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RECESSIONARY SHOCKS AND REGIONAL EMPLOYMENT: EVIDENCE ON THE RESILIENCE OF U.K. REGIONS*

Bernard Fingleton
Department of Land Economy, University of Cambridge, Cambridge, CB3 9EP, United Kingdom. E-mail: bf100@cam.ac.uk

Harry Garretsen
Faculty of Economics and Business, University of Groningen, Broerstraat 5 9712 CP Groningen, The Netherlands. E-mail: j.h.garretsen@rug.nl

Ron Martin
Department of Geography, University of Cambridge, Cambridge CB2 1TN, United Kingdom. E-mail: rlm1@cam.ac.uk

ABSTRACT. We analyze the resilience of U.K. regions to employment shocks. Two basic notions of resilience are distinguished. With engineering resilience, there is an underlying stable growth path to which a regional economy rebounds following a shock. With ecological resilience, shocks can permanently affect the growth path of the regional economy. Our data set consists of quarterly employment series for 12 U.K. regions (NUTS I) for the period 1971–2010. Using a seemingly unrelated regression (SUR) model specification, we test for the relevance of (engineering) resilience of U.K. regional employment to the four recessionary shocks in our sample. It turns out that U.K. regions do indeed differ in their resilience, but that these differences mainly concern the initial resistance to these shocks and not so much the recovery stage. The SUR model does not allow shocks to have permanent effects and it also does not take the possibility of time differentiated shock spillovers between the 12 regions into account. To this end, we also estimate a vector error-correction model (VECM) specification where employment shocks can have permanent effects and where also interregional employment linkages are included. We find that employment shocks typically have permanent effects when it concerns the own-region effects. Permanent effects can also be found for the impact on other regions but the interregional effects are typically only significant for nearby regions.

1. INTRODUCTION

Over the past three decades, a considerable body of empirical economic research has developed around the issue of long-run regional growth patterns. A by-product of the debates surrounding the relevance of neoclassical growth theory and the emergence of so-called "endogenous growth theory" in the 1980s and 1990s, the focus of this literature on regional growth has overwhelmingly been on how fast regional per capita incomes converge over time, using cross-section regression methods to estimate an "average" speed of convergence (see Martin and Sunley, 1998). By comparison, there have been very few studies of how regional growth varies over time, and whether and why such temporal

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variation itself differs from region to region. Within this context, there has been virtually no study of the impact of major recessionary shocks on long-run regional growth patterns. Do regional economies always recover fully from such major shocks? Or do some regions fail to return to their pre-shock growth paths? How regions respond to major recessionary shocks may in fact be highly pertinent to the question of long-run regional growth patterns, and hence to the issue of whether regional incomes and other dimensions of regional economic disparity converge or diverge over time.

In this regard, some recent work on the impact of shocks on national growth paths suggests that countries that experience severe and/or frequent economic disruptions (recessions, financial crises, and political upheavals) tend to have lower growth rates over the long run (Cerra and Saxena, 2008; Cerra, Panizza, and Saxena, 2009). There is evidence that severe recessionary shocks tend to depress a country's long-run growth rate. Patterns of long-run national income convergence and divergence may thus be linked to how different countries have reacted to recessionary and other shocks. This raises the intriguing question of how recessions affect regional growth paths. Do regions differ in the extent to which their economies recover and rebound from severe recessionary shocks? Do regions that are more severely affected by such shocks grow more slowly than other regions as a result? These are the issues we wish to explore in this paper.

We do this by setting our analysis within a "regional resilience" framework. The notion of regional resilience has begun to attract attention within regional and urban studies, where interest focuses on how regional and urban economies and communities react to and recover from major shocks or disturbances (see the papers in the special issue of *Cambridge Journal of Regions, Economic and Society*, 2010). These studies have tended to draw on ideas of resilience developed in ecological dynamics and social-ecology (see e.g., Walker et al., 2006). Economists do not tend to use the idea of resilience, but as we show, at least of one of the forms of resilience discussed in ecology turns out to be very similar to the so-called "plucking model" of business cycles as developed by Friedman (1993), a model that is easy to align with a standard neoclassical growth model. At the same time, a second definition of resilience found in ecology is closely related to the notion of hysteresis found in economics. These ideas are used to identify, in stylized fashion, some possible impacts of major recessionary shocks on regional growth paths.

We then turn to some preliminary empirics to examine the evidence for these hypothetical impacts, using time series data for the U.K. standard regions, over the period 1971–2009. A number of major recessionary shocks disrupted the regional economies of the United Kingdom over this period, notably in the early-1980s and the early-1990s. Attention is thus focused on how resilient the U.K. regions were to these recessionary shocks, and on whether and to what extent the regions recovered from them, or whether their growth paths were permanently affected. Given that this involves testing for possible shifts in both regional growth paths and regional growth rates, undertaking such an analysis raises a series of challenging econometric issues, especially once we allow for interregional interactions.

Our analysis focuses on regional employment, rather than output, for a number of reasons. Examination of past recessions suggests that, in most cases, the proportionate decline in employment during a recessionary downturn tends to be significantly greater than that in output. In this respect, the issue of regional resilience assumes particular significance in relation to how regional and local labor markets are affected by and recover from major recessionary shocks. Within a local or regional setting, much of the impact of a major recession is borne by the labor market. Redundancies and layoffs of workers are key forms of adjustment by which employers seek to reduce costs and the scale of production in response to major falls in output demand. A fall in local employment imposes

a complex mix of different types of adjustment on the workers concerned. How far local employment falls, and how fast and far it recovers, will shape and limit the outcomes for local workers. Many will join the ranks of the unemployed. Some of these may find themselves particularly disadvantaged, perhaps because of the wrong sort of skills, and thus vulnerable to long-term unemployment. Still others may drop out of the labor market altogether, into inactivity, perhaps moving onto sickness or disability benefits. Yet others may decide to migrate to other localities or regions where employment prospects are better. And some may be able to find work in, and be prepared to commute to, neighboring local labor markets. How local wage structures react may also influence the scale and duration of the fall in employment. And of course, employers may seek to increase output when recovery comes without resuming their pre-shock workforce levels. The response of regional or local employment to a major shock, such as deep recession, will thus be a complex outcome of a variety of adjustment strategies, mechanisms, possibilities, and constraints on local employers and local workers. The nature and extent of these labor market adjustment processes were the focus of the seminal paper by Blanchard and Katz (1992) on long-run regional economic evolutions in the United States, though surprisingly they did not cast their analysis in terms of resilience or hysteresis (Eichengreen, 1992). These are precisely the focus of our paper.

Thus, while our paper has been stimulated, in part, by the work on the impact of shocks on national growth, by for instance Cerra et al. (2009) referred to earlier, it goes beyond their analyses in four important respects. First, and most importantly, our focus is on how regional, rather than national, economic growth paths are affected by recessionary shocks. Second, we cast our analysis explicitly in terms of resilience and hysteresis, notions that are absent from the studies by Cerra et al. Third, whereas these authors focus on a one-off shock, in our analysis of U.K. regional employment growth paths we are concerned with the different (and cumulative) impacts of a sequence of recessions. And fourth, this aspect, together with the need to allow for interregional effects, imposes additional demands from an econometric point of view. This latter dimension of the paper also sets our analysis apart from existing work on regional resilience in geography and regional studies, which has thus far tended to be either conceptual or empirically descriptive (see Simmie and Martin, 2010; Martin, 2012).

2. REGIONAL REACTIONS TO RECESSIONARY SHOCKS: RESILIENCE AND HYSTERESIS

The "Plucking" Model and "Engineering" Resilience

A useful starting point for thinking about how regional economies react to recessionary shocks is Friedman's so-called "plucking model" of business fluctuations (Friedman, 1993). According to the "plucking model," the path of an economy's real output or employment can be likened to a string attached to the underside of an upward-sloping board, which is "plucked" downward at irregular intervals by recessionary (or other) shocks (see Figure 1). The board represents a slowly rising upper limit or ceiling on output or employment set by an economy's human and capital resources, the way they are organized, and their productivity. Though the extent of decline caused by a recessionary shock will vary from downturn to downturn, output is assumed to rebound in each case to the (upward-sloping) ceiling level. In other words, the plucking model predicts that recessionary shocks should be *transitory*, and should have no permanent effect on the economy's long-run growth ceiling or growth trend (note that the trend growth rate, as change

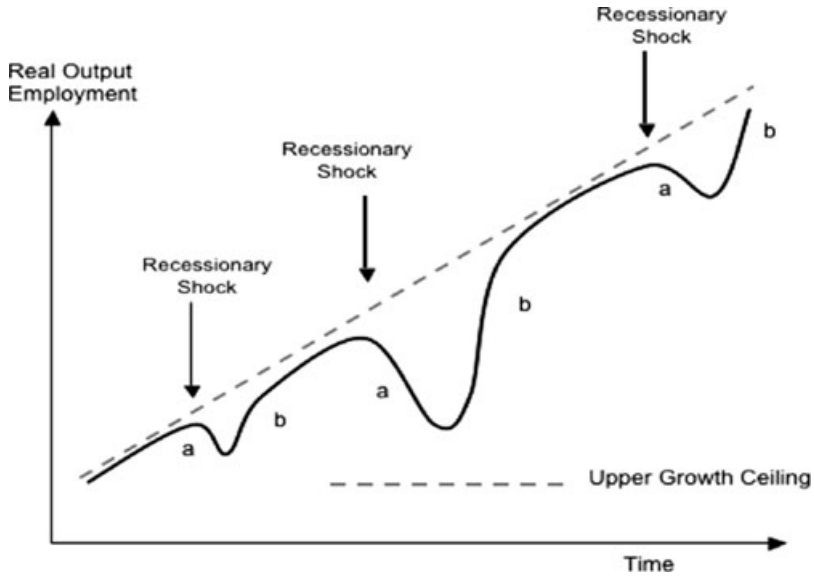


FIGURE 1: Friedman's "Plucking Model" of Recessionary Shocks.

per unit of time, is assumed to be constant, as depicted by the straight line in Figure 1). This basic idea from the plucking model will be used in our estimations in Section 4.[1]

It is further sometimes argued that there is likely to be an asymmetry in this reaction. Much of the recent research into the "plucking model" has been concerned with devising econometric methods to test for the existence and extent of this asymmetry (see e.g., Kim and Nelson, 1999; Kim and Piger, 2002; Sinclair, 2008). This asymmetry will not be the focus of our empirical analysis. Instead, we try to test for the key point about this model, namely that the economy "bounces back" to its upper growth ceiling, implying that recessionary shocks, however severe, do not have any permanent effect on the growth ceiling itself.[2]

This notion of bounce back that underpins the "plucking model" has close affinities with certain definitions of the concept of resilience (see Martin, 2012). According to its strict Latin root, *resilire*, to leap back or to rebound, the idea of resilience refers to the ability of an entity or system to "recover form and position elastically" following

[1]Assume that the vertical axis in Figure 1, see also Figures 2 and 3 later, depicts the variables mentioned as natural logs. Constant growth as reflected by a straight line in Figure 1 means constant change per unit of time, not constant percent growth. In Section 4 we will, however, analyze the impact of recessionary shocks on U.K. regional employment as percent growth. But with natural log employment level on the vertical axis in Figures 1–3, the straight line in these figures approximately also means constant percent growth, since $\log(y2/y1)$ is approximately $(y2 - y1)/y1$ for reasonable growth rates of 0.1 or less.

[2]As pointed out by one of the referees, the standard neoclassical growth model has similar implications as the plucking model. More generally, and in line with our paper, subsequent developments in growth or business cycle theory, such as real business cycle theory or endogenous growth models, also analyze the relationship between short- and long-run dynamics: see Stadler (1990), Phelps (1962), or Caballero and Hammour (1994) for seminal contributions. A key difference between the (recent) mainstream business cycle and growth literature and the resilience literature is that the former is based on strong notions of a (return to) equilibrium, whereas we think that for engineering resilience the assumption of equilibrium is not essential.

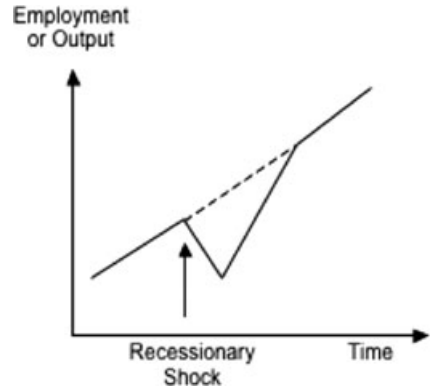


FIGURE 2: Engineering Resilience and the Impact of a Recessionary Shock on a Region's Growth Path: Region Returns to Pre-Shock Growth Trend (From Martin, 2012).

a disturbance or disruption of some kind.[3] In the ecology and related literature, where the concept of resilience has attracted considerable discussion and debate, the notion of so-called "engineering resilience" is used to refer to the *resistance* of a system to disturbances (shocks) and the speed of return or *recovery* to its pre-shock state.[4] In many discussions, the system is assumed to be in "equilibrium" before the shock, so that resilience is defined in terms of the stability of a system near its equilibrium or steady state (e.g., Holling, 1973; Pimm, 1984; Perrings, 1998). This definition, with its focus on stability of a system near its equilibrium, clearly resonates with the idea (assumption) of self-correcting forces in mainstream economics. The concept of engineering resilience with its focus on resistance to and recovery from shocks will be at the heart of our empirical analysis in Section 4, where we will test for this notion of resilience for four recessionary shocks in the United Kingdom, and their impact on the employment growth of U.K. regions.

Under the perspective of engineering resilience, a regional economy would be assumed to be self-equilibrating: any shock that moves the region's economy from its equilibrium state automatically activates compensating adjustments that bring it back to that equilibrium. However, the assumption of equilibrium is not essential to the idea of engineering resilience. All that is required is that there is an underlying stable state or growth path, to which a regional economy rebounds following a shock (Figure 2).

Hysteresis and "Ecological" Resilience

In ecology there is, however, a second way that the notion of resilience is used—so-called "ecological resilience." This focuses on the role of shocks or disturbances in pushing a system beyond its "elasticity threshold" to a new domain. In this case, resilience is measured by the magnitude of disturbance or shock that can be absorbed before the system changes form, function, or position (Holling, 1973, 1996, 2001; McGlade et al., 2006). According to this definition, then, systems are characterized by *multiple* stability

[3]*Chambers Dictionary* definition.

[4]This is close to the definition found in physics, where resilience is the property of a material to absorb energy when it is deformed elastically and then, upon removal of the deforming force, to resume its initial form.

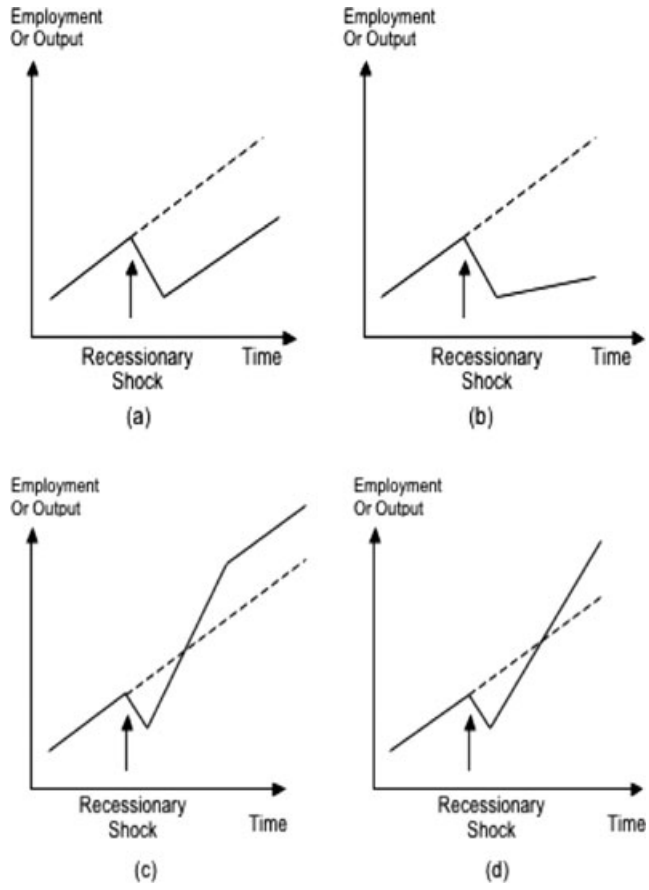
domains, and that if a shock pushes a system beyond its "elasticity threshold" associated with its existing domain or state, the system may move to a different domain or state.

It is here that the idea of "hysteresis" assumes relevance. The concept of hysteresis has recently become the subject of renewed interest in economics (see, e.g., Göcke, 2002; Cross, Grinfeld and Lamba, 2009; Cross, Mcnamara and Pokrovskii, 2010; Setterfield, 2010). Mainstream economics now admits of the possibility of multiple equilibria or steady states, and that an economy can be moved from one such equilibrium or domain to another as a result of a shock or disturbance. But again, the assumption of equilibrium is not essential to the notion.[5] Romer (2001) for example, defines hysteresis as a situation "where one-time disturbances permanently affect the path of the economy" (p. 471), that is where the effect or "memory" of the disturbance is left behind in the economy even after the disturbance or shock has passed, a process also known as "remanence." In effect, hysteresis would imply that the growth ceiling in Friedman's model is shifted as a result of the shock.

One possibility is where a recession causes a hysteretic downward shift in a regional economy's growth path as depicted by the straight lines in Figure 3 (see also footnote 2 on this). Such a downward shift could take two forms. It could be that the recession permanently lowers the level of regional output or employment, but that the region's growth rate recovers to its pre-shock rate. In other words, the slope of the growth ceiling or growth path is the same as before the shock, but it has been permanently lowered (Figure 3a). A more pathological case is where the severity of the shock is such that both the economy's level of output (or employment) and its postshock growth rate are lowered: the growth ceiling is not only shifted downward, but its slope is also lowered (Figure 3b). In each of these two cases, the economy in question could be said to have a low resilience to shocks.

But it is also possible for positive hysteretic effects to occur. An economy may more than rebound from a recession and again two possibilities suggest themselves (Figures 3c and 3d). In both examples the regional economy initially experiences rapid growth out of the recession, at a rate above the pre-shock growth trend. This might be due to highly optimistic business expectations, the availability of spare capacity to expand output and jobs, perhaps some initial opportunities to increase productivity, an initial wave of new firm formation, and similar factors. The issue is whether this postshock recovery rate of growth can be sustained. If the scope for continued rapid growth becomes exhausted, or if the regional economy approaches its "growth ceiling," for example, because it is unable to attract the additional resources (capital and labor) required, or the potential for continued productivity improvements declines, then the economy may then return to its pre-shock growth path, though at a permanently higher level of output (or employment, Figure 3a). If, on the other hand, the region is able to attract in labor and capital from elsewhere, or witnesses the emergence of new sectors of activity, and/or a new wave of productivity- and growth-promoting innovation, then the rapid growth out of recovery may well be sustained (Figure 3b). A deep economic crisis may also facilitate beneficial economic and political reforms that lead to a permanent increase in regional output and output growth (Gali and Hammour, 1993; Caballero and Hammour, 1994), and possibly also employment, though that will depend on the nature and sources of the growth in output. Regional economies

[5]As with our discussion of engineering resilience (see also footnote 3), the literature on hysteresis in mainstream economics following, for instance, Azariadis and Drazen (1990) clearly overlaps with the notion of ecological resilience, but here too we think that the concept of ecological resilience is much broader and less confined to the notion of equilibrium that characterizes mainstream of neo-classical models of hysteresis in economics.



Note: (a) Permanent Decline in Level, Resumption of Pre-Recession Growth Rate; (b) Permanent Decline in Level, and Lowered Growth Rate; (c) Recovery to Higher Level, Resumption of Pre-Recession Growth Rate; (d) Recovery to a Sustained Higher Growth Rate.
Source: Martin, 2012.

FIGURE 3: Hysteretic Impacts of a Recessionary Shock on a Region's Growth Path.

that exhibit positive hysteretic effects of either type would presumably be regarded as highly resilient.

When applied to our case of the impact of recessionary shocks on the U.K. regions, we will take the basic idea of shocks potentially having permanent effects in the sense of Romer (2001) seriously in Section 5. In that section we will estimate a vector error correction model and thereby allow for employment shocks to have permanent effects thus testing for the relevance of ecological resilience.

Of course, of themselves, these different stylized forms of regional reaction to and recovery from shocks like those illustrated in Figure 3 do not tell us why particular regions display particular types of resilience or whether a region's resilience varies over time.[6] Though this question is beyond the scope of this paper, several factors can be thought of as

[6]As one referee pointed out, much of the theoretical literature on regional resilience is essentially about (coping with) structural change, whereas our empirical analysis takes the (U.K.) business cycle, or more precisely U.K. recessions, as its starting point. This is correct, but one of the central tenets of our

possible *determinants* of regional resilience to recessions (Glaeser, 2005; Glaeser, Ponzetto, and Tobio, 2011; Martin, 2012). In general, determinants that come to mind are a region's underlying growth dynamic, sectoral composition, export orientation and specialization, human capital, innovation rate, business and enterprise culture, its location, its institutional arrangements, and so on.[7] A region that has above average productivity, a strong trend rate of output and employment growth, has a high innovation rate, and is adaptive (i.e., is successful in replacing declining or uncompetitive activities with new, dynamic, and competitive activities) is likely to be more resilient, in terms of being less vulnerable to and quicker to recover from recessionary shocks, than a region without these features and characteristics. The role of industrial structure, and of structural change, could be hypothesized as being particularly significant, given that it is well known that different industries react differently to—have different sensitivities to—the economic cycle: manufacturing industry, for example, is typically assumed to be more cyclically sensitive than private services.[8] Thus a region that is specialized in manufacturing might be expected to be less resilient than a region dominated by services. At the same time, of course, the nature of the recessionary shock itself may be crucial, since this is likely to impact more on some sectors of activity than on others.[9] And then there is the question of how a region's resilience changes and evolves over time. Structural change could be expected to change a region's economic resilience. Further, how a region reacts to one recessionary shock could, via hysteretic effects or induced structural change, influence its resilience to subsequent shocks. The explanation of regional patterns of resilience to recessionary shocks is thus a complex issue. But first it is necessary to identify the nature and scale of those patterns: this is the focus of the rest of this paper.

3. THE BRITISH REGIONS: SOME BASIC EMPIRICS[10]

Our empirical analysis will be based on U.K. regional data for employment and output (GVA).[11] To be more specific, we have quarterly series ranging from 1971 to 2010 for output and employment for the 12 major U.K. regions (NUTS-1 level). This gives us a panel with a relatively limited cross-section dimension N (=12) but with a reasonable time series T (=160). The sample period covers four U.K.-wide recessionary shocks, a relatively brief one right at the start of our sample in the mid 1970s that ended in 1975, and three main recessionary shocks in the early-1980s, the early-1990s, and the recession that started in 2008. To be more precise, these four recessionary shocks are dated (from peak to trough) as follows: 1973(3)–1975(3); 1980(1)–1981(1), 1990(3)–1991(4), and 2008(2)–2009(2). The dating of the recessions is thus not region specific but uniform across our 12 regions and

paper is that shocks can have permanent (structural) effects: in our view the resilience literature indicates that shocks and structural change must be seen as interdependent.

[7]In Glaeser et al. (2011, pp. 23–26), the regional resilience of U.S. cities is seen as a function of a region (city) to produce new ideas, which is in turn driven by entrepreneurship. Empirically, locations with a higher firm density and smaller average firm size are seen as locations with greater entrepreneurship and hence greater resilience to shocks.

[8]For two detailed analyses that use shift-share techniques to assess the role of industrial structure in regional employment dynamics in the United Kingdom, see Fingleton (1994) and Robson (2006).

[9]When it comes to the possible role of a region's specialization pattern as a determinant of its resilience, recent empirical findings in the evolutionary economic geography literature (see for instance, Frenken, Van Oort and Verburg, 2007) suggest that it is key for regions to have a specialization pattern characterized by so-called "related variety" in order for regions to be more resilient to shocks.

[10]This section draws on Martin (2012).

[11]In what follows and in Section 4, the basic data used were provided by Experian (London), to whom we are grateful.

FIGURE 4: U.K. Employment (Level, Millions), 1971(2)–2008(4)).

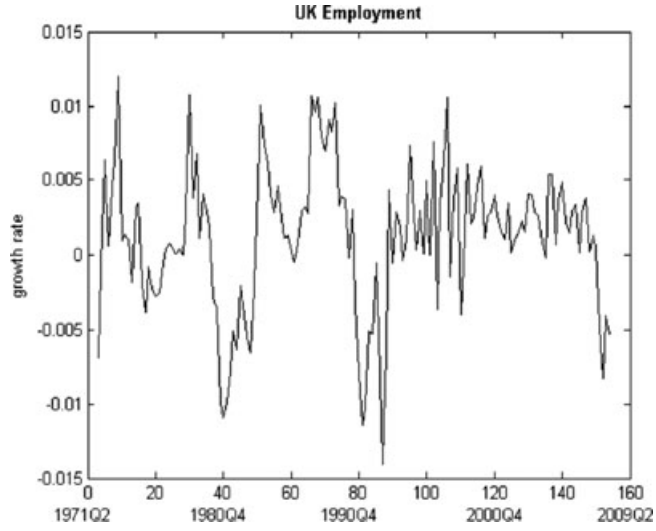


FIGURE 5: U.K. Employment Growth Rate (1971(2)–2008(4)).

follows the official dating of U.K. national recessions. In our empirical analysis, the focus will (mainly) be on regional employment. Given our discussion of both "engineering" and "ecological" resilience in the previous section, we are thus interested in how the impact and aftermath of these four recessionary shocks may differ for regional employment (though obviously our analysis of the most recent recessionary shock is necessarily restricted). Before we turn to our econometric evidence in Sections 4 and 5, we will first provide some descriptive evidence for our central variable of interest, regional employment.

For the total sample period, Figures 4 and 5 show the level of employment and employment growth for the United Kingdom as whole. The recessionary shocks that are the focus of analysis are clearly discernible. The national experience seems to bear some

TABLE 1: Resistance to Recession across U.K. Regions: "Sensitivity" Indices of Relative Employment Contraction in Three Downturns

	1979(4)–1983(1)	1990(2)–1992(4)	2008(2)–2010(2)
South East	0.40	1.24	0.91
Greater London	0.89	1.69	0.60
Eastern	0.39	1.39	0.86
South West	0.28	0.90	1.37
East Midlands	0.86	0.85	0.98
West Midlands	1.52	1.33	1.20
Yorks-Humberside	1.21	0.88	1.15
North West	1.55	0.89	0.88
North East	1.84	0.40	0.73
Wales	1.67	0.75	1.43
Scotland	1.08	0.08	1.11
N. Ireland	0.44	0.13	1.81

Source: Martin, 2012.

resemblance to the idealized "plucking model" pattern depicted in Figure 1, with each of the recessions pushing total employment down from an upward sloping "ceiling" linking the successive peaks in the long-run time path of employment. The severity of the shocks of the early-1980s and early-1990s is particularly evident.

For our present purposes, we are, however, primarily interested in the regional variation in employment during our sample period and in particular in regional employment differences during and after recessions. To this end, we provide some descriptive evidence on the regional *resistance* to and *recovery* from recessions by using the sensitivity of the 12 U.K. regions to recessionary shocks. Keeping the discussion on engineering resilience from the Section "The 'Plucking' Model and 'Engineering' Resilience" in mind, both resistance and recovery are important elements of a region's resilience to shocks. A region's sensitivity to a recession can be measured simply as the regional percentage decline in employment relative to the U.K. national percentage decline in employment during that recession. A region with a "sensitivity index" greater than unity can be deemed less resistant to a national recessionary shock than a region with an index of less than unity. Table 1 shows this for the 12 regions for the three main recessionary shocks in our sample.

Without going into detail, it is clear that the "resistance" of regions to recessions varies. In the recession of the early-1980s, the southern and eastern U.K. regions were more resistant to the recessionary shock than the (industrial) regions in the Midlands and the northern areas of the United Kingdom. This picture is largely reversed for the 1990s recession. For the 2008–2009 recession, a more mixed picture emerges (the caveat here is of course that it is not clear yet whether the last recession is truly over).[12]

When it comes to the regional variation in the *recovery* to recession, Table 2 gives the corresponding "recovery indexes," defined as the postrecession percentage growth in employment in a region relative to the percentage growth in national employment. Postrecession employment growth refers here to the employment growth until the onset

[12]Another caveat with respect to the 2008–2009 recession is that when compared to the three other recessions, this latest downturn was part of a financial crisis. We know from the literature on the impact of financial crises on the real economy (see Claessens, Kose, and Terrones, 2008 or Reinhart and Rogoff, 2009) that recessions associated with these shocks have different causes or transmission channels, lead to more GDP or employment losses, and also tend to last longer. Having said this, our analysis is not concerned with different features of a recession but simply with establishing, irrespective of the "type" of recession, what the regional employment effects are of U.K.-wide recessionary shocks.

TABLE 2: Regional Employment Recovery from Two U.K. Recessions

	1983(1)–1990(1)	1992(4)–2008(1)
South East	1.69	1.43
Greater London	0.37	1.48
Eastern	1.39	1.26
South West	1.60	1.38
East Midlands	1.07	1.26
West Midlands	1.15	0.62
Yorks-Humber	0.97	0.73
North West	0.73	0.49
North East	0.62	0.32
Wales	1.23	0.80
Scotland	0.69	0.64
N. Ireland	0.77	1.82

Note: "Recovery" index measured as percentage growth in employment in region/percentage growth in employment in U.K.

Source: Calculated from data supplied by Experian, London.

of the next recession. Comparing Table 2 with Table 1 suggests that for the early-1980s recession, there was a negative relationship across regions between resistance to the early-1980s recession, on the one hand and employment growth in the postrecession recovery, on the other hand. This implies that regions that were hit harder by the early-1980s recession in terms of employment, like the North East, also had a slower postrecession recovery. This relates to our discussion in Section "The 'Plucking' Model and 'Engineering' Resilience," where we noted that in the resilience literature it is found that the impact of the recession is predictive of the size or strength of the recovery.

For the 1990s recession, comparison of Tables 1 and 2 suggests that for this downturn there is no clear relationship between the resistance and recovery phase. Nevertheless, the raw evidence strongly indicates that U.K. regions differ when it comes to their employment path during as well as after recessionary shocks. As we discussed in Section "Hysteresis and 'Ecological' Resilience" on ecological resilience, these regional employment differences to shocks may not only matter when it comes to the regional cyclicality in employment but they could also matter for the long-term or trend behavior of employment. Once hysteresis is allowed for, shocks (can) have an impact on the trend growth of employment. For the early-1980s recession and its aftermath, the key fact is that compared to the South East, regions in the North East were hit harder during the recessions and recovered less well in the wake of the recession. For the 1990s recession, employment fell much stronger in the South East but the rebound in employment in that region was also much stronger following the recession. Combined, these differences in what we would dub regional *resilience* between the North East and South East regions in the United Kingdom contribute to the fact that the long-term (1971–2010) employment paths in these two regions have been very different, in fact divergent, as shown in Figure 6. We return to this finding in Section 5 when we look into the permanency of employment shocks.

The descriptive evidence presented in this section raises a number of important questions. First of all, how can we subject our data set and these first notions as to regional differences in resilience to econometric testing? More particularly, do the 12 U.K. regions indeed differ significantly in terms of the impact of recession and postrecession growth? This is the subject of the following section. Second, and again using an econometric approach in Section 5, we would like to know more about the permanency of the employment shocks and about the relevance of interregional resilience linkages, that is whether and how interregional shocks matter. Third, there is the question that was also raised at

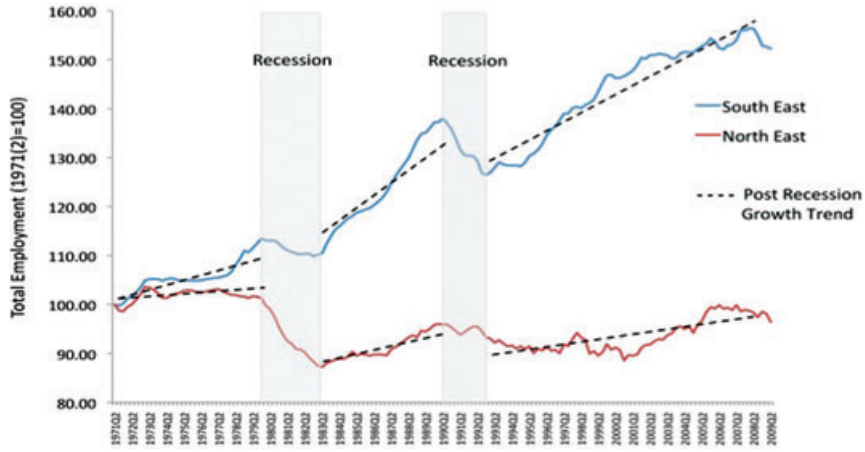


FIGURE 6: Hysteresis? Employment 1971–2010 in the North East and South East Regions, United Kingdom.

the end of Section 2, as to what might explain the regional employment differences in resilience.

4. U.K. RECESSIONS, REGIONAL EMPLOYMENT GROWTH, AND ENGINEERING RESILIENCE

In this section we employ a seemingly unrelated regression (SUR) model to estimate the impact of the four U.K. recessions and three postrecession periods on regional employment growth. Given the nonstationarity of the employment (level) series, we opt here for the use of regional employment *growth* (see also footnote 2 as to implications of this in terms of Figures 1–3). In the next section we will return to the issue of nonstationarity. An SUR model is quite flexible and though spatial (in our case, interregional) interdependencies are not explicitly expressed in the form a particular parameterized function; rather, the model allows for spatial linkages in the sense of being left unspecified as general covariance in the error term for each region's employment growth equation. This implies that a shock affecting employment growth in one region may simultaneously affect employment growth in other regions also. In fact, within spatial econometrics, this model has been suggested as an alternative to the use of spatial weights (Anselin, 1988).[13] By using a SUR specification, we do not need to specify *a priori* the spatial linkage matrix as is required for the spatial error model, spatial lag, or spatial Durbin model. These latter types of models may be weakened by the dependence of the results on the W matrix. It is very difficult to know, *a priori*, what the W matrix should be as we have only weak or nonexistent theory to guide us (see Corrado and Fingleton, 2011). Our assumption in using our SUR model is that spatial effects come through the unobserved error component of the model, and are not due to a direct spatial interaction in which the employment growth rate in region i is a direct response to employment growth rates in regions j and k. In unreported results we provide supporting empirical evidence for this handling of the spatial dependence.[14]

[13]We thus actually tested first for spatial dependence (instead of merely assuming that spatial dependence is important).

[14]These results are available upon request.

To keep the analysis as simple as possible, we adopt an SUR estimation in which regional employment growth is determined by (i) an autonomous growth rate; (ii) (the onset of each of) the four recessions; and (iii) the three postrecession periods. This model specification is very much in keeping with Friedman's plucking model as summarized by Figure 1. In particular, with respect to (ii) and (iii) we would like to know if there is a significant change in the regional employment growth rate. More specifically, we estimated the following model using SUR:

$$e_{it} = b_{oi} + b_{1i}R_{1t} + b_{2i}R_{2t} + b_{3i}R_{3t} + b_{4i}R_{4t} + b_{5i}S_{1t} + b_{6i}S_{2t} + b_{7i}S_{3t} + \varepsilon_{it}, \quad (1)$$

where var $\varepsilon_{it} = \sigma_{ii}^2$; cov $\varepsilon_{it}\ \varepsilon_{jt} = \sigma_{ij}^2$, and where also

e_{it} = employment growth in region i ($i = 1 \ldots 12$) at quarter t ($t = 1971(2) \ldots 2009(2)$);
b_{0i} = autonomous growth rate;

$b_{1i}, b_{2i}, b_{3i}, b_{4i}$ = change in employment growth rate as recession dummies R_{1t}, R_{2t}, R_{3t}, and R_{4t} which take values 0 (no recession) or 1 (recession);

b_{5i}, b_{6i}, b_{7i} = change in employment growth rate in post-recession periods, where (in quarters from 1971(2) onwards) $S_{1t} = 20 \ldots \ldots 36$; $S_{2t} = 42 \ldots 78$; $S_{3t} = 85 \ldots 159$.

In the Appendix we show the estimation results for the SUR model (1) for each of the 12 regions. For each region, the actual and fitted employment growth rates are depicted. We are not so much interested in how well this (unrestricted) SUR model fits the data for each region but much more in the comparison between regions. From the discussion in Section 3 we know that regional employment growth was hit harder in the early-1980s recession in the "northern" regions and it also recovered more slowly in the postrecession period. For the early-1990s recession, the "southern" regions saw a more pronounced drop in employment during the recession but it subsequently rebounded relatively quickly. Figure 7 uses the SUR estimation results for two regions, the South East (an example from the "south") and Scotland (an example from the "north"), to illustrate that the SUR model picks up these differences in (engineering) resilience, both in terms of resistance to and recovery from shocks.

Even though Figure 7 suggests that the resistance or impact stage of the recession as well as the recovery or postrecession stage differ systematically across the U.K. regions, it offers no conclusive evidence of regional differences in resilience. For one thing, Figure 7 only shows 2 of the 12 regions, but more importantly we want to know if the resistance and recovery resilience differences in employment growth are indeed significant across regions. To find out if the latter is indeed the case, we imposed various restrictions on our SUR model and tested whether these restrictions were permitted.

More specifically, we tested whether:

(i) for each region the impact of recessions is constant over time ($b_{1i} = b_{2i} = b_{3i} = b_{4i}$);

(ii) a given recession has the same impact regardless of region ($b_{r1} = b_{r2} = b_{r3} =$ etc., where r is recession, $r = 1 \ldots 4$);

(iii) for each region the postrecession recovery is constant across time ($b_{5i} = b_{6i} = b_{7i}$);

(iv) for a given recession the postrecession recovery is the same across regions ($b_{s1} = b_{s2} = b_{s3} =$ etc., where $s = 1 \ldots 3$).

After testing for the four restrictions, we ended up with the restricted SUR model (1A) where, with the notable exception of the 2008–2009 recession, the data allow us to impose the restriction that regions do differ when it comes to the impact or resistance stage, but we also find that we cannot impose the restriction that regions differ in their postrecession or recovery employment growth. For the 2008–2009 recession, we find that

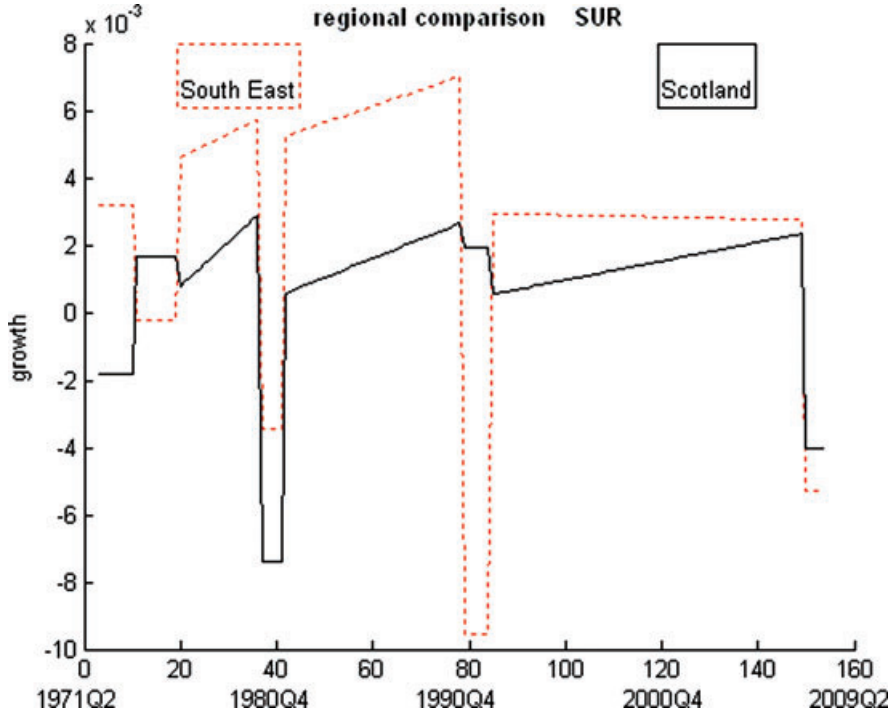


FIGURE 7: Estimation of Unrestricted SUR Model for South East and Scotland.

the impact of the recession is also the same across regions. The restricted SUR model is therefore

$$(1A) \qquad e_{it} = b_{oi} + b_{1i}R_{1t} + b_{2i}R_{2t} + b_{3i}R_{3t} + b_{4i}R_{4t} + b_{5i}S_{1t} + b_{6i}S_{2t} + b_{7i}S_{3t} + \varepsilon_{it},$$

with the following restrictions imposed: $b_{4i} = b_4$; $b_{5i} = b_5$; $b_{6i} = b_6$; $b_{7i} = b_7$.

These restrictions imply that for instance the Scotland versus the South East comparison from Figure 7 needs to be amended in the sense that the post-recession or in-between recession employment growth paths have the same slope (note that the level of employment growth still differs in these post-recession periods for these two regions because of the autonomous growth rate, which is notably higher for the South East). Given the permitted restrictions, we should thus focus on the relative impact of or resistance to the recessions because it is here that regional differences between regions are to be found (and thus not in the recovery stage). So from the perspective of (engineering) resilience, we find that regional differences in regional employment growth are to be found in the resistance and not in the recovery stage. Or, in other words, in terms of the plucking model illustration in Figure 1, the U.K. regions seem to differ in the (a) stage and not in the (b) stage. Table 3 therefore shows for each of the 12 regions the "impact or resistance coefficients" b_{1i} b_{2i} b_{3i} b_{4i} from estimating model (1A), where the b_{4i} coefficient is thus the same across regions.

From Table 3 we can see that the impact of the first recession (mid-1970s) on employment growth was relatively mild and that five regions did not actually experience negative employment growth at all according to our impact coefficients. The second recession (early-1980s) had its largest impact on industrial regions like the West Midlands and the North East. Here we see considerable regional differences (see also the entries

TABLE 3: Impact Coefficients and Autonomous Growth Rate (Restricted SUR Model)

U.K. Region	Recession 1 b_{1i}	Recession 2 b_{2i}	Recession 3 b_{3i}	Recession 4 b_{4i}	Autonomous Growth Rate, b_{0i}
South East	−0.00170	−0.00490	**–0.01101**	−0.00422	**0.00145**
South West	−0.00496	**0.00205**	−0.00638	−0.00422	0.00082
East Midlands	0.00582	−0.00649	−0.00501	−0.00422	−0.00036
West Midlands	−0.00793	**–0.01235**	−0.01065	−0.00422	−0.00089
Greater London	−0.00378	−0.00393	**–0.01251**	−0.00422	−0.00083
Yorks-Humber	0.00306	−0.00930	−0.00623	−0.00422	−0.00098
Northern Ireland	0.00199	−0.00857	**0.00266**	−0.00422	0.00052
Eastern	−0.00035	−0.00519	−0.00938	−0.00422	0.0094
North East	0.00133	**–0.01334**	**0.00035**	−0.00422	−0.00191
North West	−0.00179	−0.009714	−0.00447	−0.00422	−0.00149
Scotland	0.00282	−0.00618	−0.00311	−0.00422	**–0.00118**
Wales	0.00458	**−0.01504**	−0.00560	−0.00422	−0.00033

in bold in Table 3): compare for instance the impact coefficients for the West Midlands or the North East with those for the South West. A similar conclusion holds for the third recession (early-1990s), but in that case it was the South East and Greater London that experienced a relatively much stronger impact of the recession on their employment growth compared to, for instance, the North East or Northern Ireland. All in all, these estimation results with respect to the impact coefficients are in line with the descriptive evidence on regional employment as presented by Table 1 and to lead us to conclude that that the U.K. regions differ in terms of their resilience (resistance) to recessionary shocks.

The last column of Table 3 shows the estimation results for the autonomous growth rate b_{0i} for each of the 12 regions. Only 4 of the 12 regions have a positive employment growth rate when we control for the impact of shocks and the recovery phase. The last column of Table 3 highlights the growth rates for the South East and Scotland so as to emphasize that even if the recession impact and the subsequent recovery phase look or actually are similar, this may still hide large differences in the underlying trend growth of employment.

In terms of resilience, the estimation results thus imply that the employment growth for U.K. regions differs mainly in terms of the resistance to shocks and less so in terms of the recovery from these shocks. This conclusion is, however, subject to a number of qualifications. First of all, and see model (1A) and the last column of Table 3, shocks do not have a bearing on the trend growth rate. This precludes an analysis of hysteresis (and ecological resilience). In terms of the discussion on resilience in Section 2, this means that the estimation results are restricted to an economic model where the employment shocks are seen as temporary deviations from an (exogenous) trend growth rate. If we allow for recessionary shocks to have a permanent effect, this could help to explain why the trend employment growth rate is for instance higher in the South East than in Scotland. A second qualification is that the SUR model employed in this section does not show how employment shocks play out over time or how shocks to one region may spill over through time to other regions. In the remainder of the paper we will address these two limitations.[15]

[15]Another limitation of model specification (1A) is that besides the autonomous growth rate, and the recession and postrecovery dummies, the model does not include other covariates of employment growth, like for instance (lagged) output growth. Our goal is not to come up with a model specification that provides the best fit (explanation) for regional employment growth, but rather to single out the relationship between employment growth and the (U.K.-wide) recessionary shocks.

5. PERMANENT AND INTERREGIONAL EMPLOYMENT EFFECTS OF SHOCKS

The Vector Error-Correction Model (VECM) Specification

In this section we address the specific question of differential response to shocks to employment, either within a region or to shocks coming from other regions.[16] In particular, we focus on shocks emanating from the South East region, looking to see whether we have evidence that they tend to die away to zero, as the "plucking model" from the Section "The 'Plucking' Model and 'Engineering' Resilience" implies, or whether they have a permanent impact on the level of employment as the discussion on ecological resilience in the Section "Hysteresis and 'Ecological' Resilience" suggests. Here we take Romer's (2001, p. 471) depiction of *hysteresis* seriously in the sense that we analyze whether or not a one time shock to a region's employment will have a permanent effect on this region's or other regions' employment. The vehicle we use to interpret shock impacts is a VECM, fitted to the levels of employment (measured in millions). Naturally the interpretation rests on a model that provides a good description of the data. The key issues in determining the VECM specification are the number of lags in the vector error correction representation, and the rank of the matrix of long-run responses equal to the number of linearly independent rows, as indicated by the number of nonzero eigenvalues (or characteristic roots). The rank is equal to the number of cointegrating vectors, that is the number of independent cointegrating relationships between the 12 regional series, and we infer this using the well-known Johansen procedure. The application of a VECM implies that the series are nonstationary I(1) processes, and this assumption has fundamental consequences for whether a shock has a transient or persistent effect. We have tested for the nonstationarity of the regional employment series. For every single region we cannot reject the null of a unit root. In addition, we have also tested for the number of lags imposed (2), the number of cointegrating vectors (4), and the specification and fit of the VECM employed.[17]

In our VECM, some shocks are permanent, not transitory, and we have I(1) variables modeled in a cointegrating VECM that are not mean reverting. To illustrate this phenomenon for specific regions, we make use of orthogonalized impulse response functions (OIRFs). These impulse response functions quantify the responses over time in all the endogenous variables to a one unit (one standard error) shock confined to one specific endogenous variable at a particular time *t,* keeping everything else constant. Because they are orthogonalized in this way, avoiding contemporaneous correlation, which would make it impossible to "shock" one region without "shocking" others, we can give a causal interpretation to the impulse response functions. This implies a recursive structure equal to the ordering of the Cholesky decomposition of the cross-equation covariance matrix, which is required to identify the causal responses, but because the identifying restrictions are arbitrary, with different Cholesky decomposition orderings possible, there are different possible outcomes. Indeed, with 12 regions there are 12! orderings, which is a number in excess of 479 million. We have explored the outcomes from a very small sample of these possible orderings, and find that they support the interpretations given below on the basis of a specific Cholesky decomposition, namely that responses to shocks can be permanent, and that response tends to weaken with distance, being strongest within regions and in neighboring regions.

[16]Holly, Pesaran and Yamagata (2011) carry out a similar analysis based on somewhat different models of U.K. regional house prices.

[17]The test results for the nonstationarity of the employment series, the number of lags, the number of cointegrating vectors, and the preferred VECM specification are not shown here but available upon request.

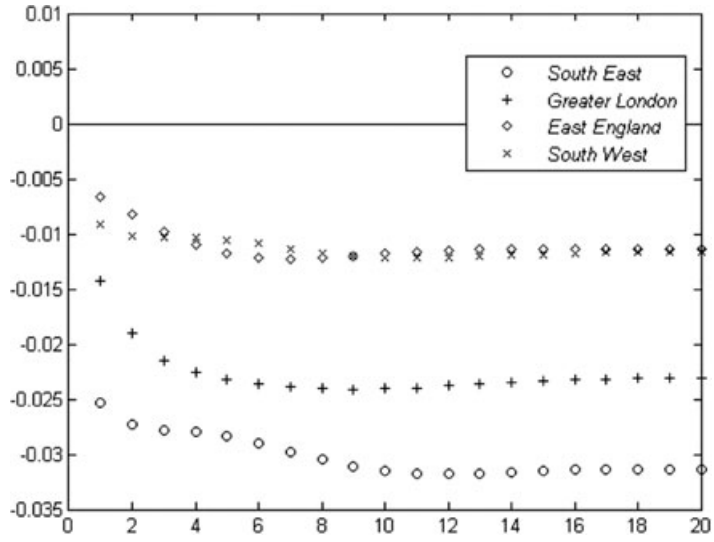


FIGURE 8: Responses to a Shock in the South East Region: Southern England.

Impulse Responses for an Employment Shock Emanating from the South East

Because of the wealth of information available, given 12 responses to each impulse emanating from 12 regions, we focus on *responses to impulses from the South East region.* On the basis of our VECM, we find that a one unit negative shock to employment in the South East region has a negative and a significant permanent effect not only on the South East region itself, but also on the neighboring region of Greater London. The impact on the other neighboring regions, the South West and Eastern England is smaller (see Figure 8). In (ecological) resilience terms, this suggests that shocks can indeed have permanent effects on employment, not only in their own region but also in (surrounding) regions.

More remote responses to the one unit downward employment shock in the South East are more mixed. There seems to be a strong distance decay when it comes to the impact of the South East shock on the other 11 U.K. regions. The permanent response of the West Midlands (Figure 9) trends to a more negative value than that of the East of England and South West, but is above the negative response of Greater London. In contrast, the East Midlands has a much more muted response to the negative shock emanating from the South East. In the North, the largest response is in the North West (Figure 10), which is similar in magnitude to that of the West Midlands. Both the North East and Yorkshire and the Humber have weaker short-run responses and in the longer run they are not far from zero. Similarly for regions outside England, the responses are also numerically very small (Figure 11), being effectively zero, suggesting that overall the responses in these more distant locations to impulses from the South East are most probably transitory rather than permanent. To sum up, when it comes to (ecological) resilience, see Section "Hysteresis and 'Ecological' Resilience," the example of the impulse responses to a one unit shock in the employment of the South East region indicates that permanent effects in own and (relatively nearby) other regions are possible, which is consistent with the idea of hysteresis.

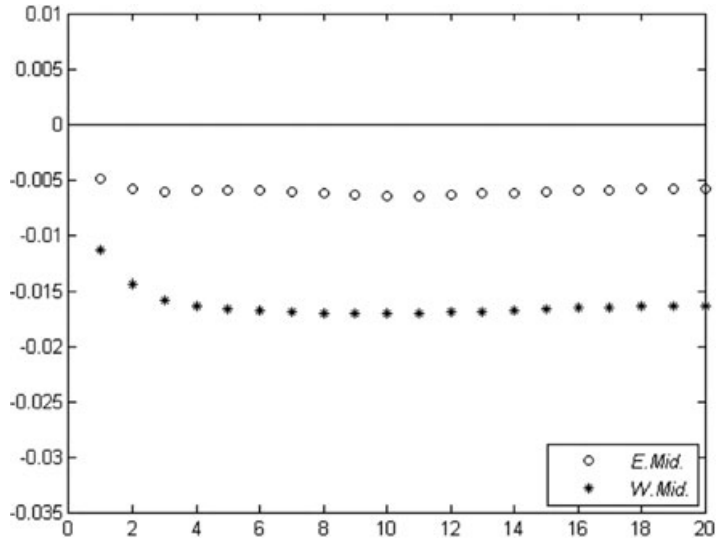


FIGURE 9: Responses to a Shock in the South East Region: Midlands.

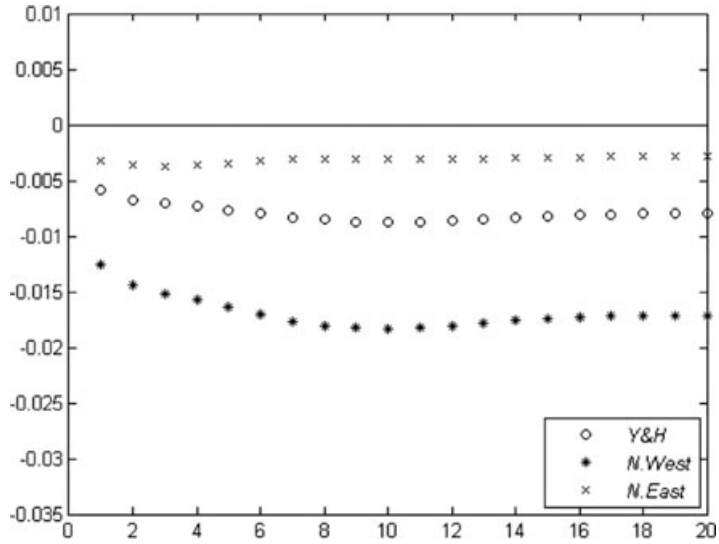


FIGURE 10: Responses to a Shock in the South East Region: The North.

Mean Responses to Shocks

Of course, impulses emanate from all regions and produce responses in all 12 regions. For example Figure 12 shows the varied responses in Scotland to impulses from *all* regions (so not just to an impulse from the South East).

In an attempt to show the overall sensitivity of each region to shocks *regardless of region of origin*, we have calculated the mean response over 19 periods[18] in each region

[18]Excluding the initial responses, because the Cholesky ordering entails differing numbers of nonzero initial responses across regions.

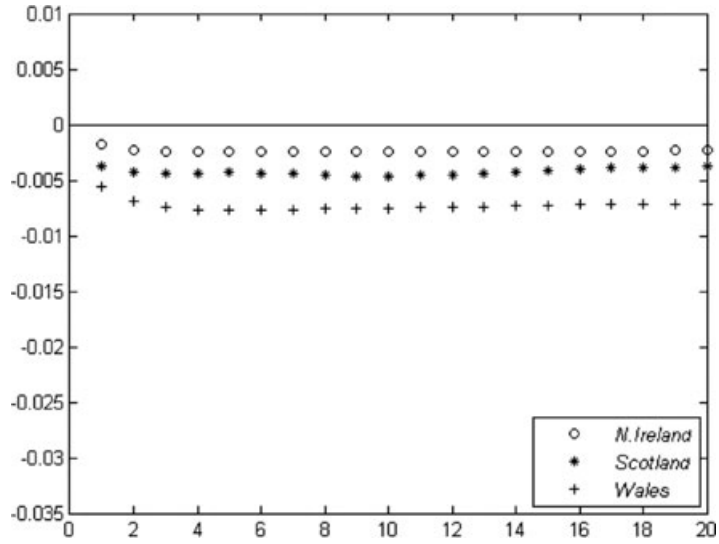


FIGURE 11: Responses to a Shock in the South East region: Outside England.

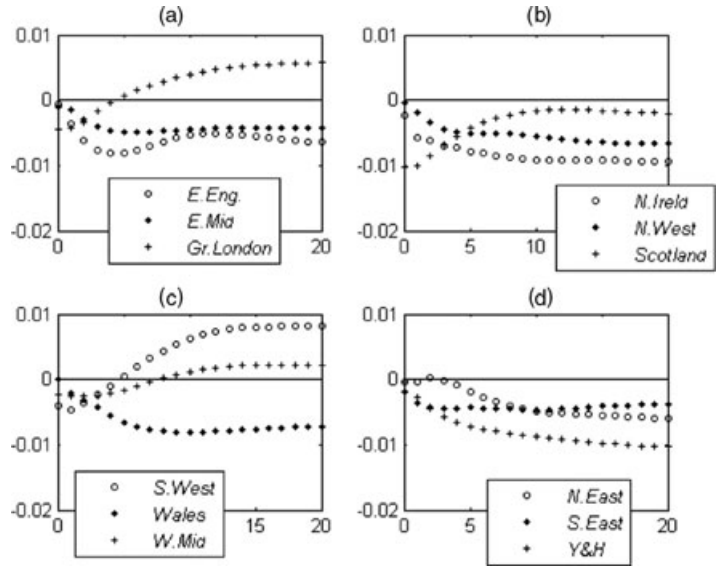


FIGURE 12: Responses in Scotland to Shocks from All Regions.

(Table 4). This indicates that the North West region and Scotland are most sensitive to shocks regardless of origin. Figures 13–15 show the mean responses over time in the different regions. These again highlight the relative sensitivity of the North West and Scotland to shocks and also the comparative immunity of Northern Ireland to shocks both local and from other regions. This as an indication that both the North West and Scotland are more vulnerable on average, or potentially less resilient, than other regions. With regard to Greater London, although we saw a negative permanent response to a negative impulse emanating from the South East region in Figure 8, Figure 13 suggests

TABLE 4: Mean Responses to Shocks from All Regions

Region	Mean OIRF
South East	−0.001841336
South West	−0.00163307
East Midlands	−0.001588602
West Midlands	−0.002356154
Greater London	0.001117204
Yorkshire and the Humber	−0.002467946
Northern Ireland	−0.000713571
East England	−0.001510232
North East	−0.001774403
North West	−0.004165019
Scotland	−0.003365239
Wales	−0.002186694

Note: Mean over periods 2–20.

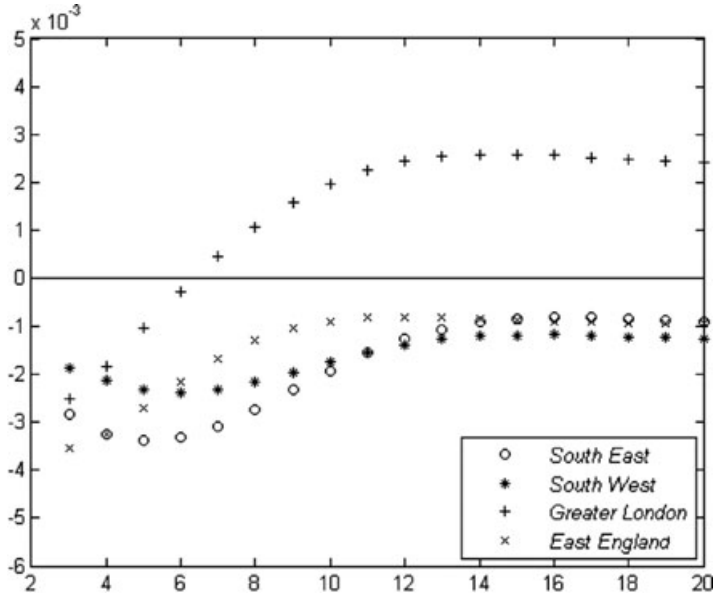


FIGURE 13: Mean Responses in Southern England.

a marginally *positive* long-run response averaging over all regions. This is driven by mainly positive responses to shocks in the South West, West Midlands, Eastern England, the North East, and Scotland. Figure 13 does suggest that the Greater London labor market is somewhat different from that of the provinces. This may be due to the capital's more detached position in the U.K. economy and stronger association with global financial markets. We can only speculate about this since here we do not look into the determinants of resilience (see also Section 6). In the case of London, negative shocks on average will evidently produce a short-run negative response, but in the longer run a slight positive increment in employment. Just like the case of a shock emanating from the South East region only, the mean responses, as summarized in Table 4 and Figures 13–15, do confirm the conclusion that the U.K. regions differ in their resilience to employment shocks:

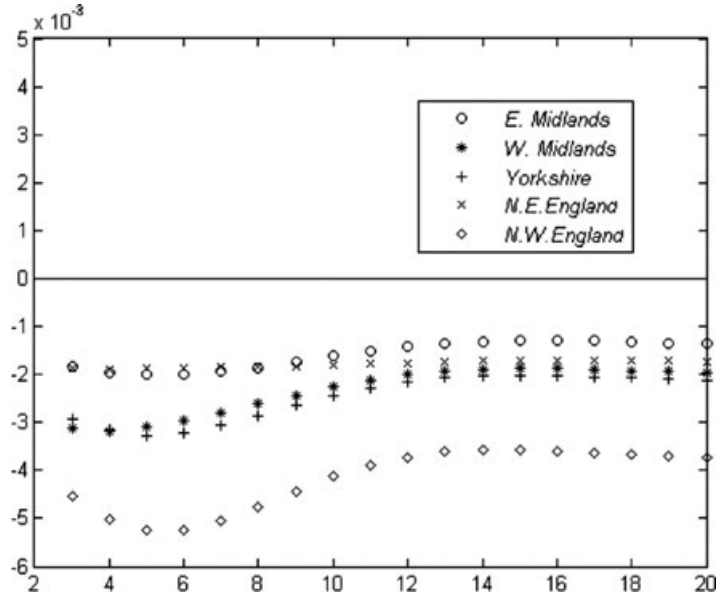


FIGURE 14: Mean Responses in the Midlands and Northern England.

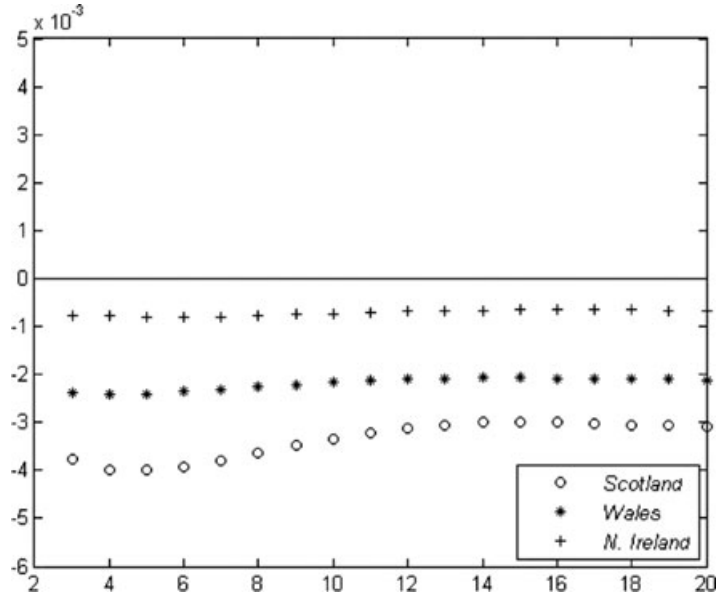


FIGURE 15: Mean Responses Outside England.

the North West and Scotland, especially, seem more sensitive to shocks regardless of origin.[19]

[19]Because of the Cholesky ordering, for the initial period, the South East only responds to shocks to itself, while the South West responds to its own shock and the shock to the South East, and the East

Of course, our interpretations are conditional on the model we have used as the basis of the impulse response functions, and while we have endeavored to justify our choice, it remains the case that other models could also be suggested that might provide different interpretations. In our case, our model is a statistical one containing no exogenous causal variables, or indeed other endogenous variables apart from employment. It is possible that we could make our model more elaborate, but at this juncture the interpretations provided by our simple structure do seem to us to be reasonable and in line with our preconceptions. Moreover, our modeling has enabled us to quantify the relative impact of shocks to employment across regions in a way that has hitherto not been done, and we see this as an important innovative contribution of the paper.

6. CONCLUSIONS

In this paper we have analyzed the resilience of U.K. regions to employment shocks. Two basic notions of resilience can be distinguished. According to the first one, engineering resilience, there is an underlying stable growth path to which a regional economy rebounds following a shock to employment. Milton Friedman's so-called "plucking model" (Friedman, 1993) is a prime example of this notion of resilience. According to the second notion of resilience, ecological resilience, shocks can permanently affect the (employment) growth path of the regional economy. Models of hysteresis are in line with this concept of resilience. The data set we use consists of quarterly series on employment for 12 U.K. regions (NUTS I) for the period 1971–2010. The descriptive evidence already suggests that these regions differ in their resilience to recessionary employment shocks. Using an SUR model specification, we then test for the relevance of (engineering) resilience of U.K. regional employment to the four recessionary shocks in our sample. It turns out that U.K. regions do indeed differ in their resilience to these shocks but that these differences mainly concern the initial resistance to shocks and not so much the recovery stage. The SUR model does not allow shocks to have permanent effects and it also does not take the possibility of time-differentiated shock spillovers between the 12 regions into account. To this end, we also estimated a VECM specification where, in line with the notion of ecological resilience, employment shocks can have permanent effects and where also interregional employment linkages are included. We find that an employment shock typically has permanent effects when it concerns the own-region effects but that permanent effects can also be found for the impact on the employment of other regions. As to the latter, our VECM estimations indicate that the interregional effects typically only apply to nearby regions. Given that we have established that U.K. regions differ in their resilience to employment shocks, the question arises how to explain these differences in resilience. In Section 2 we have listed a number of possible determinants of regional resilience. We leave the answer to this important question to future research. Our data set for instance allows us to see if differences in the regional economic structure of a region are relevant in this respect, and we intend to investigate how a region's economic structure both shapes regional resilience to recessionary shocks, and in turn whether that structure is itself changed by such shocks.

Midlands responds to impulses from the South East, South West, and East Midlands, and so on. Hence we take the means over the subsequent periods.

APPENDIX

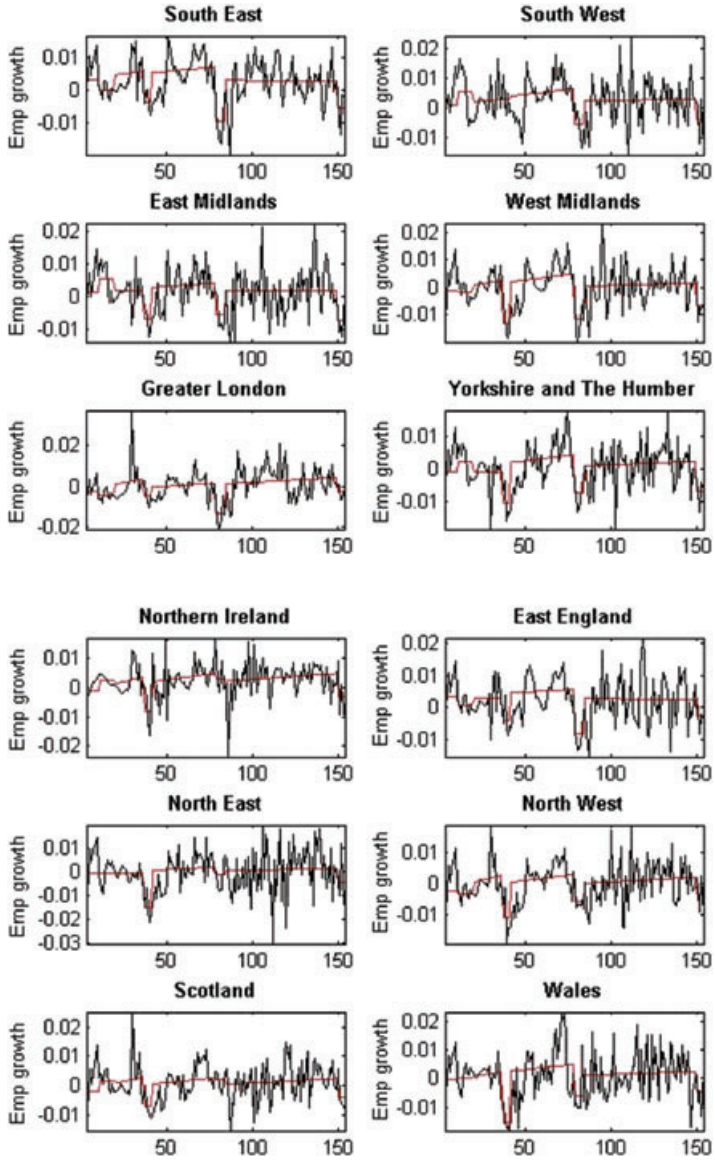


FIGURE A1: Estimation Results for Unrestricted SUR Model.

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