level of surplus labour. This is the motivation for using data on regional unemployment statistics at the NUTS1 level, as are available from Eurostat Regio.

Table 6.3: NUTS1 Regions Used

NUTS1 Code	Region Name	NUTS1 Code	Region Name
BE1	Région de Bruxelles-Capitale	FR1	Île de France
BE2	Vlaams Gewest	FR2	Bassin Parisien
BE3	Région wallonne	FR3	Nord - Pas-de-Calais
CH	Switzerland	FR4	Est (FR)
DE1	Baden-Württemberg	FR5	Ouest (FR)
DE2	Bayern	FR6	Sud-Ouest (FR)
DE3	Berlin	FR7	Centre-Est (FR)
DE4	Brandenburg	FR8	Méditerranée
DE5	Bremen	IE0	Éire/Ireland
DE6	Hamburg	NL1	Noord-Nederland
DE7	Hessen	NL2	Oost-Nederland
DE8	Mecklenburg-Vorpommern	NL3	West-Nederland
DE9	Niedersachsen	NL4	Zuid-Nederland
DEA	Nordrhein-Westfalen	NO	Norway
DEB	Rheinland-Pfalz	PT1	Continente
DEC	Saarland	SE1	Östra Sverige
DED	Sachsen	SE2	Södra Sverige
DEE	Sachsen-Anhalt	SE3	Norra Sverige
DEF	Schleswig-Holstein	UKC	North East (UK)
DEG	Thüringen	UKD	North West (UK)
DK0	Danmark	UKE	Yorkshire and The Humber
ES1	Noroeste (ES)	UKF	East Midlands (UK)
ES2	Noreste (ES)	UKG	West Midlands (UK)
ES3	Comunidad de Madrid	UKH	East of England
ES4	Centro (ES)	UKI	London
ES5	Este (ES)	UKJ	South East (UK)
ES6	Sur (ES)	UKK	South West (UK)
ES7	Canarias (ES)	UKL	Wales
FI1	Manner-Suomi	UKM	Scotland
		UKN	Northern Ireland (UK)

6.7 The Counterfactual Input Series

Three alternative counterfactual series are presented. The first is what is termed the AR counterfactual, which represents the counterfactual derived from an autoregressive time series model based on the 2001 to 2008 data available for each individual region. The second is based on carrying forward the average annual growth rate of a region from the 2001 to 2008 period over the years to 2010. The third is based on an assumption that the rate of unemployment would have remained the same. For this the unemployment rate is set at the 2008 level of unemployment. Table 6.4 illustrates the no recession counterfactual series for the unemployment rate, in this case for all the major city regions of the sample (a major city region is the region in which the capital city of the country is located).

Table 6.4: Actual and Alternative Counterfactual Unemployment rates for EU NUTS0 Capital Regions

NUTS0	Actual Unemployment	AR Counterfactual Unemployment	Average Annual Growth Rate Unemployment	2008 Unemployment
BE1	17.30%	15.75%	19.85%	15.90%
CH	4.50%	3.44%	4.35%	3.30%
DE3	13.20%	14.76%	18.84%	15.20%
DK0	7.50%	3.69%	3.50%	3.40%
ES3	16.10%	5.98%	4.27%	8.70%
FI1	8.40%	6.33%	4.96%	6.40%
FR1	8.90%	7.51%	7.83%	7.20%
IE0	13.90%	4.41%	4.78%	6.00%
NL1	4.90%	3.58%	3.76%	3.40%
NO0	3.50%	2.18%	2.24%	2.50%
PT1	11.00%	7.78%	15.17%	7.70%
SE1	8.20%	5.71%	7.95%	5.90%
UKI	9.00%	5.87%	6.37%	7.10%

Note 1: AR Counterfactual refers to the counterfactual unemployment rate derived from the autoregressive model outlined in Section 4.3. The average annual growth rate unemployment counterfactual refers to the counterfactual based on the average annual growth rate from 2001 to 2008. The 2008 unemployment rate is based on the assumption that the unemployment rate would not have change from 2008 to 2010 had the crisis not occurred.

Each of these measures comes with advantages and disadvantages. In the case of the autoregressive models this has the advantage of generating dynamic forecasts based on the actual evolution of the data over the time period studied. However, the main drawback is that the relatively short time period leaves few degrees of freedom and raises questions as to the robustness of the forecasted counterfactual unemployment levels. The second approach of using the average annual growth rate and assuming that this continues post 2008 has the advantage of looking at the trend in the data and assuming this continues forward. However, the disadvantage is the average annual growth rate is based on the first and last year of the data and may be subject to these values not being representative of the time period overall. The final method has the advantage of simplicity, in that it is simply assuming that the *status quo* would continue. However, the disadvantage is that it is a big assumption to assume that the 2008 level of unemployment would not have changed if the crisis had not occurred, as the previous indicators show constant change over the 2001 to 2008 period. Therefore, to ensure robustness all three measures are employed and all three yield similar results. The reason similar results may be observed is that, even though all three counterfactuals are based on differing assumptions and calculations, the correlation coefficients between them are very high. Between the AR and average annual growth rate the correlation is 0.93. Between the AR and 2008 level measures the correlation coefficient is 0.96. Finally between the average annual growth rate and 2008 level measure the correlation coefficient is 0.87.

6.8 Empirical Results

Table 6.5 gives parameter estimates based on equation (6.1) and on the four waves of data, for 2002, 2004, 2006 and 2008 (giving approximately 25,000 observations per wave). Model (1) relates to the probit estimation of equation (6.1). Model 2 involves instrumental variable probit estimation of equation (6.1) using the three group method and Le Gallo and Paez (2013) synthetic instruments to instrument the unemployment rate. In order to assess whether endogeneity is an issue in the estimation method adopted the Wald endogeneity test is used (Stata, 2009). The null hypothesis for this test is that the specified variable (in this case the regional unemployment rate) is not endogenous. When this test is applied a p-value of 0.2385 is obtained, which indicates that there is not sufficient evidence to reject the null hypothesis in favour of the alternative hypothesis of endogeneity. The results suggest that the estimates from Model (1), the standard probit model, are consistent and not biased. Therefore, this Chapter proceeds with interpreting the estimates from Model 1 (while also presenting Model 2, the IV probit estimation, for completeness).[49]

As expected, both individual level and regional level variables impact on the probability of employment to varying degrees. It appears that younger individuals are more likely to be employed relative to those in the age category >65, with those aged between 25-34, 35-44 and 45-54 being the most likely to be employed. Regarding educational attainment, relative to those with *less than lower secondary education*, individuals with *post-secondary non-tertiary education completed* and *tertiary education completed* are the most likely to be employed. Union members have a higher probability of being employed than non-union members, and the probability of employment increases if one is a male. Also the greater the number of people in the household, the more likely the respondent is to be employed, although this is not a significant effect.

[49] Note that as Germany, France, Spain and the UK account for the majority of the regions considered I re-run the analysis using these four countries as a sub sample to test the robustness of the results. What is observed is that the results from the alternative sub-sample are consistent with the full sample results presented in Sections 6.9 and 6.9. The alternative sub-sample estimates are presented in Appendix 6.1.

From a regional perspective, having controlled for individual-level variables, there is some tentative evidence of an association between regional unemployment rates and individuals' employment probabilities. The results suggest an association between a high rate of unemployment and a lower individual employment probability. However, caution should be exercised when considering this result. It is possible that omitted variables, at the individual level, may be correlated with the regional unemployment rate, and as a result the finding of a significant regional unemployment coefficient may be spurious, if these possible omitted variables are correlated with regional unemployment. While a similar analysis is conducted in Baum and Mitchell (2010) and they interpret their finding as a net outcome of labour supply and labour demand, here, given the restricted availability of independent variables, I interpret this finding as an indication of a possible association as opposed to a causal impact. While the region of residence has a significant effect, the spatial lag of the unemployment rate this is statistically insignificant. This indicates that the labour market in neighbouring regions does not impact on an individual's probability of employment in a given region.

The regional fixed effects are included in the model estimation and a brief interpretation of these results is as follows. These results shows that, relative to the 'Belgium effect' (NUTS1 region BE1), being a resident of Denmark and Finland tends to lower the employment probability, while being resident in Portugal, Spain and Switzerland increases it. The regional dummies, on balance and across the models, show little difference between the regions of France, Germany, the Netherlands, Norway, the UK and the reference category Belgium, with effects mainly insignificantly different from zero. The higher employment probabilities associated with regions in Spain and Portugal may reflect the unsustainable growth in these economies at a time (2002 to 2008) when capital was freely available and demand was high due to boom conditions in local and international economies.

Table 6.5: Results of PROBIT Estimation of Equation (1), probability of employment

Variable	Model 1	Model 2
Constant	-0.4355*	-0.2275
	(0.2675)	(0.4475)
Age Category		
16-24	1.5867***	1.5866***
	(0.0664)	(0.0664)
25-34	1.6989***	1.6986***
	(0.0672)	(0.0675)
35-44	1.7708***	1.7710***
	(0.0804)	(0.0803)
45-54	1.6942***	1.6942***
	(0.0932)	(0.0934)
55-65	0.9712***	0.9710***
	(0.0880)	(0.0880)
Education		
Lower secondary education completed	-0.0236	-0.0235
	(0.0333)	(0.0333)
Upper secondary education completed	0.0352	0.0356
	(0.0353)	(0.0351)
Post-secondary non-tertiary education completed	0.1493***	0.1489***
	(0.0444)	(0.0446)
Tertiary education completed	0.3240***	0.3241***
	(0.0395)	(0.0394)
Individual Specific Factors		
Union Membership (1/0)	0.5095***	0.5091***
	(0.0571)	(0.0568)
Female	-0.1670***	-0.1669***
	(0.0291)	(0.0291)
Number of People in Household	0.0179	0.0177
	(0.0116)	(0.0117)
Regional Unemployment rate	-0.0306***	-0.0462***
	(0.0149)	(0.0291)
W*Regional Unemployment rate	0.0018	0.0084
	(0.0090)	(0.0170)
Year		
2002	-0.0082	-0.0083
	(0.0425)	(0.0417)
2004	0.0006	0.0078
	(0.0396)	(0.0422)
2006	0.0305	0.0346
	(0.0352)	(0.0362)
Obs	102,075	102,075
Log-Likelihood	-49512	-159378
Pseudo R2	0.2543	na

Note 1: Dummy variables representing the NUTS1 region the individual is located in are included. The coefficients of these regional controls are excluded due to space constraints but include a discussion of them in the Chapter.
2: ***, ** and * indicate significance at the 99, 95 and 90 percent levels
3: Model 1 is the probit estimation of equation (1), Model (2) is the instrumental variable probit estimation of equation (1) using Bartlett's three group method and Le Gallo and Paez (2013) synthetic instruments to generate instruments to control for potential endogeneity.
4: The p-value for the Wald test of endogeneity for Model 2 is 0.2854. This suggests that the unemployment rate is exogenous.
5: The standard error estimates are corrected for intra-cluster correlation with respect to NUTS1 regions.

6.9 Individual Employment Resilience

Table 6.6 gives the estimates from equation (6.6), with the focus now being on the effect on individual level resilience of individual level characteristics, namely education, union membership and age. As the Wald test of endogeneity indicates that the unemployment rate is exogenous, estimation is via OLS rather than instrumental variable techniques. As there are three alternative measures of the counterfactual unemployment rate, three separate sets of estimates are given in Table 6.6. The first column is based on the resilience index calculated using the AR counterfactual unemployment rate series. The second column is based on the resilience index calculated using the average annual growth rate counterfactual unemployment rate series. The final column of results is based on the resilience index calculated assuming that the 2010 unemployment rate would equal the 2008 unemployment rate. The only significant change in the results across these three alternatives is that under the second and third assumptions the age 35-44 coefficient is significant and positive. While the values of the other coefficients obviously vary according to how the counterfactual unemployment rate was calculated, the sign and significance of the variables do not change, suggesting that the results are reasonably robust.

Regarding age, it is evident that those whose probability of employment has been least affected by the crisis fall into the middle aged category, with those aged 3*5-44* the most resilient (in two of the models). In contrast, people at the extremes of the age spectrum have been affected more, so that younger individuals (in model 1) and older individuals come out as relatively less resilient (in model 2 and 3).

Table 6.6 also indicates that those with higher levels of educational attainment are more resilient than those with less education. *Tertiary education* is the most important factor enhancing resilience to the economic crisis. Tertiary education appears to convey a dual benefit to individuals; increasing their probability of employment (as seen in Table 6.5) while also increasing their resilience to economic shocks (as seen in Table 6.6). Post-secondary (but non tertiary) education conveys an advantage in terms of employment probability but does not appear to impart resilience to shocks. When considering gender, men turn out to be more resilient than women. Finally, union membership conveys resilience to individuals increasing their resilience compared to those who are not in a union. This is despite the fact that many public sector jobs are unionised, and it is the public sector which has taken the direct impact of Government inspired austerity measures in most countries.

The results also show a significant regional unemployment coefficient in the resilience analysis. However, as discussed in the previous section, causal inferences regarding this coefficient should be avoided. Instead when discussing this coefficient I cautiously interpret this as possibly providing some indication of association between the variables. However, the relationship, as discussed previously, may be spurious should a significant omitted variable bias be present. The results appear to suggest that there is a negative association between living in a high unemployment region and individual resilience. A tentative suggestion here, based on Baum and Mitchell (2010), may be that a tougher regional labour market would make it less likely for an individual to obtain employment. However, this is a preliminary conclusion from this analysis, and in order to robustly affirm this finding, more detailed analysis would need to be conducted to ensure that the issue of potential omitted variable bias had been addressed. Moreover, in contrast to the employment probability analysis, there is a significant positive effect for the spatial lag of the unemployment rate. This suggests that there may be some spatial pattern to the association between regional unemployment and individual level resilience (however, as noted earlier further analysis would be required to ensure that this association is meaningful and not a result of a spurious relationship). The presence of a spatial effect may suggest that there is also a sorting effect present. This might be hypothesised to be that more resilient individuals sort from poorly performing regions to regions which possess better labour markets. However, this hypothesis is merely a suggestion for future research and not a conclusion from this research.

Table 6.6: Estimates of equation (6), Individual Resilience

Variable	Model 1	Model 2	Model 3
Constant	0.1968***	-0.0050	-0.0027
	(0.0020)	(0.0045)	(0.0045)
Age Category			
16-24	-0.0054***	-0.0050	-0.0050
	(0.0025)	(0.0036)	(0.0036)
25-34	-0.0016	0.0046	0.0048
	(0.0022)	(0.0035)	(0.0035)
35-44	0.0001	0.0086***	0.0089***
	(0.0020)	(0.0036)	(0.0036)
45-54	-0.0022	0.0038	0.0040
	(0.0023)	(0.0035)	(0.0036)
55-65	-0.0128***	-0.0260***	-0.0263***
	(0.0037)	(0.0040)	(0.0041)
Education			
Lower secondary education completed	-0.0015	-0.0018	-0.0018
	(0.0010)	(0.0019)	(0.0019)
Upper secondary education completed	-0.0007	-0.0013	-0.0013
	(0.0009)	(0.0018)	(0.0018)
Post-secondary non-tertiary education completed	0.0009	0.0025	0.0026
	(0.0010)	(0.0020)	(0.0020)
Tertiary education completed	0.0034***	0.0076***	0.0078***
	(0.0011)	(0.0020)	(0.0021)
Individual Specific Factors			
Union Membership (1/0)	0.0066***	0.0153***	0.0156***
	(0.0020)	(0.0025)	(0.0026)
Female	-0.0012***	-0.0030***	-0.0030***
	(0.0004)	(0.0006)	(0.0006)
Number of People in Household	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)
Regional Unemployment rate	-0.0124***	-0.0074***	-0.0076***
	(0.0001)	(0.0001)	(0.0001)
W*Regional Unemployment rate	0.0013***	0.0013***	0.0013***
	(0.0001)	(0.0001)	(0.0001)
Obs	24,952	24,952	24,952
R2	0.9237	0.8667	0.8656

Note 1: Dummy variables representing the region the individual is located in are included. The coefficients of these regional controls are excluded due to space constraints but include a discussion of them in the Chapter.

2: ***, ** and * indicate significance at the 99, 95 and 90 percent levels

3: Model 1 is the probit estimation of equation (6) when the resilience index is based on the AR unemployment rate counterfactual. Model 2 is when the resilience index is based on the average annual growth of the unemployment rate counterfactual. Model 3 is when the resilience index is based on the assumption that the unemployment rate in 2010 remains the same as the rate in 2008.

4: The standard error estimates are corrected for intra-cluster correlation with respect to NUTS1 regions.

6.10 Conclusions

This Chapter analyses the resilience of individual employment to the 2008 economic crisis taking into account not only the evolution of the regional economy in which the individual resides, but also individual-specific characteristics. In doing so it is among the first studies to consider resilience from the perspective of the individual rather than an aggregate measure of employment or output at a regional level while also considering the role played by regional factors, captured by the regional unemployment rate variable, in determining the individual's likelihood of employment. This two-level approach leading to counterfactual analysis is the main innovatory contribution of the Chapter.

The analysis is accomplished through the use of five waves of the European Social Survey (ESS) which is a repeated cross-sectional survey conducted across European countries. The Chapter models employment outcomes for individuals using the 2002, 2004, 2006 and 2008 waves of the ESS and subsequently generates predicted employment outcomes for individuals using the actual economic conditions in 2010 and then by using no-recession counterfactual assumptions about regional unemployment. Thus it predicts individuals' employment probabilities on the basis of actual economic conditions experienced through the recession and on the basis of hypothetical data assuming that the crisis did not occur. It then generates a measure of resilience based on the difference between 'actual' and counterfactual employment outcomes. The focus is on employment resistance to the crisis as the period does not facilitate an analysis of recovery.

The Chapter finds that there is significant regional variation in the employment resilience of individuals. While employment outcomes in regions in Ireland, Spain and Portugal were higher in the pre-2008 period relative to German and French regions (among others), post 2008 it is observed that Spanish and Portuguese regions had lower levels of employment resilience relative to French and German regions. The majority of regions' actual employment outcomes were below the counterfactual prediction, however there is substantial heterogeneity with some regions being far more adversely affected than others. Notwithstanding heterogeneity, there is a large degree of spatial correlation in resilience, with Central European regions proving relatively more resilient than peripheral regions, with instances of low resilience increasing as distance from Germany and Eastern France increased, so that the regions of Ireland, Spain and Portugal were the most adversely affected.

Regarding the individual factors which drive resilience, having controlled for region level factors via the regional dummies and the regional unemployment rate, it is noted that more educated individuals prove more resilient than those with lower levels of education, suggesting that not only does higher levels of education increase the probability of an individual being employed (see Table 6.5) but that it also increases their employment resilience during periods of economic crisis (see Table 6.6). Likewise middle age individuals as well as those in a union are more resilient than younger and older individuals or those not in a union.

Chapter 7: Conclusions

7.1 Overview of the PhD

This PhD analyses the concept of economic resilience beginning with an analysis of historical national resilience to shocks. It then progresses to analysing the impact of the most recent economic crisis in 2007/2008 on metropolitan areas in the United States. Following this the analysis progresses to analyse the determinants of individual level resilience, focusing on two elements; wages (in a US context) and employment (in a European context). In doing so this PhD provides a detailed analysis of resilience at differing spatial scales. This Chapter summarises the contributions and findings of each Chapter and brings together the overall conclusions for the concept of resilience.

Chapter 3 provides an analysis of how selected EU economies' productivity growth paths have been affected by previous recessions and uses this to cast light on how the post-2007 economic downturn experienced across the EU and other developed economies may impact on their subsequent productivity. The Chapter focuses on the alternative concepts of resilience, engineering and environmental resilience and assesses whether shocks have a permanent or transient effect. It begins by considering the post-recession path of productivity relative to counterfactuals based on pre-recession trends. This is accomplished through the use of Vector Error Correction (VEC) models. The models are estimated up to the point of the crisis and a counterfactual post crisis growth path is derived from dynamic forecasts. Following this analysis it uses a different set of VEC models to analyses the responsiveness of economies to hypothetical domestic and external GDP shocks, addressing the question of which of domestic, US or neighbouring EU economies are more influential in terms of the responses they invoke, and, whether some economies are more exposed than others to negative spillover effects. Five European countries are analysed; Ireland, Germany, the UK, France and Italy using quarterly GDP and employment levels from 1960q1 to 2011q1. A series of five preferred VEC models are estimated which include each of these countries' GDP and employment, US GDP and employment and an aggregate of the EU15 countries' (excluding the individual country considered) GDP and employment. A preliminary comparison of the resilience of countries based on their industrial structure is carried out.

Chapter 4 builds on the work of Martin et al. (2016), Fingleton et al. (2012), Fingleton et al. (2015), and Martin (2012), who analyse the impact of recessionary shocks to UK or EU regions, by applying a dynamic spatial panel model (DSPM) estimator, following Baltagi et al. (2014), to US metropolitan statistical areas. In this Chapter I further analyse the notion that regional resilience can depend on industrial structure. The hypothesis that resilience to economic shocks is shaped by, and shapes, industrial structure, broadly defined, has been considered elsewhere in the literature (Glaeser, 2005; Glaeser et al., 2014; Martin, 2012; Combes, 2000; Quigley, 1998; Holm and Østergaard, 2015; Fingleton and Palombi, 2013). This Chapter possess a number of novel contributions which are highlighted again here. First, the modelling approach, involving both dynamic and spatial interaction, is relatively unusual and a clear advance on static spatial panel approaches which do not take account of time-dependency in spatio-temporal series. Secondly, and somewhat unusually, the DSPM estimation takes account of the potential endogeneity of the regressor, output, with respect to employment. Thirdly, the focus is essentially on city-region (i.e. MSA) resilience, in contrast to the more usual region- or country-specific estimates of resilience found in the literature. Fourthly, the analysis seeks to avoid omitted variables bias by introducing covariates, and allows for endogeneity in the regression analysis, in an attempt to obtain consistent causal effects of industrial structure on resilience.

Chapter 5 progresses the analysis from the level of the region to the level of the individual. A significant number of alternative approaches have been adopted to analyse regional economic resilience. These include case studies, the generation of indices, time series analysis and causal economic models, with the focus being on national, regional or city economies (Ormerod, 2010; Foster, 2007; Fingleton et al., 2012). This Chapter is motivated by the recent application of regional wage models to micro-data series (Fingleton and Longhi, 2013; Hering and Poncet, 2010).

Chapter 6 considers the impact of the crisis on employment resilience at the individual level across European regions. To date there has been relatively little analysis of resilience in the regional context which uses the individual as the unit of analysis. This Chapter provides insights into how individual specific characteristics and regional variations can help explain the resilience of employment outcomes during an economic crisis. Data from the European Social Survey (ESS) are used in the analysis. The model explains individual-level employment outcomes using individual specific variables together with a regional economic variable (namely unemployment rates in the NUTS1 region in which the individual is located).

7.2 Key results from the PhD

In Chapter 3 when comparing post-recession outcomes with counterfactual series the results suggest varying responses to recession. Analysis of shocks in the 1990s (and 1980s in the case of Ireland) suggest that in the case of Germany, France and Italy these shocks resulted in these countries' productivity shifting to a lower growth path. A different outcome is observed for the UK and Irish economies where productivity recovered from the recessionary shocks they experienced, with the UK even performing above expectation. The implications is that there was strong heterogeneity in the response of European countries to recessionary shocks.

When progressing the analysis through the use of impulse response functions (IRFs) the results indicate that the source of a shock has differentiated impacts across countries. However, in the short-run the impact of a shock to GDP from any source is invariably negative for productivity. External shocks from the US were a common element among the countries considered and these were found to have a permanent negative effect. In the case of all countries bar Ireland (which for much of the period was tied closely to the UK economy), this negative response to US shocks is greater than to shocks originating in the EU. It is possible that the US economy is proxying for the global economy, and the responses of countries to shocks originating in the US may in part be a reflection of their response to global shocks. The relative importance of domestic and external shocks also varies across countries with both Ireland and the UK being most vulnerable to domestic shocks. These results suggest that the ability of countries to rebound from shocks is predicated upon the origin of the shock experienced and the specific country. The results also suggest that two countries, which experience the same types of shock, may have substantially different long run outcomes resulting from the shock.

Within Chapter 3 economic structure is proposed as a possible explanation of the varying responses across countries. Martin (2010) and Martin et al. (2016) notes that one of the central elements of resilience post shock is restructuring involving structural change. In Chapter 3 it was identified that there were some similarities in how countries' industrial structure evolved following the recessionary shock. For instance, most countries, with the exception of Ireland, observed a decrease in the contribution of industry to GDP following a recession. This decrease in industry appears to have corresponded to an increased contribution to GDP from Financial intermediation, real estate, renting and business activities and also from other service activities. This suggests that following these shocks, there was a move away from traditional industry towards services. The analysis of the role of industry structure in Chapter 3 is further explored, in more details, in Chapter 4.

The central element of Chapter 4 is the analysis of whether industry structure impacts on a metropolitan statistical area's (MSA's) resistance and recovery. While Verdoorn's law is again used to provide a theoretical underpinning for the empirical estimation the lens of adaptive resilience is explored in more detail. This concept supposes that the relationship between shock-impact and industrial structure is complex and two-way, so that a shock-effect depends on industrial structure, but also industrial structure may change as a consequence of a shock. In the modelling framework developed in this Chapter, which used the dynamic spatial panel data with random effects estimator presented in Baltagi et al. (2014), this endogenous relationship between resilience and industry structure is explicitly considered. The use of this methodology is an advancement of the analysis of resilience and industry structure as it allows for causal inferences to be obtained, as it controls for the afore mentioned endogeneity.

The analysis indicates that the Krugman index and the Herfindahl index both have a negative effect on resistance, indicating that specialization increases susceptibility to shocks. In contrast post-crisis, specialisation appears to positively aid recoverability. However, the main element of interest is the significant positive effect of the Lilien index (which measures structural change). This indicates that shifts in industrial employment following a shock have a beneficial effect on post-shock recovery. Essentially suggesting that adaptive MSAs, which reorienting themselves away from impacted sectors to sectors which were not impacted by the crisis, are more resilient.

When considering Chapter 5 and 6, the main contribution of these two Chapters is to focus on the individual as the unit of analysis, as opposed to the country, region, or city level analysis more common in the literature. Beginning with Chapter 5, the results indicate that there is a large degree of heterogeneity in the geographical distribution of resilience across the US. The initial PUMA level analysis conducted in this Chapter suggested that those living in areas with higher levels of employment density (typical urban concentrations), which possess higher wages during the 2005-2007 period, are less resilient to the 2008 economic shock than people located in lowers levels of employment density. Importantly, however, I note that, when one looks overall at the relationship between employment density and proportional resilience, having controlled for individual characteristics, this negative relationship does not persist. Thus, while high employment density is correlated with low proportional resilience, this is attributable to the characteristics of the individuals rather than to inherent location-specific characteristics. In contrast for market potential it is noted that there is a positive effect on PUMA level resilience and this effect persists having controlled for individual level characteristics. Thus, living in a location with good market and supplier access imparts resilience in addition to the effects on resilience of having a college education, or being of a certain age, ethnicity or employed in a certain industrial sector..

The findings in this Chapter suggest that the is a role for economic policy on two fronts; place-based and people-centred. From the analysis conducted in Chapter 5 the results suggest that *both* people and places. As is discussed in Chapter 5, with regard to place-based intervention, this could come via policies aimed at enhancing access to markets and suppliers, both by way of investment in transport infrastructure and by attracting sectors which are best suited to the locally accessible markets and suppliers. Boosting market potential in this way would lead to wages higher than they otherwise would be, given individual characteristics which also impart additional resilience.

Chapter 6 also focuses on individual level data but extends on Chapter 5 by analysing the impact of the crisis on the probability of employment across European regions rather than focusing on wages. Significant regional variation in the employment resilience of individuals is observed with both individual and regional characteristics impacting resilience. While employment outcomes in regions in Ireland, Spain and Portugal were higher in the pre-2008 period relative to German and French regions (among others), post 2008 it is observed that Spanish and Portuguese regions had lower levels of employment resilience relative to French and German regions. Central European regions proved to be relatively more resilient than peripheral regions, with instances of low resilience increasing as distance from Germany and Eastern France increased, so that the regions of Ireland, Spain and Portugal were the most adversely affected.

Regarding the individual factors which drive resilience, having controlled for region level factors, it is noted that more educated individuals are more resilient than those with lower levels of education. These individuals were also more likely to be employed, suggesting that education not only increases the probability of employment but also increases the probability of retaining that employment during a crisis. Likewise middle age individuals as well as those in a union are more resilient than younger and older individuals or those not in a union.

7.3 Contribution of this PhD to the Analysis of Resilience

This PhD has endeavoured to make a number of contributions to the understanding of economic resilience which I summarise in this sub-section.

Firstly, there is a focus in the thesis on applying econometric models as a way to promote our understanding of resilience impacts, and as a vehicle for counterfactual and simulation of alternative scenarios. Accordingly, one contribution relates to the development and application of methods in the context of resilience analysis. The methods employed comprise one of the several alternative approaches which have been applied in the literature. Martin and Sunley (2014) summarise the alternatives thus; (i) case studies, (ii) resilience indices, (iii) statistical time series models, and (iv) causal structural models. Each of these approaches brings with it its own insights and benefits, but on the whole there has been very limited focus on the fourth element, causal structural models, in the literature. The contribution in this thesis has been to set out the possibilities and insights available from adopting an econometric-based approach to the analysis of resilience, which together with the other various approaches may help us collectively to move towards a better and fuller understanding of the subject.

More specifically, the work in the thesis utilises a series of forecasting methods to provide counterfactual estimations of economic indicators to compare with actual observations of these indicators. In doing so the work in this PhD provides a mechanism through which resilience indicators can be calculated, which show the differences between the outcomes for economies or individuals which might have been and which actually occurred. The application of these forecasting techniques in Chapter 4 is new and novel and is based on state of the art estimation and forecasting techniques published by Baltagi et al. (2014) and Fingleton (2014).

An additional area of contribution has been the focus given in some of the work to analysis at the level of the individual person, almost totally in contrast to the more usual aggregate regional-level analysis that tends to dominate the literature. While the analysis of individual or firm level data in conjunction with regional data has a long pedigree in regional science [see Fingleton and Longhi (2013) for an example of the application of individual level wage data and Baum and Mitchell (2010) for an example of regional determinants of individual employment outcomes], the work featured in Chapters 5 and 6 provides the first application of regional economic resilience to individual level data, combining regional economic indicators of predictors of individual level wage and employment resilience.

An additional contribution relates to the emphasis given to the role played by industrial structure as an important aspect of the resistance and recovery of regions and individuals to economic shocks. This is most evident in Chapter 3 and 4. Again at the individual level, in Chapters 5 employment in specific industrial sectors helps explain resilience to economic shocks when considering individuals' wages.

Together, hopefully, these contributions will be regarded as helpful in moving towards a better understanding of the impacts of shocks on regions and individuals. This has been accomplished through the use of formal economic models which have provided the theoretical lens through which resilience has been considered using applied econometric techniques.

7.4 Contributions of this PhD to the Conceptualisation of Resilience

The findings in this PhD have implications for the conceptualisation of regional economic resilience. The conceptualisation of regional economic resilience which is utilised and developed upon in this PhD is the conceptualisation presented in Martin et al. (2016), which is based on earlier work by Martin and Sunley (2014) and Martin (2012). Specifically this PhD focuses on the concepts of adaptive resilience and specifically it has focused on the use of causal economic models to provide insights into the determinants of resilience. It is the insights into the determinants of resilience which results in this PhD's contribution to the conceptualisation of regional economic resilience. Two specific contributions are highlighted in this section. The first is the contribution to the discussion on industrial structural change and the second is on the introduction of the individual as the unit of analysis in regional economic resilience studies.

7.4.1 Industrial Structural Change

One of the central elements of Martin et al. (2016) conceptualisation of resilience is the discussion of reorientation which occurs prior to the recovery phase of a shock but post the resistance phase of the shock. In this phase Martin et al. (2016) and Martin and Sunley (2014) highlights that some form of readjustment takes place whereby "the region … move[s] into new industries and technologies. Successful regions will be those that are able to restructure and reorient their human and capital resources in this way - in effect to branch into related or entirely new paths of development – and hence to renew their resilience" (Martin and Sunley, 2014: pp. 26). This reorientation is central to the concept of 'adaptive' resilience. They also highlight that resilience is a recursive process, whereby reorientation of the economy can result in better resistance to shocks and that recovery can lead to reorientation etc. Martin et al. (2016) provide five broad categories into which the factors which shape regional resilience fall; (i) industrial and business structure, (ii) financial arrangements, (iii) agency and decision making, (iv) labour market conditions, and (v) governance arrangements. As noted by Martin et al. (2016) "isolating the contribution of the multifarious determinants [of] resilience would be a major task, assuming that the requisite data were even available" (pp 569). The contribution of this PhD is to the conceptualisation of the first of these five categories, industrial and business structure.

Regarding the contribution made to this element of the conceptualisation of resilience this PhD has provided the first conceptualisation (to the authors knowledge) which has causally linked industry structure change to resistance and recovery which accounting for the recursive and endogenous nature of this industry structural change. Prior to this PhD much of the work focused on case study analysis and index analysis. However, the framework provided in this PhD allows for causal inferences to be drawn in relation to the role of structural change. This has been accomplished through the use of advanced spatial panel econometric techniques which allow for endogeneity to be controlled for.

The development made by this PhD thesis is to provide a framework whereby it is shown how to apply empirical estimation techniques to the conceptualisation of reorientation in industry structure to identify its impact on resistance and recovery. This is an advance on current conceptualisations as these have, to date, focused on case study or index approaches to assess whether there is a link between these factors. The application of an empirical technique which attempts to identify causal relationships provides an extension to the current state of the art conceptualisation of resilience.

7.4.2 The individual as the unit of analysis

The second conceptual contribution is the identification and utilisation of the individual as the unit of analysis in the resilience studies undertaken in Chapters 5 and 6. To date the analysis of regional economic resilience has used nations, administrative regions, cities, or functional urban regions, as the unit of analysis. However, as noted by Fingleton and Longhi (2013) by utilising the individual as the unit of analysis it allows for issues such as the role of gender and other individual-level characteristics to be examined as possible determinants of resilience.

The focus on the analysis of the individual in regional economics is not novel in and of itself as numerous authors have highlighted the benefits of doing so. Fingleton and Longhi (2013) highlight the increasing relevance of using the individual as the unit of analysis with reference to Garretsen and Martin's (2011) editorial in the Journal of Economic Geography which highlighted the importance of economic geographers considering the role of individual worker level heterogeneity in explaining regional variations in economic performance. Authors such as Ottaviano (2010), Van Oort et al. (2012), Ghani et al. (2013), and Jacobs et al. (2013) have described the advantages of utilising the lowest possible spatial scale of the individual or the firm when analysing issues of importance to economic geographers.

This PhD has applied this approach of using the individual as the unit of analysis to the conceptualisation of regional economic resilience by focusing on individuals' wages and employment outcomes. In doing so it has extended the conceptualisation of regional resilience, which has typically focused on economic output or aggregate employment, by focusing on outcomes at an individual level. This has allows for insights beyond the five afore mentioned resilience inducing factors proposed by Martin et al. (2016)[50]. The analysis in Chapters 5 and 6 highlight that individual heterogeneity must also be considered, with factors such as individuals' genders and union membership impacting their own resilience to shocks (and therefore the aggregate regions' resilience to shocks). This suggests that the five factors identified in the conceptualisation of resilience by Martin et al. (2016) could be augmented to include a sixth factor, the composition of the individuals within the region. With corresponding subcategories (in a similar fashion to the sub-categories of the five previous headings) including gender, age profile, and educational profile."

7.5 Limitations of the Research

In this sub-section I provide an outline of some of the limitations of this research and possible future avenues of research which could alleviate these limitations.

A limitation of Chapter 3 is the availability of quarterly time series data on employment. While annual data is available, and it is possible to impute quarterly data from this it would be ideal if actual quarterly data was available. Likewise, data on other important variables such as capital is not availably quarterly. Data prior to 1960 would also be extremely useful in identifying the compounded impact of crises over time on European countries. While for some countries better time series data is available this is not available for all countries and is not necessarily consistent in its computation. This limits resilience analysis using vector error correction methodologies to countries which have data available, which are usually advanced economies.

A limitation noted with Chapter 4 is that these interpretations are open to revision as longer series become available for analysis. The re-orientation of economies is an ongoing process and the US MSAs considered in Chapter 4 are continuing to adapt following the 2008 economic crisis. In addition it would be useful to look retrospectively at earlier recessions to see if more

[50] These being (i) industrial and business structure, (ii) financial arrangements, (iii) agency and decision making, (iv) labour market conditions, and (v) governance arrangements.

evidence could be gained regarding the determinants of resilience, taking account also of the type, strength and duration of that shock. In the Chapter examples are given such as the 1861–63 Cotton Famine, the great stock market crash of 1929, and indeed the two World wars of 1914 and 1939, each having its own particular consequences for local, regional, national and global economies. The above noted problems with data availability again play a role here as data on these time-periods are difficult to obtain. Initiatives such as the AIRO (2018) Census Mapping initiative in Ireland which is making available regional data from historical census returns goes some way towards alleviating this issue in an Irish context.

For Chapter 5 and Chapter 6 a limitation of this research is the pseudo panel nature of the data. It would be ideal if individual identifiers had been present in the data which would have allowed the Chapter to track individuals over time. This would have facilitated a full panel analysis, allowing for individual level heterogeneity to be considered. In addition to this it would also allow for a fuller consideration of the impact of the crisis on the independent variable in the models. While counterfactual estimates of what the regional indicators might have looked like had the crisis not occurred were generated in both Chapters, due to the pseudo nature of the panel it was not possible to control for possible changes in individuals' characteristics such as education and union membership. Complete panel data would allow for such an analysis and would also allow for more robust causal inferences to be drawn from the analysis. However, this data is simply not available in the current research context. Smaller samples are available which contain individual identifiers, however, typically these datasets do not provide detailed geographical data on the location of the individual. Future research, as discussed in the next sub-section, could exploit data such as the British Household Panel Survey which provides panel data on individuals. However, the sample is relatively small compared to that utilised on Chapter 5.

A limitation of Chapter 6 is that, in the case of EU regions, there is limited data available at the individual level on wages. The ESS, the data source used in this Chapter, contains information on income, but only on a ten-point scale. Therefore, in the EU context it is difficult to recreate the analysis presented in Chapter 5 and to analyse wages. While some countries possess data which may be used individually, a pan-European perspective on the impact of the crisis on wages at the individual level across Europe is not easily accomplished. Data on regional wages, available from Eurostat, may be used as an alternative approach. However, this deviates from the individual level approaches adopted in Chapter 6.

A final limitation in the analysis of employment resilience, at the individual level which can also be applied to Chapter 5 when considering individual level wages, is the absence of data on hours worked. In the context of Chapter 5 and 6 it is possible that individuals, rather than having their wages cut or losing their job may have had their hours of work increased (meaning that their wages per hour would fall) or have had their hours of work cut (meaning that while they retained employment this may have been at the cost of having their working hours significantly reduced). It would be of interest in future research to consider the impact of economic shocks on hours worked by individuals, to assess whether the shock has led to an increase in part time work as opposed to full time work.

7.5 Avenues for Future Research

The research presented here has been set in the context of the 2008 economic crisis. However, it opens a number of avenues for future research. Some of these avenues are discussed briefly in this section.

Firstly, the recovery from the 2008 economic crisis is ongoing. Therefore, as further time series data becomes available a more detailed analysis of the recovery stage of resilience will be possible. This is particularly relevant as the reorientation of economies away from sectors impacted by the economic crisis may take a significant period of time (Martin et al., 2016). Also the impact of the crisis may be long lasting in terms of its impact on regional inequality. These issues would be important future areas of research as more data becomes available. For instance, in the case of Ireland which was one of the countries worst affect by the 2008 economic crisis in Europe, census data has just become available at a very low spatial scale for the years 2006, 2011, and 2016. This data corresponds to the period just before the onset of the crisis, at the height of the crisis in Ireland, and when the economy was well into its recovery phase. Analysis of this data, which contains information on regional employment at industry level, educational attainment etc. could provide interesting insights into the role structural change across regions plays in promoting resistance to and recovery from a crisis (Central Statistics Office, 2018). Other data is also becoming available across Europe which would facilitate similar studies. For instance, the regionalised European Innovation Scoreboard provides regionalised data on regional innovation performance. An analysis of the impacts of innovation on resistance and recovery using panel data would be possible as the latest 2017 edition has just been released (European Commission, 2018).

Secondly, the European Union is currently facing the prospect of another shock giving the imminent departure of the United Kingdom from the EU. A number of significant analyses have been undertaken which have attempted to forecast the impact of Brexit on the UK economy or on the regions of Europe. Two avenues of future research, using the types of methodologies developed in this PhD, may be possible post-Brexit. These are discussed in the following paragraphs.

Recent work by Los et al. (2017) highlights that the regions which voted most strongly to leave the EU are the regions most dependent upon EU funding. The authors suggest that the impact of leaving the EU is likely to be most keenly felt in these regions. Post-Brexit the types of analysis conducted in Chapters 4, 5, and 6, could be performed for UK regions and individuals. This would facilitate an analysis of how regions within the UK have been affected by leaving the EU, possibly considering the role structural change may play in explaining resistance to and recovery from the impact of the shock. Data for such an analysis is readily available from the ONS. The individual level analysis could focus on the impact of the shock on wages or employment levels and could utilise data such as the British Household Panel Survey. This would provide information on the key variables of interest used in Chapters 5 and 6 of this PhD which would allow for an analysis of the resistance and recovery of wages and employment outcomes of individuals following Brexit.

The second avenue of research within this Brexit theme could be the analysis of the impact of Brexit on other European regions. Forecasting models similar to those used in Chapter 4 of this PhD are being employed by papers such as Fingleton (2018) who analyses the possible impact of Brexit on job shortfalls across UK and European regions. His analysis identifies regions which are particularly exposed to Brexit, within the UK and also outside. His findings suggest that the impact on Irish regions and regions in the South-East of the UK is likely to be particularly adverse. This analysis is based on simulating the Brexit effect, essentially forecasting what the impact will be post-2018. Once regional data become available post-2018 the methods employed in Chapter 4 could be utilised to assess the impact of Brexit on European regions. It is worth noting that the methodologies utilise din the PhD operate on the assumption that the shock has happened and that post-shock data is available. However, the methods could be augmented to provide counterfactual forecasts under different Brexit scenarios. This could provide interesting insights as to how Brexit could have progressed under different conditions.

Appendix for Chapter 4

Table A4.1: IV Estimation of Resistance

VARIABLES	(1) TGM Resistance	(2) W*l Resistance	(3) W*TGM Resistance	(4) LeGallo Resistance	(5) Full Resistance
Lilen 2007-09	-0.270	2.895	4.919	-0.305	-0.270
	(0.341)	(4.519)	(6.965)	(1.780)	(0.326)
Krugman D-Index	-0.0733**	-0.210	-0.297	-0.0718	-0.0769**
	(0.0324)	(0.193)	(0.303)	(0.0766)	(0.0308)
Herfindahl Index	-0.00324**	0.00333	0.00753	-0.00331	-0.00329**
	(0.00162)	(0.00980)	(0.0148)	(0.00406)	(0.00162)
Log of population density	-0.00249	0.00112	0.00344	-0.00253	-0.00280
	(0.00283)	(0.00622)	(0.00929)	(0.00324)	(0.00276)
% Bachelor Degree	0.000844**	0.000711	0.000626	0.000845**	0.000869**
	(0.000379)	(0.000547)	(0.000753)	(0.000382)	(0.000377)
Construction	-0.280*	-0.504	-0.647	-0.277	-0.280*
	(0.145)	(0.368)	(0.546)	(0.185)	(0.144)
Manufacturing	-0.304***	-0.281**	-0.266	-0.304***	-0.308***
	(0.103)	(0.137)	(0.174)	(0.102)	(0.102)
Wholesale trade	-0.0732	0.388	0.684	-0.0783	-0.0870
	(0.312)	(0.751)	(1.179)	(0.424)	(0.310)
Retail trade	-0.123	-0.197	-0.245	-0.123	-0.123
	(0.129)	(0.221)	(0.328)	(0.137)	(0.128)
Transportation etc.	-0.0453	-0.0670	-0.0809	-0.0450	-0.0482
	(0.131)	(0.187)	(0.258)	(0.131)	(0.130)
Information etc.	0.0900	0.425	0.639	0.0862	0.0776
	(0.317)	(0.638)	(0.915)	(0.355)	(0.315)
Finance insurance	-0.490***	-0.658**	-0.765*	-0.488***	-0.492***
	(0.136)	(0.293)	(0.450)	(0.167)	(0.136)
Professional	-0.235	-0.192	-0.165	-0.235	-0.237
	(0.149)	(0.226)	(0.307)	(0.151)	(0.149)
Educational	-0.161	-0.0616	0.00228	-0.163	-0.171
	(0.112)	(0.212)	(0.295)	(0.122)	(0.111)
Arts entertainment	-0.267**	-0.109	-0.00851	-0.269**	-0.271**
	(0.110)	(0.268)	(0.407)	(0.135)	(0.109)
Other services	-0.457**	-0.724	-0.894	-0.454	-0.474**
	(0.229)	(0.488)	(0.740)	(0.280)	(0.227)
Public administration	-0.104	-0.0525	-0.0193	-0.105	-0.116
	(0.120)	(0.173)	(0.231)	(0.120)	(0.118)
Middle Atlantic	0.0172**	0.0171**	0.0171**	0.0172**	0.0168**
	(0.00788)	(0.00684)	(0.00813)	(0.00791)	(0.00787)
East North Central	-0.00515	-0.00165	0.000583	-0.00519	-0.00487
	(0.00853)	(0.00926)	(0.0121)	(0.00885)	(0.00851)
West North Central	0.0198**	0.0303	0.0369	0.0197*	0.0193**
	(0.00892)	(0.0189)	(0.0279)	(0.0103)	(0.00886)
South Atlantic	-0.000707	-0.00191	-0.00269	-0.000693	-0.000169
	(0.00799)	(0.00780)	(0.00968)	(0.00808)	(0.00796)
East South Central	0.0107	0.0119	0.0127	0.0107	0.0103
	(0.00905)	(0.00973)	(0.0120)	(0.00910)	(0.00899)
West South Central	0.0293***	0.0274**	0.0262*	0.0293***	0.0295***
	(0.00863)	(0.0110)	(0.0154)	(0.00880)	(0.00859)
Mountain	-0.00315	-0.00649	-0.00863	-0.00311	-0.00377
	(0.0103)	(0.0128)	(0.0171)	(0.0107)	(0.0102)
Pacific	-0.00967	-0.0192	-0.0254	-0.00957	-0.00958
	(0.00880)	(0.0167)	(0.0255)	(0.0111)	(0.00870)
Constant	0.171*	0.197*	0.213	0.171*	0.178*

	(0.0917)	(0.115)	(0.151)	(0.0938)	(0.0909)
Observations	341	341	341	341	341
R-squared	0.339	0. 340	0. 340	0.339	0.339
	296.631	1.38516	.868249	2.93688	73.4317

Note 1: Robust standard errors in parentheses
2: : ***, ** and * indicate significance at the 99, 95 and 90 percent level.

Table A4.2: IV Estimation of Recovery

VARIABLES	(1) TGM Recovery	(2) W*l Recovery	(3) W*TGM Recovery	(4) LeGallo Recovery	(5) Full Recovery
Lilen 2009-14	0.515*	-106.1	-3.802	1.729	0.473*
	(0.289)	(1,259)	(30.37)	(1.291)	(0.277)
Krugman D-Index	0.103**	3.808	0.253	0.0606	0.0865**
	(0.0414)	(43.67)	(1.054)	(0.0602)	(0.0405)
Herfindahl Index	0.00435**	-0.382	-0.0113	0.00875**	0.00472***
	(0.00197)	(4.560)	(0.111)	(0.00438)	(0.00169)
Log of population density	0.00912**	-0.129	0.00354	0.0107**	0.00725**
	(0.00388)	(1.609)	(0.0388)	(0.00472)	(0.00345)
% Bachelor Degree	0.00218***	-0.0109	0.00164	0.00232***	0.00187***
	(0.000633)	(0.155)	(0.00380)	(0.000757)	(0.000586)
Construction	-0.117	-2.022	-0.194	-0.0956	0.139
	(0.258)	(25.05)	(0.819)	(0.227)	(0.182)
Manufacturing	-0.443**	-9.937	-0.828	-0.335*	-0.250
	(0.220)	(113.3)	(2.874)	(0.174)	(0.157)
Wholesale trade	-0.113	-0.940	-0.147	-0.104	0.0454
	(0.411)	(17.10)	(0.791)	(0.421)	(0.377)
Retail trade	-0.167	-18.26	-0.900	0.0388	-0.0424
	(0.235)	(213.8)	(5.326)	(0.239)	(0.191)
Transportation etc.	-0.379*	-11.37	-0.824	-0.253	-0.206
	(0.222)	(131.1)	(3.396)	(0.204)	(0.181)
Information etc.	-0.648	0.493	-0.602	-0.661	-0.333
	(0.410)	(22.93)	(0.964)	(0.480)	(0.343)
Finance insurance	-0.163	-0.974	-0.196	-0.154	-0.00469
	(0.237)	(12.71)	(0.528)	(0.223)	(0.193)
Professional	-0.442	-0.523	-0.446	-0.441	-0.267
	(0.271)	(9.579)	(0.469)	(0.294)	(0.218)
Educational	-0.601**	-7.069	-0.863	-0.528**	-0.368**
	(0.248)	(78.08)	(2.064)	(0.206)	(0.169)
Arts entertainment	-0.694***	-8.094	-0.994	-0.610***	-0.469***
	(0.225)	(89.34)	(2.291)	(0.190)	(0.160)
Other services	0.127	8.552	0.468	0.0305	0.207
	(0.317)	(99.70)	(2.497)	(0.343)	(0.317)
Public administration	-0.768***	-10.96	-1.181	-0.652***	-0.565***
	(0.244)	(121.7)	(3.111)	(0.202)	(0.181)
Middle Atlantic	0.00772	0.271	0.0184	0.00472	0.00626
	(0.00865)	(3.137)	(0.0781)	(0.00956)	(0.00836)
East North Central	0.0232***	0.133	0.0277	0.0220**	0.0229***
	(0.00884)	(1.320)	(0.0343)	(0.00938)	(0.00868)
West North Central	0.0264***	-0.0965	0.0214	0.0278***	0.0270***
	(0.00949)	(1.456)	(0.0382)	(0.0101)	(0.00936)
South Atlantic	0.0256***	0.247	0.0346	0.0231**	0.0250***
	(0.00890)	(2.639)	(0.0648)	(0.0105)	(0.00865)
East South Central	0.0308***	0.0961	0.0335	0.0301***	0.0320***
	(0.0114)	(0.823)	(0.0254)	(0.0115)	(0.0111)
West South Central	0.0486***	0.848	0.0810	0.0395***	0.0449***
	(0.0113)	(9.379)	(0.229)	(0.0136)	(0.0107)
Mountain	0.0210*	0.0856	0.0236	0.0202	0.0212*
	(0.0122)	(0.884)	(0.0261)	(0.0136)	(0.0118)
Pacific	0.0170	-0.0238	0.0154	0.0175	0.0218*
	(0.0125)	(0.573)	(0.0229)	(0.0129)	(0.0112)
Constant	0.285	4.067	0.438	0.242	0.120
	(0.187)	(45.98)	(1.254)	(0.158)	(0.137)
Observations	341	341	341	341	341

R-squared	0.418	0.318	0.327	0.317	0.403
	186.798	.006901	.03637	5.41231	49.2878

Note 1: Robust standard errors in parentheses
2: : ***, ** and * indicate significance at the 99, 95 and 90 percent level.

Table A4.3: Alternative estimation of Table 4.5

VARIABLES	(1) Resistance	(2) Recovery	(3) Recovery
Lilen 2007-09	-0.278		
	(0.325)		
Lilen 2009-14		0.495*	0.506*
		(0.278)	(0.275)
Krugman D-Index	-0.0770**	0.0865**	0.0806**
	(0.0308)	(0.0407)	(0.0391)
Herfindahl Index	-0.00344**	0.00508***	0.00493***
	(0.00165)	(0.00171)	(0.00172)
Resistance			-0.0778
			(0.0663)
22 additional variables plus constant	l.i.	l.i.	l.i.
Observations	341	341	341
R-squared	0.338	0.398	0.400

l.i. denotes of limited interest
Note 1: Robust standard errors in parentheses
Note 2: *** p<0.01, ** p<0.05, * p<0.1

Appendix for Chapter 5

Appendix 5.1: Full Results of Factors affecting wage levels

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-4.1907***	-2.0200***	-1.4061***	-6.3437***	-6.1317***
	(1.0290)	(1.2904)	(2.5384)	(0.9745)	(0.9770)
Age	0.0893***	0.0894***	0.0895***	0.0892***	0.0893***
	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0005)
Age2	-0.0010***	-0.0010***	-0.0010***	-0.0010***	-0.0010***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sex	-0.3238***	-0.3237***	-0.3238***	-0.3242***	-0.3242***
	(0.0024)	(0.0024)	(0.0025)	(0.0024)	(0.0024)
Marital Status					
Married, spouse absent	-0.0816***	-0.0822***	-0.0840***	-0.0813***	-0.0814***
	(0.0044)	(0.0044)	(0.0047)	(0.0044)	(0.0045)
Separated	-0.1305***	-0.1309***	-0.1326***	-0.1305***	-0.1306***
	(0.0034)	(0.0034)	(0.0035)	(0.0034)	(0.0034)
Divorced	-0.0416***	-0.0425***	-0.0438***	-0.0410***	-0.0411***
	(0.0018)	(0.0018)	(0.0020)	(0.0018)	(0.0018)
Widowed	-0.1024***	-0.1025***	-0.1029***	-0.1028***	-0.1028***
	(0.0037)	(0.0037)	(0.0037)	(0.0037)	(0.0037)
Never married/single	-0.1407***	-0.1416***	-0.1452***	-0.1411***	-0.1413***
	(0.0024)	(0.0025)	(0.0032)	(0.0024)	(0.0024)
Ethnicity					
African American	-0.1415***	-0.1425***	-0.1467***	-0.1423***	-0.1426***
	(0.0039)	(0.0039)	(0.0046)	(0.0038)	(0.0038)
American Indian or Alaska Native	-0.0235	-0.0254	-0.0189	-0.0179	-0.0178
	(0.0168)	(0.0154)	(0.0162)	(0.0178)	(0.0177)
Chinese	-0.1636***	-0.1637***	-0.1698***	-0.1671***	-0.1672***
	(0.0089)	(0.0089)	(0.0099)	(0.0088)	(0.0088)
Japanese	0.0141	0.0095	0.0049	0.0019	0.0016
	(0.0160)	(0.0152)	(0.0151)	(0.0135)	(0.0135)
Other Asian or Pacific Islander	-0.1029***	-0.1040***	-0.1087***	-0.1081***	-0.1083***
	(0.0059)	(0.0058)	(0.0065)	(0.0052)	(0.0052)
Other Race	-0.1268***	-0.1289***	-0.1333***	-0.1266***	-0.1269***
	(0.0046)	(0.0046)	(0.0054)	(0.0047)	(0.0047)
Two major races	-0.0711***	-0.0730***	-0.0749***	-0.0740***	-0.0742***
	(0.0058)	(0.0054)	(0.0056)	(0.0052)	(0.0052)
Three or more major races	-0.0543***	-0.0585***	-0.0622***	-0.0746***	-0.0749***
	(0.0224)	(0.0212)	(0.0208)	(0.0184)	(0.0184)
Education					
Nursery School to Grade 4	-0.0398***	-0.0401***	-0.0399***	-0.0400***	-0.0400***
	(0.0150)	(0.0150)	(0.0150)	(0.0150)	(0.0150)
Grade 5, 6, 7 or 8	0.0515***	0.0518***	0.0524***	0.0509***	0.0509***
	(0.0129)	(0.0129)	(0.0129)	(0.0129)	(0.0129)

Grade 9	0.1169***	0.1176***	0.1188***	0.1162***	0.1163***
	(0.0136)	(0.0136)	(0.0135)	(0.0136)	(0.0136)
Grade 10	0.1691***	0.1703***	0.1723***	0.1687***	0.1689***
	(0.0132)	(0.0132)	(0.0132)	(0.0132)	(0.0132)
Grade 11	0.1984***	0.1994***	0.2017***	0.1981***	0.1983***
	(0.0131)	(0.0131)	(0.0131)	(0.0131)	(0.0131)
Grade 12	0.3604***	0.3615***	0.3633***	0.3595***	0.3597***
	(0.0126)	(0.0126)	(0.0126)	(0.0126)	(0.0126)
1 year of college	0.4801***	0.4800***	0.4806***	0.4798***	0.4798***
	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0127)
2 years of college	0.5811***	0.5815***	0.5825***	0.5805***	0.5806***
	(0.0129)	(0.0129)	(0.0129)	(0.0129)	(0.0129)
4 years of college	0.8289***	0.8289***	0.8274***	0.8280***	0.8280***
	(0.0129)	(0.0129)	(0.0129)	(0.0129)	(0.0129)
5+ years of college	1.0976***	1.0978***	1.0951***	1.0961***	1.0961***
	(0.0130)	(0.0130)	(0.0132)	(0.0130)	(0.0130)
Industry					
Mining	0.6401***	0.6393***	0.6377***	0.6408***	0.6407***
	(0.0172)	(0.0171)	(0.0176)	(0.0174)	(0.0174)
Utilities	0.4743***	0.4727***	0.4636***	0.4725***	0.4720***
	(0.0104)	(0.0105)	(0.0118)	(0.0105)	(0.0105)
Construction	0.3032***	0.3010***	0.2900***	0.3005***	0.3000***
	(0.0100)	(0.0100)	(0.0120)	(0.0100)	(0.0100)
Manufacturing	0.3303***	0.3290***	0.3183***	0.3276***	0.3272***
	(0.0097)	(0.0098)	(0.0117)	(0.0098)	(0.0098)
Wholesale Trade	0.2910***	0.2885***	0.2763***	0.2889***	0.2883***
	(0.0098)	(0.0099)	(0.0122)	(0.0099)	(0.0099)
Retail Trade	0.0249***	0.0225***	0.0109***	0.0229***	0.0223***
	(0.0096)	(0.0097)	(0.0118)	(0.0097)	(0.0097)
Transportation and Warehousing	0.2825***	0.2803***	0.2687***	0.2804***	0.2798***
	(0.0100)	(0.0101)	(0.0123)	(0.0101)	(0.0101)
Information and Communications	0.3010***	0.2986***	0.2849***	0.2981***	0.2974***
	(0.0103)	(0.0105)	(0.0132)	(0.0104)	(0.0104)
Finance, Insurance, Real Estate, and Rental and Leasing	0.3613***	0.3586***	0.3450***	0.3586***	0.3579***
	(0.0103)	(0.0103)	(0.0131)	(0.0103)	(0.0103)
Professional, Scientific, Management, Administrative, and Waste Management Services	0.2453***	0.2429***	0.2293***	0.2425***	0.2419***
	(0.0101)	(0.0102)	(0.0130)	(0.0101)	(0.0101)
Educational, Health and Social Services	0.1059***	0.1038***	0.0928***	0.1037***	0.1032***
	(0.0097)	(0.0098)	(0.0117)	(0.0098)	(0.0098)
Arts, Entertainment, Recreation, Accommodations, and Food Services	-0.1483***	-0.1511***	-0.1633***	-0.1520***	-0.1526***
	(0.0104)	(0.0104)	(0.0125)	(0.0104)	(0.0104)
Other Services (Except Public Administration)	-0.1140***	-0.1163***	-0.1281***	-0.1163***	-0.1169***
	(0.0102)	(0.0103)	(0.0125)	(0.0103)	(0.0103)

Public Administration	0.2961***	0.2943***	0.2835***	0.2937***	0.2932***
	(0.0098)	(0.0100)	(0.0119)	(0.0099)	(0.0099)
Year					
2005	0.0128***	0.0134***	0.0133***	0.0121***	0.0121***
	(0.0013)	(0.0014)	(0.0015)	(0.0013)	(0.0013)
2006	0.0134***	0.0233***	0.0260***	0.0034***	0.0044***
	(0.0049)	(0.0061)	(0.0117)	(0.0047)	(0.0047)
Weeks Worked					
14-26	0.8421***	0.8420***	0.8419***	0.8416***	0.8416***
	(0.0096)	(0.0096)	(0.0096)	(0.0097)	(0.0097)
27-39	1.3460***	1.3460***	1.3464***	1.3455***	1.3455***
	(0.0089)	(0.0089)	(0.0089)	(0.0089)	(0.0089)
40-47	1.6707***	1.6706***	1.6702***	1.6696***	1.6695***
	(0.0085)	(0.0085)	(0.0085)	(0.0085)	(0.0085)
48-49	1.8942***	1.8937***	1.8929***	1.8936***	1.8936***
	(0.0086)	(0.0086)	(0.0086)	(0.0086)	(0.0086)
50-52	2.0384***	2.0384***	2.0378***	2.0372***	2.0372***
	(0.0083)	(0.0083)	(0.0083)	(0.0082)	(0.0082)
PUMA-level Variables					
ln(Employment Density)	0.0245***	0.0318***	0.0443***	0.0215***	0.0225***
	(0.0031)	(0.0032)	(0.0080)	(0.0030)	(0.0030)
ln(Market Potential)	0.9967***	0.7848***	0.7194***	1.2049***	1.1840***
	(0.0991)	(0.1245)	(0.2454)	(0.0939)	(0.0941)
R2	0.4723	0.4723	0.4719	0.4725	0.4725
Obs.	1988212	1988212	1988212	1988212	1988212

Note 1: PUMA level dummies are included in the model but not presented here in order to save space.

2: ***, ** and * indicate significance at the 99, 95 and 90 percent level.

3: Estimates based on ACS 2005-2007 for those employed.

4: Model 1 refers to the use of Bartlett's three group method, Model 2 refers to the Le Gallo and Paez (2013) instruments, Model 3 refers to the alternative Le Gallo and Paez (2013) instruments which exclude the weighting of the eignvectors by their respective coefficient, Model 4 refers to Bartlett's three group method and the spatial lags of Bartlett's three group method and finally Model 5 refers to Bartlett's three group method, the spatial lags of Bartlett's three group method and the alternative Le Gallo and Paez (2013) instruments.

Appendix 5.2: Full Results of Factors Affecting Individual Resilience

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-1.4960***	-1.1459***	-1.0208***	-1.6957***	-1.6900***
	(0.1126)	(0.1491)	(0.2742)	(0.1117)	(0.1119)
Age	0.0023***	0.0021***	0.0021***	0.0024***	0.0024***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Age2	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Sex	0.0012***	0.0016***	0.0017***	0.0008***	0.0009***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Marital Status					
Married, spouse absent	-0.0025**	-0.0023**	-0.0020**	-0.0026***	-0.0026***
	(0.0010)	(0.0010)	(0.0010)	(0.0011)	(0.0011)
Separated	-0.0004	-0.0002	0.0002	-0.0006	-0.0005
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Divorced	-0.0024***	-0.0023***	-0.0021***	-0.0025***	-0.0025***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Widowed	0.0016**	0.0018***	0.0019***	0.0016**	0.0016**
	(0.0007)	(0.0007)	(0.0007)	(0.0008)	(0.0008)
Never married/single	-0.0078***	-0.0075***	-0.0068***	-0.0081***	-0.0080***
	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0005)
Ethnicity					
African American	-0.0011**	-0.0007	0.0002	-0.0014**	-0.0013**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
American Indian or Alaska Native	0.0047	0.0043	0.0024	0.0048	0.0047
	(0.0036)	(0.0029)	(0.0025)	(0.0039)	(0.0038)
Chinese	0.0016	0.0022*	0.0036***	0.0011	0.0012
	(0.0013)	(0.0013)	(0.0014)	(0.0013)	(0.0013)
Japanese	-0.0075***	-0.0068**	-0.0059**	-0.0085***	-0.0084***
	(0.0032)	(0.0030)	(0.0030)	(0.0032)	(0.0032)
Other Asian or Pacific Islander	-0.0010	-0.0005	0.0005	-0.0014*	-0.0014
	(0.0009)	(0.0009)	(0.0010)	(0.0008)	(0.0008)
Other Race	0.0022***	0.0025***	0.0033***	0.0019**	0.0020***
	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0008)
Two major races	-0.0068***	-0.0064***	-0.0060***	-0.0070***	-0.0070***
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Three or more major races	-0.0039	-0.0034	-0.0027	-0.0054	-0.0053
	(0.0040)	(0.0038)	(0.0038)	(0.0037)	(0.0037)
Education					
Nursery School to Grade 4	0.0117***	0.0117***	0.0117***	0.0117***	0.0117***
	(0.0030)	(0.0029)	(0.0029)	(0.0030)	(0.0030)
Grade 5, 6, 7 or 8	0.0038	0.0037	0.0036	0.0039	0.0038
	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Grade 9	0.0006	0.0004	0.0003	0.0007	0.0007
	(0.0026)	(0.0026)	(0.0026)	(0.0027)	(0.0027)

Grade 10	0.0037	0.0034	0.0030	0.0041	0.0040
	(0.0026)	(0.0026)	(0.0026)	(0.0027)	(0.0026)
Grade 11	0.0062***	0.0058**	0.0053**	0.0066***	0.0065***
	(0.0026)	(0.0025)	(0.0025)	(0.0026)	(0.0026)
Grade 12	0.0063***	0.0057**	0.0052**	0.0070***	0.0069***
	(0.0024)	(0.0024)	(0.0023)	(0.0024)	(0.0024)
1 year of college	0.0037	0.0030	0.0027	0.0044*	0.0043*
	(0.0024)	(0.0024)	(0.0023)	(0.0024)	(0.0024)
2 years of college	0.0115***	0.0105***	0.0101***	0.0126***	0.0124***
	(0.0024)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
4 years of college	0.0137***	0.0126***	0.0125***	0.0151***	0.0150***
	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0024)
5+ years of college	0.0174***	0.0159***	0.0161***	0.0190***	0.0189***
	(0.0025)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
Industry					
Mining	0.0077***	0.0067***	0.0067***	0.0086***	0.0085***
	(0.0022)	(0.0022)	(0.0022)	(0.0023)	(0.0023)
Utilities	0.0003	-0.0001	0.0014	0.0008	0.0008
	(0.0015)	(0.0015)	(0.0016)	(0.0015)	(0.0015)
Construction	-0.0022	-0.0023	-0.0004	-0.0019	-0.0018
	(0.0015)	(0.0015)	(0.0017)	(0.0015)	(0.0015)
Manufacturing	-0.0037***	-0.0039***	-0.0019	-0.0033***	-0.0033**
	(0.0014)	(0.0014)	(0.0016)	(0.0014)	(0.0014)
Wholesale Trade	-0.0062***	-0.0062***	-0.0040***	-0.0059***	-0.0058***
	(0.0015)	(0.0015)	(0.0018)	(0.0015)	(0.0015)
Retail Trade	-0.0125***	-0.0121***	-0.0099***	-0.0127***	-0.0126***
	(0.0014)	(0.0014)	(0.0017)	(0.0015)	(0.0015)
Transportation and Warehousing	-0.0074***	-0.0074***	-0.0053***	-0.0071***	-0.0070***
	(0.0015)	(0.0015)	(0.0018)	(0.0015)	(0.0015)
Information and Communications	-0.0097***	-0.0096***	-0.0071***	-0.0096***	-0.0095***
	(0.0016)	(0.0017)	(0.0020)	(0.0017)	(0.0017)
Finance, Insurance, Real Estate, and Rental and Leasing	-0.0076***	-0.0077***	-0.0052***	-0.0073***	-0.0072***
	(0.0015)	(0.0015)	(0.0018)	(0.0015)	(0.0015)
Professional, Scientific, Management, Administrative, and Waste Management Services	-0.0090***	-0.0088***	-0.0063***	-0.0089***	-0.0088***
	(0.0015)	(0.0015)	(0.0018)	(0.0015)	(0.0015)
Educational, Health and Social Services	-0.0124***	-0.0122***	-0.0102***	-0.0125***	-0.0123***
	(0.0014)	(0.0014)	(0.0017)	(0.0015)	(0.0015)
Arts, Entertainment, Recreation, Accommodations, and Food Services	-0.0116***	-0.0111***	-0.0087***	-0.0120***	-0.0118***
	(0.0015)	(0.0015)	(0.0018)	(0.0015)	(0.0015)
Other Services (Except Public Administration)	-0.0144***	-0.0137***	-0.0114***	-0.0148***	-0.0146***
	(0.0015)	(0.0016)	(0.0018)	(0.0016)	(0.0016)

Public Administration	-0.0028**	-0.0028**	-0.0009	-0.0026*	-0.0025*
	(0.0014)	(0.0014)	(0.0017)	(0.0014)	(0.0014)
Weeks Worked					
14-26	0.0547***	0.0521***	0.0514***	0.0572***	0.0569***
	(0.0026)	(0.0026)	(0.0025)	(0.0026)	(0.0026)
27-39	0.0672***	0.0637***	0.0626***	0.0708***	0.0705***
	(0.0025)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
40-47	0.0823***	0.0781***	0.0770***	0.0865***	0.0861***
	(0.0024)	(0.0024)	(0.0023)	(0.0024)	(0.0024)
48-49	0.0799***	0.0755***	0.0744***	0.0843***	0.0839***
	(0.0025)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
50-52	0.1025***	0.0976***	0.0964***	0.1075***	0.1071***
	(0.0023)	(0.0022)	(0.0022)	(0.0023)	(0.0023)
PUMA-level Variables					
ln(Employment Density)	-0.0015***	-0.0015***	-0.0036***	-0.0013***	-0.0015***
	(0.0003)	(0.0003)	(0.0010)	(0.0004)	(0.0004)
ln(Market Potential)	0.1136***	0.0825***	0.0724***	0.1304***	0.1301***
	(0.0108)	(0.0143)	(0.0263)	(0.0107)	(0.0107)
R2	0.0578	0.0536	0.0530	0.0625	0.0620
Obs.	671472	671472	671472	671472	671472
F-tests					
Marital Status	335.79***	312.65***	198.30***	347.22***	340.60***
Age	547.39***	518.91***	508.42***	580.07***	576.55***
Race	49.54***	49.25***	51.06***	54.86***	54.09***
Education	646.32***	581.61***	502.66***	734.07***	732.26***
Industry	951.56***	911.74***	754.99***	1033.30***	1024.45***
Weeks Worked	4443.85***	4271.08***	4271.91***	4631.90***	4616.52***
PUMA Market Potential and Employment Density	124.65***	35.61***	15.71***	180.91***	168.25***

Note 1: PUMA level dummies are included in the model but not presented here in order to save space.

2: ***, ** and * indicate significance at the 99, 95 and 90 percent level.

3: standard errors are in parentheses, p-values for F-tests are in square brackets.

4: Model 1 refers to the use of Bartlett's three group method, Model 2 refers to the Le Gallo and Paez (2013) instruments, Model 3 refers to the alternative Le Gallo and Paez (2013) instruments which exclude the weighting of the eignvectors by their respective coefficient, Model 4 refers to Bartlett's three group method and the spatial lags of Bartlett's three group method and finally Model 5 refers to Bartlett's three group method, the spatial lags of Bartlett's three group method and the alternative Le Gallo and Paez (2013) instruments.

Appendix for Chapter 6

Appendix 6.1 – Sub Sample of Germany, France, Spain and the UK

Variable	Probit - Employment	OLS - Resilience
Constant	-0.6485***	0.0164***
	(0.0741)	(0.0015)
Age Category		
16-24	1.7156***	-0.0017
	(0.0600)	(0.0012)
25-34	1.6770***	-0.0016
	(0.0475)	(0.0011)
35-44	1.7985***	0.0014
	(0.0512)	(0.0016)
45-54	1.7045***	-0.0016
	(0.0552)	(0.0011)
55-65	0.9286***	-0.0117***
	(0.0449)	(0.0031)
Education		
Lower secondary education completed	0.0379	0.0004
	(0.0363)	(0.0008)
Upper secondary education completed	-0.0128	0.0005
	(0.0373)	(0.0009)
Post-secondary non-tertiary education completed	0.1289***	0.0023
	(0.0487)	(0.0014)
Tertiary education completed	0.2970***	0.0044***
	(0.0347)	(0.0018)
Individual Specific Factors		
Union Membership (1/0)	0.5538***	0.0090***
	(0.0619)	(0.0028)
Female	-0.1333***	-0.0010***
	(0.0295)	(0.0005)
Number of People in Household	0.0090	-0.0002
	(0.0082)	(0.0001)
Regional Unemployment rate	-0.0278***	-0.0056***
	(0.0116)	(0.0000)
W*Regional Unemployment rate	0.0031	0.0014***
	(0.0149)	(0.0000)
Year		
2002	0.0552	na
	(0.0259)	
2004	0.0503	na
	(0.0299)	
2006	0.0668	na
	(0.0284)	
Obs	34,889	8,901

Log-Likelihood	-17358	na
Pseudo R2	0.2484	0.9354

Note 1: Dummy variables representing the region the individual is located in are included. I exclude the coefficients of these regional controls due to space constraints but include a discussion of them in the Chapter.
2: ***, ** and * indicate significance at the 99, 95 and 90 percent levels
3: I cluster the error term of the model based upon NUTS1 regions.
4: The probit estimation is comparable to Table 6.5 but with just the four countries included. The OLS equation is comparable to Table 6.6 but just based on the four countries included.

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