Journal of Economic Integration

Macroeconomic Effects of Reallocation Shocks: A Generalised Impulse Response Function Analysis for Three European Countries

Theodore Panagiotidis
Loughborough University

Gianluigi Pelloni
Ryerson University

Wolfgang Polasek
Institute of Advanced Studies

Abstract

We develop a generalised impulse response function (GIRF) approach to explore the different impacts of aggregate and sectoral shocks within a VAR-GARCH-M model. Using the output of our GIRF analysis, we explore the behaviour of three European countries (Germany, Spain and the UK). We analyse the aggregate and sectoral responses to discriminate among three different hypotheses of business cycle fluctuations. Links are established and explanations are provided within the still experimental character of our exercise.

- **JEL Classifications:** E30, C10, J21

- **Key words:** Sectoral shifts, Employment fluctuations, Generalised impulse response function, VAR-GARCH models

*Corresponding address: Professor Gianluigi Pelloni, Department of Economics, Ryerson University, Toronto, E-mail address: pelloni@arts.ryerson.ca
Doctor Wolfgang Polasek, Institute of Advanced Studies, Vienna, Austria, E-mail: polasek@ihs.ac.at
Professor Theodore Panagiotidis, Loughborough University, Uxbridge, UK.

I. Introduction

Intersectoral labour reallocations as a triggering force of aggregate unemployment fluctuations are the object of an unsolved puzzle. This puzzle persists because of the "observational equivalence" problem inherent in sectoral shifts analysis. At an empirical level, none of the existing approaches aimed at separating "reallocation unemployment" from unemployment generated by aggregate shocks can be deemed as thoroughly satisfactory. Earlier analyses could not provide definite evidence. These investigations consisted mainly of reduced forms equations measuring the response of aggregate (un)employment to a dispersion proxy of sectoral shifts. Campbell and Kuttner (1996), CK (1996) hereafter, tries to bypass the difficulties embodied in the use of dispersion proxies by modelling sectoral shocks directly using time series techniques. Pelloni and Polasek (1999, 2003; hereafter denoted as PP99 and PP03) modifies CK's approach using VAR-GARCH structures to incorporate the non-linearity of sectoral shifts. These new time series approaches, though promising, are in their early stages and need to be extended and revised. It is the purpose of the present paper to do so.

CK (1996) treats sectoral shocks symmetrically, as if they were characterised by a positive-negative nature like aggregate shocks. PP99 and PP03 point out this pitfall and estimate a VAR-GARCH-M in standard form and assess the relative importance of sectoral shocks by carrying out a Cholesky decomposition.

In this paper we expand previous strategies by exploiting the concept of Generalised Impulse Response Function (GIRF). We use the GIRF not only as a conceptual experiment useful for the analysis of the shocks impacts, but also as a tool for discriminating among different hypotheses.

Our paper is structured as follows. Section 2 provides the necessary background for our subsequent work. It contains a discussion of multivariate (G)ARCH models in sectoral shifts analysis and describes how GIRF analysis can be used for assessing alternative hypotheses. In section 3 we present the concept of GIRF and its implementation within our VAR-GARCH-M model, leaving a number of technical points for an appendix. We present the data of selected European countries in section 4. Section 5 contains the empirical implementation of our approach and the discussion of the results. The last section would provide some concluding remarks and present a further outlook

II. VAR-ARCH Models of Sectoral Reallocations

Lilien (1982a) dispersion hypothesis claims that changes in the composition of employment demand would trigger a process of job reallocation, which would affect aggregate (un)employment. Earlier representations of the hypothesis were provided by reduced form equations of unemployment with the general form:

$$u_t = \alpha_0 + \sum_{i=0}^{p} \alpha_{1i} s_{t-i} + \sum_{i=0}^{q} \alpha_{2i} z_{t-i} + u_{t-1} + \varepsilon_t \qquad (1)$$

Where u is some measure of unemployment; s is a dispersion measure[1] used to proxy the intersectoral dispersion of demand conditions and z is a vector of aggregate control variables. Unemployment, besides showing a serial correlation structure, would be positively affected by sectoral shifts and positively or negatively related to the aggregate disturbances according to the nature of the specified relationships. Although different proxies have been employed, an observational equivalence problem seems to be irrevocably associated with the use of dispersion measures (see Lilien, 1982b; Abraham and Katz, 1986). Instead of reflecting reallocation shocks, these measures could be capturing the effects of aggregate shocks. To better understand this issue we would identify three main theoretical approaches:

Following Davis (1986; 1987), we attach the label "Normal Business Cycle Hypothesis" (*NBCH* hereafter) to the first group of models. This group covers those models where aggregate shocks are the main triggering force of business cycles. The positive correlation between unemployment and dispersion indices would reflect aggregate disturbances and not labour market turbulence. Different income elasticities of sectoral demands would account for the dispersion (Abraham and Katz, 1986). Thus an aggregate shock would bring about sectoral responses of different dimensions and with different timing but all in the same direction.

The "Reallocation Timing Hypothesis" (*RTH* hereafter) is the distinguishing theoretical feature of the second category. According to the RTH (Davis, 1986; 1987), aggregate disturbances are still the triggering force of cycles but recessions will be characterised by labour intersectoral reallocations. Economic agents would optimally decide to change sector when their labour marginal productivity is relatively low (i.e. during a recession). Thus a negative aggregate shock should come along with a fairly large amount of labour intersectoral reallocations. Again

the positive correlation between unemployment and a sectoral dispersion index could emerge as a response to aggregate shocks.

The third group is provided by the "Sectoral Shifts Hypothesis" (*SSH*, hereafter) where, as discussed above, allocative shocks would bring about an aggregate response during a transition period required for the transfer of resources.

It is clear that observationally equivalent predictions could be generated by different approaches to business cycle analysis. Given the problem inherent in dispersion proxies, some researchers have recently tried to model sectoral shocks directly using multivariate time series approaches (c.f. Gallipoli and Pelloni, 2000,and references thereafter).

CK (1996) analyses the relationship between U.S. aggregate and sectoral employment through a structural vector autoregression (SVAR), devoid of cross-industry dispersion measures. CK develops a bivariate structure for the growth rates of aggregate employment and of the manufacturing sectoral share over the period 1955:2-1994:12. The analysis is subsequently extended to a seven-dimensional VAR. The results vary dramatically in accord with the VAR size and the nature of the restrictions. Sectoral shocks can account for only 6% of the aggregate variance under a short-run triangular bivariate system. Instead, under a long-run restriction for the seven-dimensional VAR, reallocation disturbances explain 82% of the aggregate variance.

CK, though path breaking, has a major drawback: it is characterised by a symmetric response of aggregate employment growth to sectoral shocks (PP99). A negative (positive) shock to the manufacturing sector will decrease (increase) aggregate employment growth. This "directional behaviour" is inconsistent with the SSH (Davis 1986). In fact the macroeconomic effects of reallocation shocks should emerge from the "unfavourable" impact of labour market turbulence on the existing allocation of resources. The actual volume of reallocations will bring about a corresponding oscillation in aggregate (un)employment.

To capture the pervasive non-linearity of sectoral shifts, PP99 introduces a five dimensional VAR model with a GARCH-M component. The latter should capture the non-linear nature of the SSH. The models variables are the aggregate employment growth and the growth rates of sectoral employment shares. The measured sectoral variances are interpreted as proxies of employment reallocations. The model allows for both shocks with a time-varying (conditional) variance and volatility clustering.

The general specification of the PPs models is given by an M-dimensional VAR

(k) - GARCH (p,q) - M(r) process:

$$y_t = \mu_t + \varepsilon_t = \beta_0 + \sum_{i=1}^{k} \mathbf{B_i} y_{t-i} + \sum_{i=0}^{r} \psi_i h_{t-i} + \varepsilon_t \qquad (2)$$

$$vech\mathbf{H_t} = \alpha_0 + \sum_{i=1}^{p} \mathbf{A_i} vech\mathbf{H_{t-i}} + \sum_{i=1}^{q} \Theta_i vech(\varepsilon_{t-i}\varepsilon_{t-i}') \qquad (3)$$

where y_t is a $(M \times 1)$ vector of variables, $\mathbf{H}_t$ is a $(M \times M)$ diagonal conditional variance-covariance matrix, $vech$ $\mathbf{H_t}$ is a $\{[M(M+1)/2] \times 1\}$ vector, h_t is an M-dimensional vector of conditional variances, ε_t is an M-dimensional process of mutually and serially uncorrelated random errors and so $vech$ $(\varepsilon_t\varepsilon_t')$ is an $[M(M+1)/2]$-dimensional vector, α_0 and β_0 are respectively $\{[M(M+1)/2] \times 1\}$ and $(M \times 1)$ vectors of time invariant intercept coefficients, $\mathbf{B}$, ψ, $\mathbf{A}$ and Θ are coefficient matrices, the first two are of dimension $(M \times M)$ whereas the other two have dimension $\{[M(M+1)/2] \times [M(M+1)/2]\}$. The $vech$ symbol denotes the column-stacking operator for the elements of a symmetric matrix lying on and below the main diagonal.[2]

The crucial feature of this specification is that the conditional means are functions of the contemporaneous and lagged values of the conditional variances. In this way we can verify whether the information content of the conditional variances is relevant in determining the estimates of the conditional mean values. The SSH is captured by imposing the dependence of the aggregate employment growth rates on the estimated sectoral variances. For sector j at time t, the estimated variance, h_t^j, would be the squared distance between the value of the random variable "sector j's employment share" and its mean. The estimated variances are interpreted as measures of labour reallocations.

PP99 estimates a five-dimensional VAR for the US economy within a Bayesian set up. The variance decomposition analysis provides strong support for sectoral reallocations. The GARCH structure seems to capture important features of the system's dynamics, thus strengthening the role of the sectoral components. However, the variance decomposition analyses in PP99 and PP03 employ a Cholesky decomposition. Though both papers use an ordering of the variables which is unfavourable to the SSH, their results cannot be invariant to the chosen ordering. In this paper we extend PP's analyses by applying the concept of GIRF which is a suitable tool for multivariate non-linear models (Koop, Pesaran and Potter, 1996; KPP hereafter). The GIRF can single out a specific shock without

Table 1. Impluse response function characteristics by theory

Theory	Characteristics	Impulse Response Function-Mean	Impulse Response Function-Variances
Normal Business Cycle Hypothesis **NBCH**	*Triggering Force*: Aggregate Shocks.	Sectoral Components move to the same direction as a result of an aggregate shock.	Small variance responses as a signal of small intersectoral real-locations.
Reallocation Timing Hypothesis **RTM**	*Triggering Force*: Aggregate Shocks. Large reallocations (when economy in recession).	Large Reallocations when economy is in recession. No (or little) reallocation otherwise.	Large variance responses as a signal of large actual reallocation.
Sectoral Shifts Hypothesis **SSH**	*Triggering Force*: Sectoral Shifts. Change in composition of demand.	Large reallocations and aggregate response to sectoral shocks.	Large variance responses as a signal of large actual reallocation.

resorting to ad hoc identifying restrictions. At the same time it generates unique responses. We can use the GIRF as a tool for discriminating among the NBCH, the RTH and the SSH. In fact we can observe if the responses to a specific shock mirror the characteristic patterns of one of the competing theories. In this manner we should be able to corroborate one of the three hypotheses by inspection of the variable's paths. Since we have VAR-GARCH-M model, we can also define the GIRF for the conditional variances. If sectoral turbulence is detected then the NBCH would have to be rejected.

Table 1 summarises the stylised facts generated by the different types of shocks. Let us assume a positive aggregate shock: If we observe positive changes in all the sectoral shares then the NBCH is corroborated. In such a case, sectoral responses could be different in size but should die out quite rapidly. If instead not all shares are moving in the same direction then the evidence favours the RTH. In this case the sectoral responses should persist for a longer span. The SSH instead requires sectoral shocks and is borne out when such shocks are accompanied by a large aggregate response associated to large sectoral reallocations. The changes in the sectoral shares should persist as they represent changes in demand composition.

III. The Generalised Impulse Response Function

As KPP points out: "The traditional impulse response function is designed to

provide an answer to the question: "What is the effect of a shock of size δ hitting the system at time t on the state of the system at time $t+n$, given that no other shocks hit the system?".

The IRF analysis is used in dynamic models such as a VAR to describe the impact of an exogenous shock (innovation) in one variable on the other variables of the system. A unit (one standard deviation) increase in the jth variable innovation (residual) is introduced at date t and then it is returned to zero thereafter. In general the path followed by the variable $y_{m,t}$ in response to a one time change in $y_{j,t}$, holding the other variables constant at all times t, is called the IRF. This is the prevalent form of IRF used in empirical work, however in our paper we follow KPP, and call it the traditional IRF, TIRF, and define it formally as

$$TIRF(n, \delta, \varpi_{t-1}) =$$
$$= E[y_{t+n}|\varepsilon_t = \delta, \varepsilon_{t+1} = 0, ..., \varepsilon_{t+n} = 0, \varpi_{t-1}] - E[y_{t+n}|\varepsilon_t = 0, ..., \varepsilon_{t+n} = 0, \varpi_{t-1}] \quad (4)$$

where y_t is a random vector, ε_{t+i} is a random shock, ϖ_{t-1} a specific realisation of the information set Ω_{t-1} and n is the forecast horizon. Thus we have a realisation of y_{t+n} generated by the system when it is hit by a shock of size δ for $i = 0$ while all shocks are equal to zero for $i = 1, 2,..., n$, and a realisation of y_{t+n} when $\varepsilon_{t+i} = 0$ for all $i = 0,..., n$ (the benchmark representation). The difference between these two realisations provides a general definition of the TIRF.

KPP argues that in the case of multivariate non-linear models, (a VAR-GARCH model for example), the application of the TIRF can be affected by problems of composition, history and shock dependence and propose a unified approach valid both for linear and non-linear models. They call this form of IRF the generalised IRF (GIRF) and define it as

$$GIRF(n, \varepsilon_t, \omega_{t-1}) = E[y_{t+n}|\varepsilon_{j,t}, \omega_{t-1}] - E[y_{t+n}|\varpi_{t-1}] \quad (5)$$

The GIRF is a random variable given by the difference between two conditional expectations which are themselves random variables[3]. In fact the GIRF is made up of two components. The first part is the expectation of y_{t+n} conditional on history ($\varpi_{t-1} \subseteq \Omega_{t-1}$) and the chosen shock $\varepsilon_{j,t}$. Thus all other contemporaneous and future shocks are integrated out. The second component is the base-line profile (i.e. the conditional expectation of y_{t+n} given the observed history). The impulse responses emerging from the GIRF are unique and invariant to the ordering of the variable of the system (KPP; Pesaran and Shin, 1998). These

properties (coping with the problems of composition dependence, history dependence and shock dependence) of multivariate non-linear systems make the GIRF an appropriate tool to carry out our experiment. We confine the technical details of our implementation of the GIRF to the appendix.

IV. Data

We estimate and test against alternative specifications (VAR, VAR-GARCH, VAR-GARCH-M) the model given by (2)-(3) using data from selected European countries. The countries of interest are Germany, Spain and the UK. The relevant variables for our analysis are the aggregate employment growth rate and the growth rates of employment shares of the relevant sectors. The utilized sectoral data are presented in Table 2. Alongside the countries, the sample periods and the data frequency, we also list the feasible sectoral decompositions for each country (see Data Appendix). The choice of the sectors was determined by both practical (data availability) and theoretical reasons. Sectors like public administration and agriculture were avoided, since the first one is largely not sensitive to shocks and the behaviour of the second is mainly determined by factors extraneous to our interests. Within the limit imposed by the data we have tried to make the sectors as homogenous as possible across the different countries. The "Rest" sector in Germany includes employees that are not included in agriculture, production industries, trade, transport and communications.

Using Bayes factor testing, all the univariate series emerge as being $I(1)$, while their first differences are stationary (c.f. PP99, for a detailed discussion of Bayesian stationary tests). As we originally considered the natural logarithms of the relevant variables, we estimate our model for the growth rates of aggregate employment and the growth rates of employment sectoral shares (All of them were found to be $I(0)$. Results available from the authors). For a more detailed discussion on the data see Panagiotidis, Pelloni and Polasek (2000).

Table 2. Data Summary

| Country	Frequency	From	To	Sectors
UK	Quarterly	1978:2	1998:2	Construction, Finance, Manufacturing, Trade
Germany	Quarterly	1962:1	1998:1	Communications, Manufacturing, Rest
Spain	Quarterly	1987:1	1999:4	Construction, Manufacturing, Services

V. Empirical Results

We estimate and test model (2)-(3) and carry out the GIRF analysis for the mean and the variance within a Bayesian framework (cf. PP99 and PP03, for details). The model has been estimated using a Gibbs-Metropolis algorithm, which provides an exact small sample solution. Model and order selection is carried out using Bayes factor testing (PP99 for details). Bayes factors are calculated according to the marginal likelihood concept illustrated by Chib and Jeliazkov (1999) which is based on Chib (1995). In each instance the VAR-GARCH-M model has been preferred to alternative specifications. In particular we selected a VAR(2)-GARCH(2,2)-M(2) for Germany and the UK, and a VAR(1)-GARCH(1,2)-M(1) for Spain. The GIRF analysis is carried out within the selected VAR-GARCH-M model.

We wish to stress that our results should be seen as preliminary. The emphasis of our experiment is more on its methodological potential than on the actual outcomes. The empirical results emerge from a specific experimental framework which, to be able to provide final evidence, may need further extensions. As we have already pointed out, the GIRF analysis can be viewed as the outcome of a conceptual experiment. The generated output depends on the nature of the estimated model and the structure of the shocks. Once a model has been selected, through appropriate testing, the configuration of the chosen shocks will become crucial for generating the paths of the relevant variables. In our experiment we would restrict ourselves to explore the implications of temporary positive shocks. Of course, we could have introduced a different and more complex design of the shocks. Probably a more articulated framework is needed to disentangle the three examined hypotheses. However, given that our interest is in the methodological potential of our approach, we restrict our exercise to the simplest scenario. Even within the boundaries of this experiment we can extract enough information to evaluate the potential usefulness of our approach.

Our output is presented in Figures 1 to 6. Figures 1-3 provide the GIRF plots for the means (GIRF) while Figures 4-6 display the GIRF plots for the volatilities (GIRF-V).

If we look at the mean responses for Germany (Figure 2) and Spain (Figure 3), we can see that they present similar profiles. When a temporary aggregate shock is introduced, all sectoral components move in the same direction and there is not much difference in the size of their responses. The effects of an aggregate shock

Figure 1. Individual impulse response plots of employment (for the mean) in UK from 1978 Q1 to 1998 Q2 for the VAR(2)-GARCH(2,2)-M(2) model.
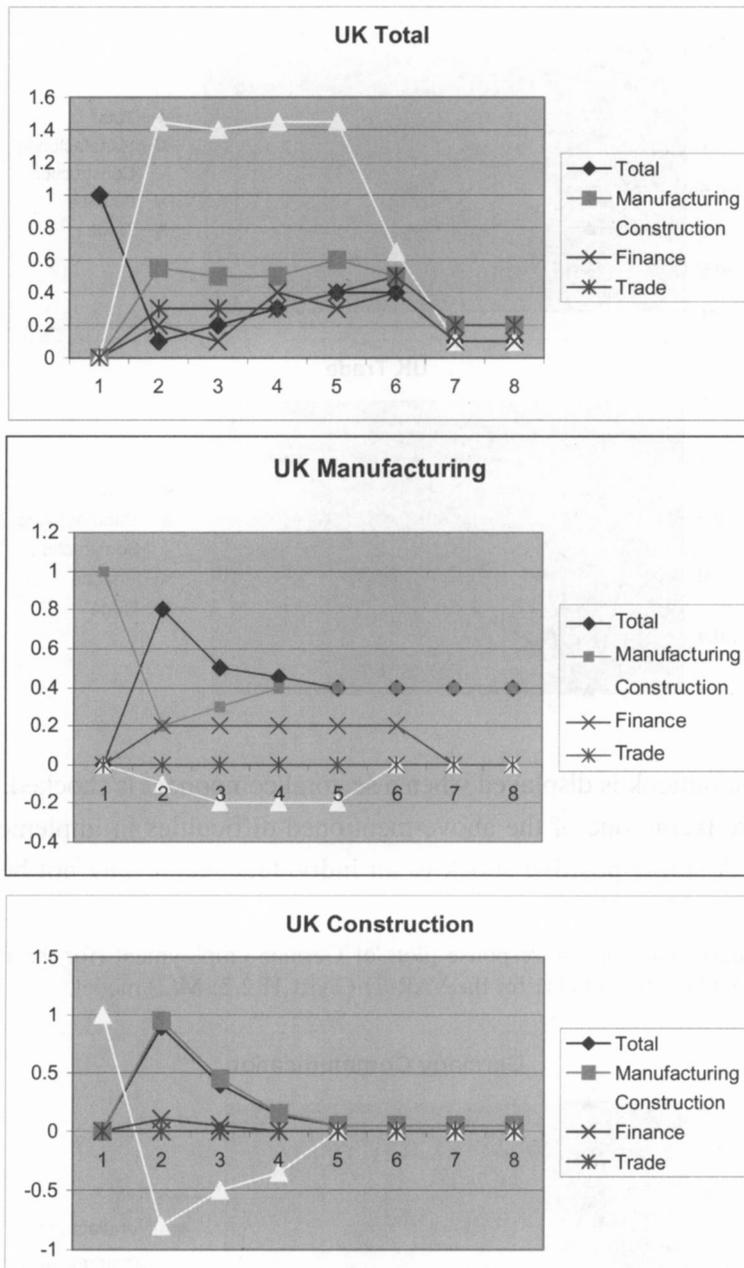

tend to die out quickly and after four quarters they are almost completely reabsorbed. These sort of temporal profiles seem to reflect what we would expect under the NBCH.

Figure 1. Continued.
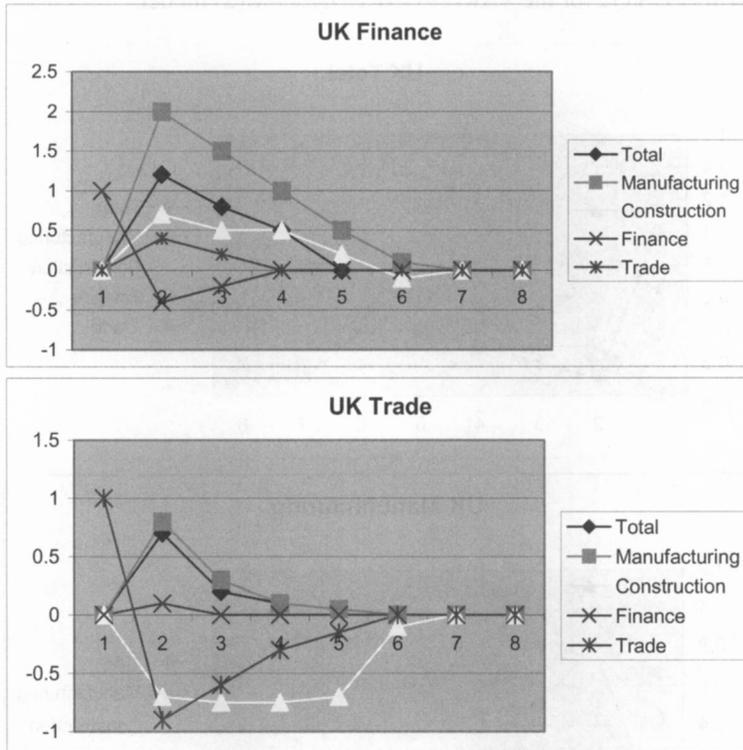
A similar outlook is displayed when a sectoral component is shocked. However here we are facing one of the above-mentioned difficulties in implementing our approach. A single positive shock to an individual sector may not be a proper

Figure 2. Individual impulse response plots of German employment (for the mean) from 1970 Q1 to 1998 Q1 for the VAR(2)-GARCH(2,2)-M(2) model.
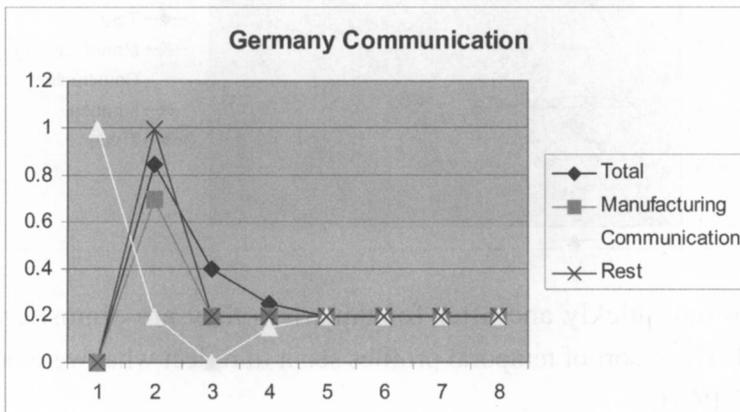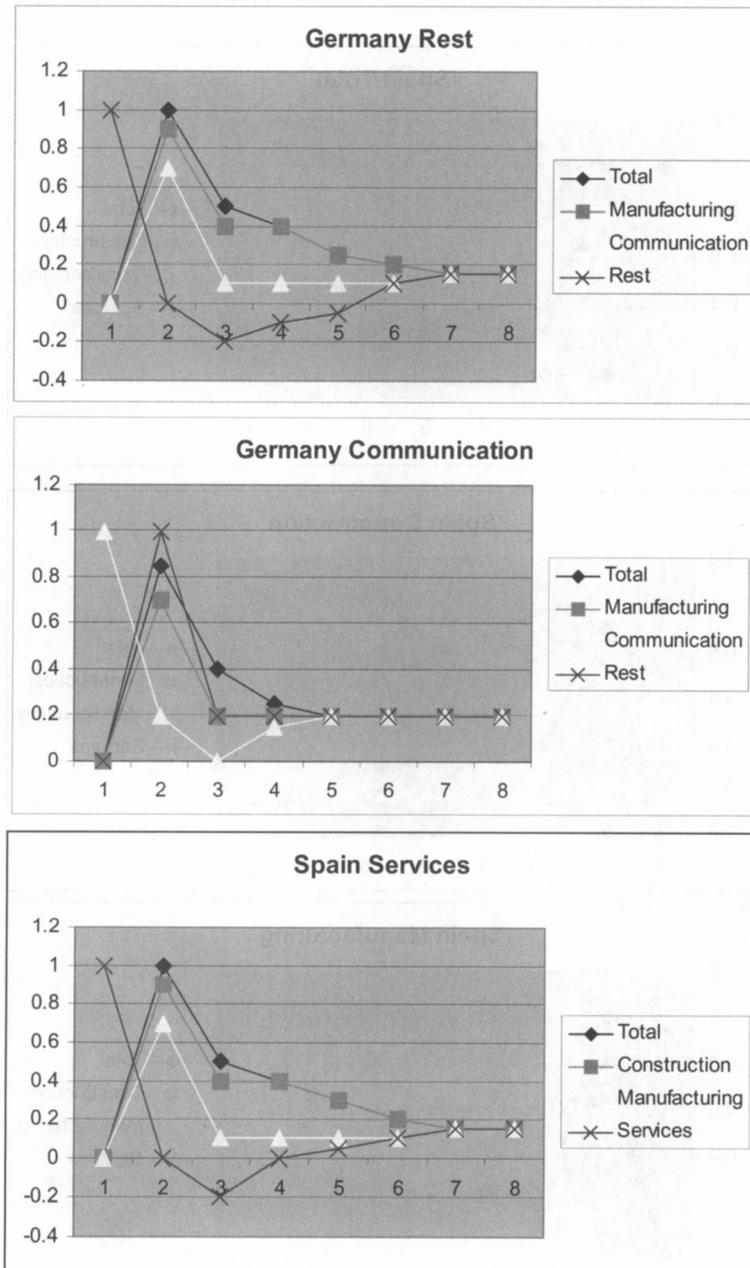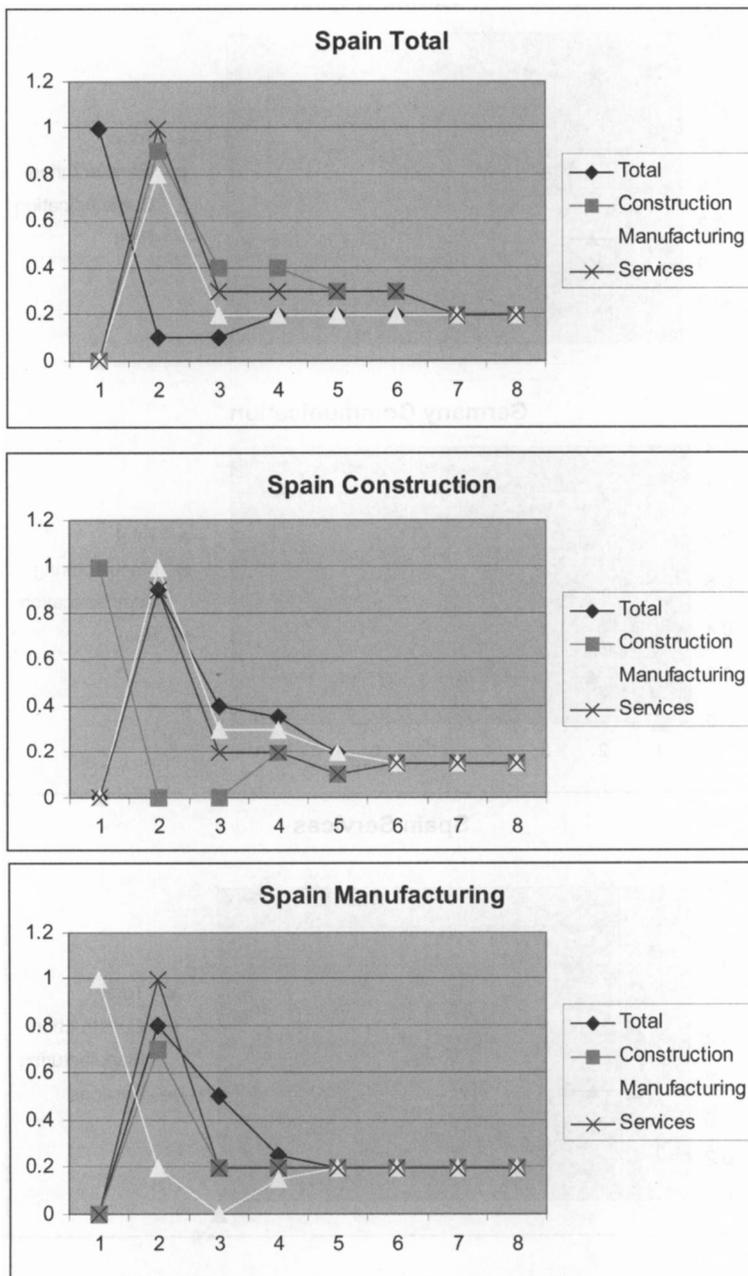
Figure 2. Continued.

representation of a reallocation shock. Allocative disturbances are "compositional" and not "directional" and could bring about permanent changes in sectoral shares. Thus the shock we are introducing either is part of a more complex structure[4] or it captures a sectoral shock which, by varying the level of

Figure 3. Individual impulse response plots of employment (for the mean) in Spain from 1987 Q1 to 1999 Q4 for the VAR(1)-GARCH(1,2)-M(1) model.

demand at industry level, can vary the level of aggregate demand. Be that as it may, the generated information is at least sufficient to discriminate between NBCH and RTH. The emerging profiles suggest that the NBCH has to be
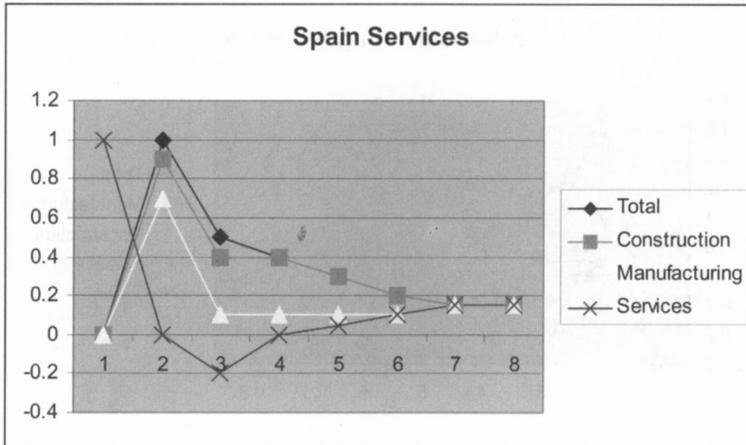
Figure 3. Continued.

Figure 4. Individual impulse response plots of employment (for the volatility) in the United Kingdom from 1978 Q1 to 1998 Q2 for the VAR(2)-GARCH(1,1)-M(2) model.
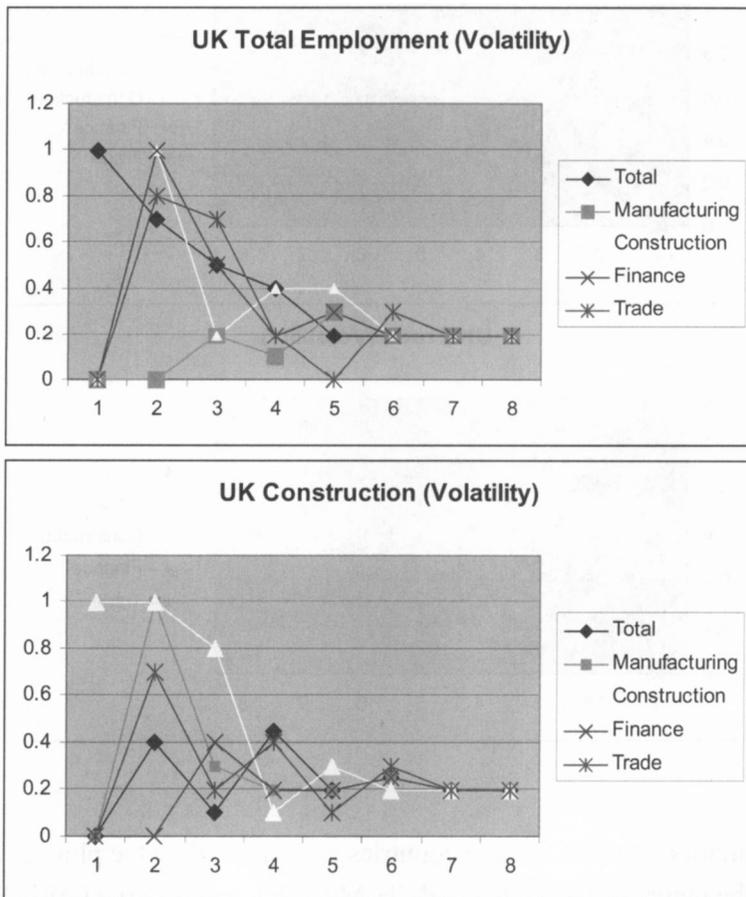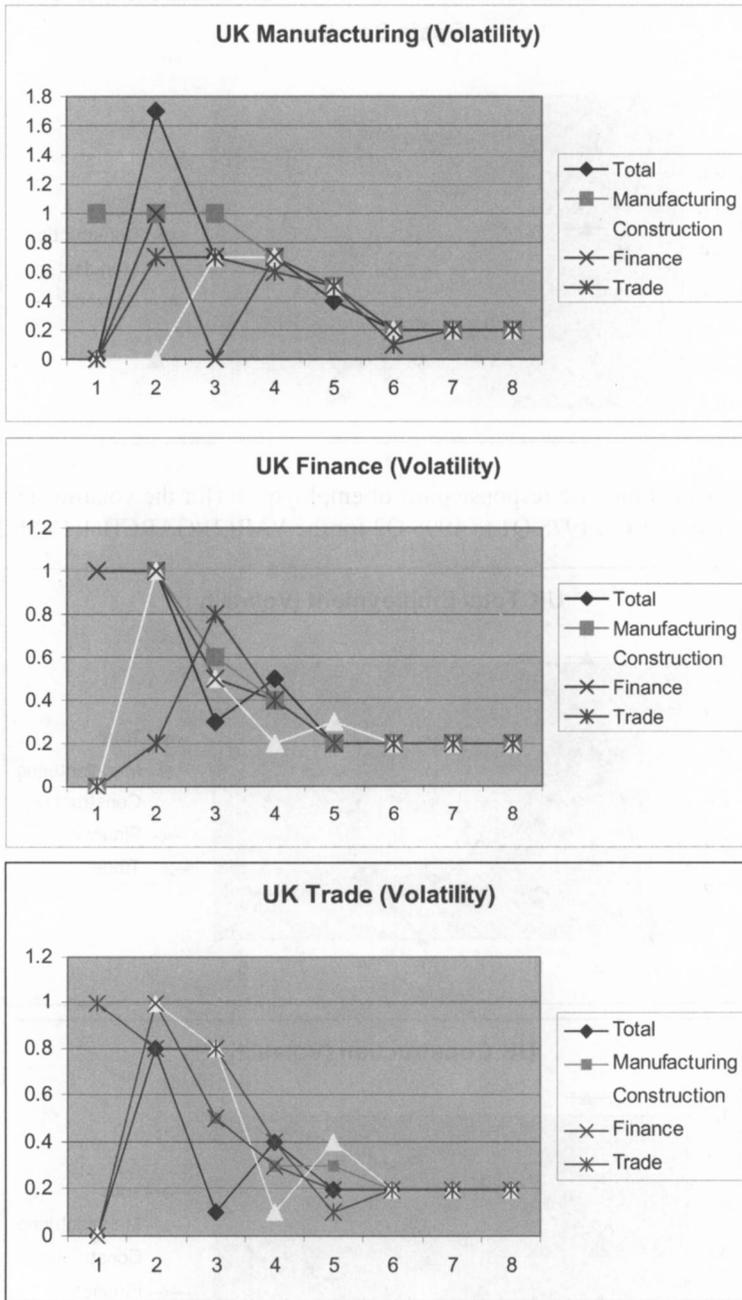
Figure 4. Continued.

UK Manufacturing (Volatility)

UK Finance (Volatility)

UK Trade (Volatility)

preferred.

The similarity between the two countries is confirmed by the plots of the GIRF-V. Given the nature of the VAR-GARCH-M model, we view the GIRF-V as a tool

Figure 5. Individual impulse response plots of German employment (for the volatility) from 1970 Q1 to 1998 Q1 for the VAR(2)-GARCH(1,1)-M(2) model.
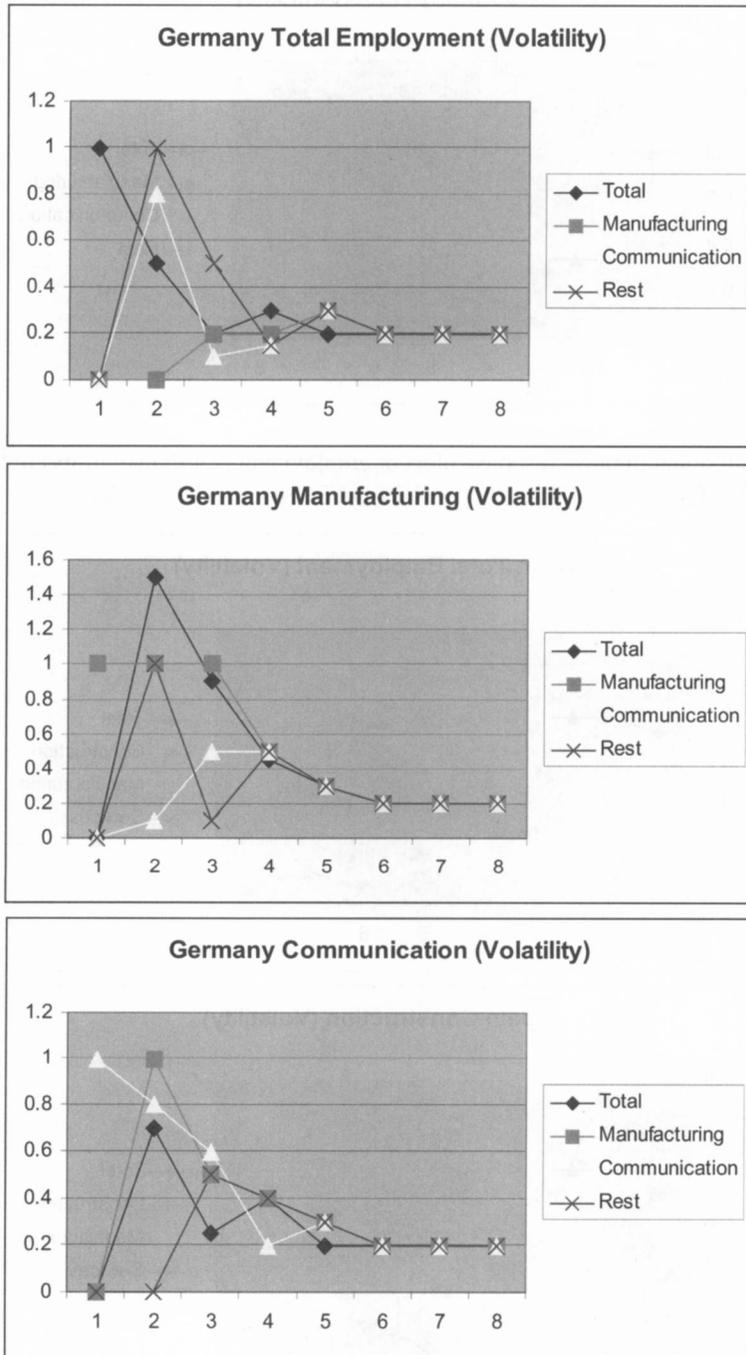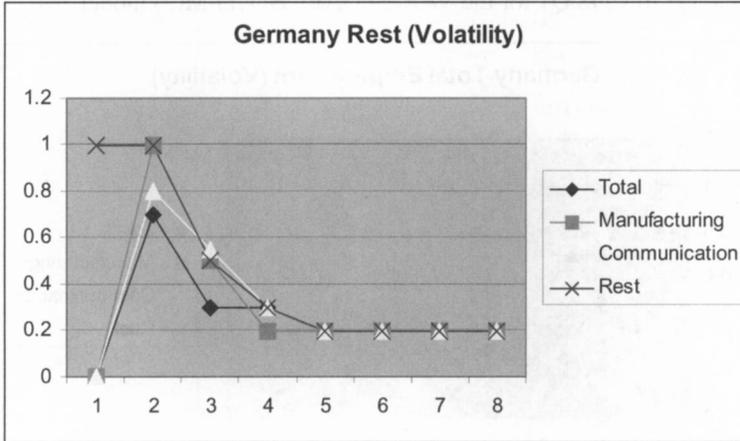
Figure 5. Continued.

Figure 6. Individual impulse response plots of employment (for the volatility) in Spain from 1987 Q1 to 1999 Q4 for the VAR(2)-GARCH(1,1)-M(1) model.
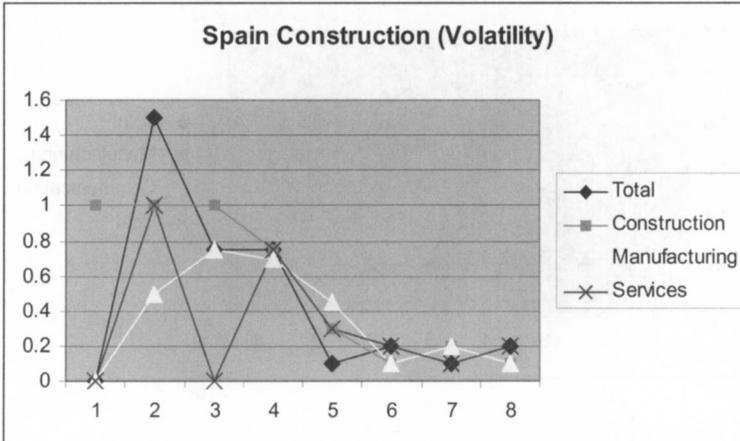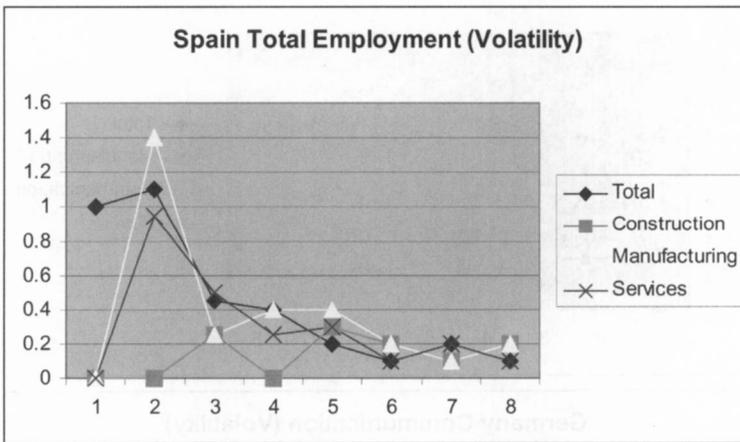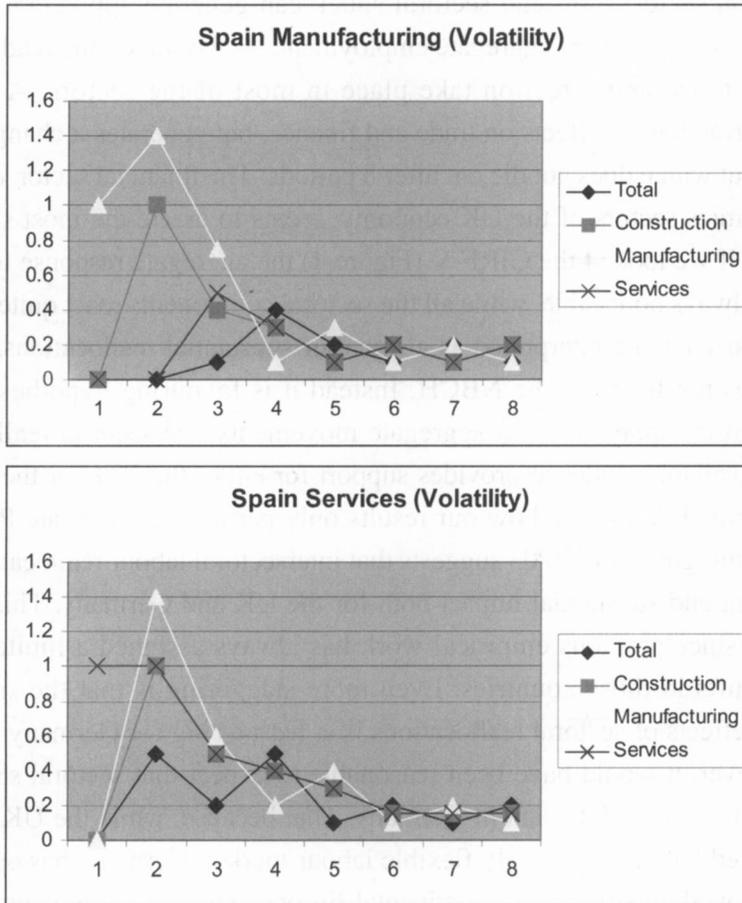
Figure 6. Continued.

Spain Manufacturing (Volatility)

Spain Services (Volatility)

which can correctly capture the effects of reallocation shocks. When we shock the sectoral variances of manufacturing (Germany) and construction (Spain), we can see the aggregate component tends to respond quite strongly. In both countries a sectoral shock brings about a certain amount of sectoral variability in the other sectors. These responses tend to die out after 5 quarters on average. The GIRF-V output seems to suggest that reallocations are taking place and that a volatility shock would result in turbulence in most of the cases. This sectoral response is slightly stronger in Germany than in Spain. For Germany we can draw a picture where the SSH could be working alongside the NBCH. In the case of Spain, the evidence in support of the SSH is slightly weaker while the GIRF profiles certainly corroborate the NBCH.

A different profile emerges for the UK (Figure 1). As far as the mean equations

are concerned, an aggregate shock brings about a sizable response only in the construction sector[5]. Instead sectoral shock can generate appreciable, though short lived, movements in aggregate employment. At the same time readjustments of different size and direction take place in most of the sectors. A shock to manufacturing has no effects on trade and finance, but generates a change in total employment which does not die out after 8 periods. The financial sector, one of the most dynamics sectors of the UK economy, seems to create the most significant responses. If we look at the GIRF-V (Figure 4) the aggregate response to sectoral shocks is always noticeable, while all the sectoral components react quite sensibly. This evidence can be interpreted as a signal of substantial reallocations. The UK output does not bear out the NBCH. Instead it is favouring hypotheses which envisage an interplay between aggregate movements and sectoral reallocations. Thus the available evidence provides support for either the RTH or the SSH.

It is worthwhile to note how our results only partially corroborate PP03. The evidence emerging from PP03 suggests that intersectoral labour reallocations have a significant and substantial impact both for the UK and Germany. This result is surprising since previous empirical work has always assigned a limited role to sectoral shifts in those countries. Even more staggering is that the size of the aggregate effects of sectoral reallocations is at least as big for Germany as for the UK. However, it would have been reasonable to expect that sectoral shifts were more effective in the UK than in Germany. That because, while the UK has been characterized by an increasingly flexible labour market, Germany has epitomized the typical welfare structure of continental Europe. Therefore PP03 suggests that the different institutional arrangements in Germany and UK do not affect the macroeconomic effects of sectoral reallocations. Our results confirm the importance of sectoral shifts for the UK, but reappraise their relevance for Germany. Sectoral shifts seem to be present and to matter, but their importance is somehow scaled down. Changes in "reallocation (un)employment" could be dependent on the different degrees of labour market flexibility.

VI. Conclusions and Further Outlook

A GIRF (Generalised Impulse Response Function) approach has been developed to explore the different impacts of aggregate and sectoral shocks within a VAR-GARCH-M model.

The goal of our experiment is to provide a new and better understanding of the

dynamics and the interactions characterising aggregate employment and sectoral reallocations. The notion of the GIRF, viewed as the result of a conceptual experiment, has been applied to this aim. We have taken into account the three main theoretical frameworks of (un)employment fluctuations: namely the normal business cycle hypothesis (NBCH), the reallocation timing hypothesis (RTH) and the sectoral shifts hypothesis (SSH). We explored the behaviour of three European countries (Germany, Spain and the UK), using the output of a GIRF analysis. We could establish links and provide explanations Thus, though our approach is still in an experimental stage, useful conclusions were drawn and policy implications could be considered. For instance, our evidence suggests that the NBCH could provide a satisfactory framework for Spain while the SSH could be operational in the UK and to a lesser degree in Germany. Appropriate macroeconomic policies could be appropriate for Spain but they should not be effective in the UK. Germany may instead provide the example of a more complex policy mix.

We wish to stress once more the innovative nature of our approach. Our results should be seen strictly in the methodological perspective of our experiment. Definitive results should be expected once more complex modelling strategies of the relevant shocks will be introduced. The main obstacle is to design a structure which could accommodate the compositional nature of sectoral disturbances alongside the intrinsic asymmetries of RTH and SSH. The exploitation of the GIRF properties seems a promising perspective in this direction.

Acknowledgements

References

Abraham, K. and L. Katz, (1986), Cyclical Unemployment: Sectoral shifts on aggregate disturbances, *Journal of Political Economy*, 94, 507-522.

Beach, C. and S. Kaliski, (1985), The Impact of Sectoral Shifts, Demographic Changes and Deficient Demand on Unemployment in Canada, *Queens Discussion Paper no. 624, Aug.*

Campbell, J.R. and K.N. Kuttner, (1996), Macroeconomic effects of employment reallocation, *Carnegie-Rochester Conference Series on Public Policy*, 44, 87-116.

Chib, S. and I. Jeliazkov, (1999), Marginal Likelihood from the Metropolis-Hastings Output, *Washington University Discussion Paper*.

Chib, S., (1995), Marginal Likelihood from the Gibbs Output, *Journal of the American Statistical Association*, 90, 1313-1321.

Davis, S.J., (1986), Allocative Disturbances and Temporal Asymmetry in Labor Market Fluctuations, *WP 86-38, Graduate School of Business*, University of Chicago.

Davis, S.J., (1987), Allocative Disturbances and Specific Capital in Real Business Cycle Theories, *American Economic Review*, 77, 326-332.

Gallipoli, G. and G. Pelloni, (2000), Macroeconomic effects of employment reallocation: a review and an appraisal from an econometric perspective, *Discussion Paper 2000-10, Department of Economics, University of Sheffield*, UK

Hamilton, J., (1994), *Time Series Analysis*, Princeton University Press.

Koop, G., H. Pesaran and S.M. Potter, (1996), Impulse Response Analysis in non-linear Multivariate Models, *Journal of Econometrics*, 74, 119-148.

Lilien, D., (1982a), Sectoral Shifts and Cyclical unemployment, *Journal of Political Economy*, 90, 777-794.

Lilien, D., (1982b), A sectoral model of the business cycle, *MRG Working Paper no. 8231*, University of Southern California.

Panagiotidis, T., G. Pelloni, and W. Polasek, (2000), Macroeconomic Effects of Reallocation shocks, *EMASE - Report No. I03A WP task 3*.

Pelloni, G. and W. Polasek, (1999), Intersectoral Labour Reallocation and Employment Volatility: A Bayesian analysis using a VAR-GARCH-M model, *Discussion Paper no. 99/4, University of York*, York, UK

Pelloni, G. and W. Polasek, (2003), Macroeconomic effects of sectoral shocks in U.S., U.K. and Germany: a BVAR-GARCH-M approach, *Computational Economics*, 21, 65-85.

Pesaran, H.H. and Y. Shin, (1998), Generalized impulse response analysis in linear multivariate models, *Economics Letters*, 58, 17-29.

Polasek, W. and L. Ren, (2000), Generalized Impulse Response Functions for VAR-GARCH-M Models, mimeo, *Institute of Statistics and Econometrics, University of Basel*, March.

Potter, S.M., (2000), Nonlinear Impulse Response Functions, *Journal of Economic*

Dynamics and Control, 24, 1425-46.

Priestley, M.B., (1988), *Non-Linear and Non-Stationary Time Series,* Academic Press, New York.

Notes

(1) Lilien (1982a) originally proposed a dispersion index based on the weighted standard deviation of the sectoral shares growth rates

$$\hat{\sigma}_t = \left[\sum_{i=1} \frac{N_{i,t}}{N_t} (\Delta \ln N_{i,t} - \Delta \ln N_t)^2 \right]^{0.5}$$

where N_t is aggregate employment, $N_{i,t}$ is employment in sector i, $i = 1, 2, \ldots, K$. Lilien's index has been widely used as a measure of intersectoral labour reallocation. Other alternative dispersion measures have been proposed in the literature. However, their implementations were equally unsuccessful in separating the movements in the proxies generated by sectoral shocks from those brought about by allocative disturbances (for a survey c.f. Gallipoli and Pelloni, 2000).

(2) For a detailed discussion of the model, the estimation technique and the model selection procedure see PP99 and PP03.

(3) The GIRF is based on the concept of "generalised transfer function" (Priestley, 1988). C.f Potter (2000), for a detailed discussion on the GIRF and its theoretical foundations.

(4) A more complex structure, reflecting the compositional nature of intersectoral reallocations, would involve sectoral shocks compensating each other so as to leave the level of aggregate demand unaffected.

(5) This might be due to the different income elasticities of sectoral demands as well.

(6) An explanation might perhaps be attempted along the lines of Beach and Kaliski, (1985).

Data Appendix

Sources of the data:
UK: National Statistics, http://www.statistics.gov.uk/
Germany: Federal Statistical Office, http://www.statistik-bund.de/
Spain: National Statistics Institute, http://www.ine.es

Appendix

A.1 Generalised Impulse Response Function

Impulse response functions are used in VAR systems to describe the dynamic behaviours of the whole system with respect to unit shocks in the residuals of the time series. For non-linear time series systems, like multivariate GARCH models, the concept has to be extended to generalised impulse response functions. In extension of the approach of Hamilton (1994, p.318) and KPP we define the generalised impulse response function to be the derivative:

$$\partial y_{t+n} / \partial \varepsilon_t' = \mathbf{M_n}, \quad s = 1, 2, \dots \qquad (A.1)$$

for the VAR-GARCH-M model; where n is the forecast horizon span and $\mathbf{M_n}$ is the lag n matrix of the MA representation of y_t. Each column of $\mathbf{M_n}$ is defined as the numerical derivative in direction

$$\Delta \hat{y}_{t+n}(\varepsilon_{t+1}) = n^{-1} [E[y_{t+n} | \varepsilon_{t+1}, \Omega_t] - E[y_{t+n} | \Omega_{t-1}]], \quad s = 1, 2, \dots \quad (A.2)$$

where Ω_t is the information set up to time t, ε_{t+1} varies over all unity vectors and $\hat{y}_{t+n}$ is the predictive distribution. The expectation is taken as the mean of the predictive distribution and is estimated by the average over the simulated future paths calculated from the MCMC output.

The difference between the predicted value of the vector $\hat{y}_{t+n}$ at time $t+n$ in (A.2) corresponds to the j_{th} column of the matrix $\mathbf{M_n}$. By doing a separate simulation for impulses to each component of the innovation vector ($j = 1, \dots, M$), all of the columns of $\mathbf{M_n}$ can be calculated, i.e.

$$M_n = [\Delta \hat{y}_{t+n}(e_1), \dots, \Delta \hat{y}_{t+n}(e_M)] \qquad (A.3)$$

where $e_1, \dots, e_M$ are the $\mathbf{M}$ unity vectors of order $\mathbf{M}$. Note that the impulse response function of a non-linear system is not time invariant, it depends on the time t, the forecast origin. Details of the approach are found in Polasek and Ren (2000). Also, we calculate the impulse response function for the conditional variances of the VAR-GARCH-M model using the following formula:

$$\Delta \hat{H}_{t+n} = n^{-1} [E_t(\hat{H}_{t+n} | \varepsilon_{t+1}, \Omega_t) - E_t[\hat{H}_{t+n} | \Omega_{t-1}]], \quad s = 1, 2, \dots \qquad (A.4)$$