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TIME VARIATION IN THE DYNAMICS OF WORKER FLOWS: EVIDENCE FROM NORTH AMERICA AND EUROPE

MICHELE CAMPOLIETI, [a]* DEBORAH GEFANG[b] AND GARY KOOP[c]

[a] *Department of Management, Centre for Industrial Relations, University of Toronto, Ontario, Canada*
[b] *Department of Economics, Lancaster University, UK*
[c] *Department of Economics, University of Strathclyde, UK*

SUMMARY

Vector autoregressive methods have been used to model the interrelationships between job vacancy rates, job separation rates and job-finding rates using tools such as impulse response analysis. We investigate whether such impulse responses change across the business cycle or over time, by estimating time-varying parameter–vector autoregressions for data from North America (the USA and Canada) and Europe (France, Spain and the UK). While the adjustment process of the labour market to shocks in Canada and the USA is similar, we find the adjustment process differs much more across the European countries, with greater persistence in shocks relative to the USA and Canada. Copyright © 2012 John Wiley & Sons, Ltd.

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1. INTRODUCTION

Changes in unemployment rates depend on both separation and job-finding rates (i.e. the flows into and out of unemployment). Understanding how unemployment is affected by both flows has a attracted a great deal of attention in the literature. Since the seminal work of Darby *et al*. (1986), many studies have used descriptive measures to investigate the ins and outs of unemployment (e.g. Hall, 2005; Fujita and Ramey, 2006, 2009; Shimer, 2007; Elsby *et al*., 2009; among many others). While this literature has primarily focused on the USA, other countries, such as Canada (Campolieti, 2011) and European countries (Elsby *et al*., 2008; Petrongolo and Pissarides, 2008) have also been studied.

However, while these descriptive methods can be helpful in characterizing the separation and job-finding rates as well as changes in unemployment rates, they do not take into account dynamics, so they miss some important aspects of the adjustment process in the labour market. Arguing that descriptive measures may not be useful in disentangling shocks generated out of the labour market, such as productivity shocks, from those generated within the job search/matching system, Fujita (2011) uses vector autoregression (VAR) models to explore the interrelationships between the separation, job-finding and vacancy rates in the USA. He uses a structural VAR that is identified using the sign restriction approach of Uhlig (2005). In particular, he identifies a negative aggregate shock as one which causes changes to unemployment to be negative for k quarters and does not immediately raise vacancies. This is the framework on which we build in the present paper.

The analysis of Fujita (2011) is conducted using a VAR with constant coefficients and thus impulse responses which are also constant. This can be potentially misleading if the mechanisms underlying the job search/matching process are varying over time. Results of many studies (e.g. Hall, 2005; Shimer, 2007; Elsby *et al*., 2009) suggest that the dynamics of the job-finding and separation rates can be closely related to the fluctuations of business cycles. In the time series literature, many empirical papers (e.g. Koop and Potter, 1999; Skalin and Teräsvirta, 2002) find considerable evidence of nonlinearities

* Correspondence to: Michele Campolieti, Department of Management, Centre for Industrial Relations, University of Toronto, Ontario, Canada. E-mail: campolie@chass.utoronto.ca

in unemployment. To take account of these possible nonlinear effects, this paper extends Fujita (2011) by using a time-varying parameter (TVP)-VAR. We adopt the TVP-VAR of Primiceri (2005) which additionally allows for multivariate stochastic volatility and is popular in the empirical macroeconomics literature. This framework is attractive since it allows both the VAR coefficients and the error covariance matrix to vary over time in a flexible and unrestricted fashion.

We estimate VARs and TVP-VARs using three series: the separation hazard (job separation rate); the job-finding hazard (job-finding rate); and vacancy rates/indexes. We examine the dynamics of the labour market adjustment process in countries from North America (Canada and the USA) and Europe (Spain, France and the UK). Our analysis allows us to compare and contrast how adjustments in the labour markets occur in these countries. Our empirical results provide support for the TVP-VAR with multivariate stochastic volatility. This support is particularly strong for the USA, Spain and the UK. We also find support for the inequality restrictions we use to identify the impulse responses in all the countries we study. More specifically, despite the relatively weak restrictions we impose, our results provide a clear picture of how the labour market responds to these shocks in the five countries we consider.

Our results indicate that there are differences in how labour market adjustments occur in North America and Europe. For example, in Canada and the USA we find that the separation hazard increases quickly after a shock before declining. In contrast, the job-finding hazard and vacancies in the USA and Canada decrease after a shock in a hump-shaped pattern. In Europe, we see differences across the countries we consider as well as compared to Canada and the USA, since the patterns in the impulse responses tend to be country specific. The common feature of the impulse response functions for Europe, relative to those in the USA and Canada, is that shocks tend to be more persistent and take much longer to decline as well as being much stronger during cyclical downturns. While we do not find much evidence of time variation in the impulse responses from France and Canada, we find some interesting time variation in the results for Spain, the UK and, especially, the USA. For the USA, while the impulse responses for most of the time periods we consider are similar, the impulse responses for the separation and job-finding hazard in the US Great Recession differ from those in earlier periods. In particular, the separation hazard responds more strongly to a shock and takes longer to dissipate. Furthermore, the job-finding hazard also responds more strongly initially and takes longer to decline and is still quite large at the end of the time horizon we consider. In Spain and the UK, we find that shocks tend to be much more persistent during cyclical downturns, since they take much longer to recover relative to other periods we consider. Interestingly, the impulse response functions for the USA during the Great Recession are quite similar to those from Europe, in that they exhibit much more persistence. We also find some interesting differences in the size of the impulse responses for the job separation and job-finding hazard, which imply variation in the contributions to changes in unemployment, across countries and time. The impulse response functions for the job-finding hazard tend to be larger than those for the job separation hazard in the USA and Canada, suggesting that the job-finding hazard will account for most of the changes in unemployment rates in the USA and Canada. While earlier papers have found that the separation hazard plays a larger role in changes in unemployment in Europe, relative to Canada and the USA, our TVP-VAR provides a more nuanced view of the role of the job-finding and job separation hazards in Europe. More specifically, our TVP-VAR allows us to determine that there is a great deal of variation in the roles of these hazard rates—both across time and the business cycle—in the European countries we study.

2. ECONOMETRIC EMTHODS

VAR methods have enjoyed wide popularity in empirical macroeconomics since the pioneering work of Sims (1980). VARs are atheoretical models which allow the researcher to investigate the relationships between time series variables without imposing any economic theory. Structural identifying restrictions

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are placed on VARs in order to give an economic interpretation to impulse responses and other features of interest. Traditionally, these identifying restrictions have been equality restrictions and, in some cases, have been criticized for being overly strong. Uhlig (2005) proposed using weaker sets of inequality restrictions in order to identify impulse responses. This attempt to impose the minimum amount of economic theory used, and let the data speak, is in the spirit of the atheoretical VAR literature. These considerations presumably motivated Fujita (2011), who used a VAR involving separation and job-finding hazards and vacancy rates along with a sign restriction approach. This approach required the minimal assumptions that a negative shock cannot immediately raise vacancies and cannot cause the unemployment rate to fall for k quarters.

Our econometric methods also begin with VARs, with impulse responses being identified through similar sign restrictions. However, we also use TVP-VARs which allow for VAR coefficients to change over time. In empirical macroeconomics, there is a plethora of evidence of structural breaks and other kinds of parameter change (see, among many others, Stock and Watson, 1996) and this has led to a large number of papers which use TVP-VARs (see, among many others, Cogley and Sargent, 2001, 2005; Cogley *et al*., 2005; Primiceri, 2005; D'Agostino *et al*., 2009; Koop *et al*., 2009). It is also worth noting that most of these TVP-VAR papers allow for multivariate stochastic volatility, which appears to be empirically important in many macroeconomic applications. One purpose of the present paper is to see whether TVP-VARs with multivariate stochastic volatility will prove equally useful in an analysis of the labour market.

In this section, we briefly outline the structure of TVP-VARs and describe how we implement the sign restriction approach to impulse response analysis. The online appendix provides additional details. Our TVP-VAR setup follows Primiceri (2005) and the sign restriction approach is implemented as in Uhlig (2005); the reader is referred to these papers for additional motivation and explanation.

The basic VAR used by Fujita (2011) can be written as

$$y_t = Z_t\theta + \varepsilon_t \tag{1}$$

where y_t is an $n \times 1$ vector of observations on the dependent variables, Z_t is an $n \times m$ matrix defined so that each VAR equation contains an intercept and p lags of all the dependent variables, and ε_t are independent $N(0, H)$ for $t = 1, 2, \ldots, T$. The TVP-VAR extends this as

$$y_t = Z_t\theta_t + \varepsilon_t \tag{2}$$

where

$$\theta_t = \theta_{t-1} + \eta_t \tag{3}$$

and η_t are independent $N(0, Q)$. Note that this takes the form of a state-space model and the time-varying VAR coefficients can be interpreted as an $m \times 1$ vector of unobserved states. This is a popular specification which allows for the coefficients to vary over time. It has the advantage that standard statistical methods for state-space models can be used. In our empirical work, we refer to this as the homoskedastic TVP-VAR, to distinguish it from the heteroskedastic TVP-VAR, which assumes ε_t are independent $N(0, H_t)$. Following Primiceri (2005), we use a triangular decomposition to model H_t:

$$H_t = A_t^{-1}\Sigma_t\Sigma_t'\left(A_t^{-1}\right)' \tag{4}$$

where Σ_t is a diagonal matrix with diagonal elements $\sigma_{j,t}$ for $j = 1, 2, \ldots, n$ and A_t is a lower triangular matrix with ones on the diagonal. That is, it takes the form

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$$A_t = \begin{pmatrix} 1 & 0 & \cdots & \cdot & 0 \\ a_{21,t} & 1 & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & \cdot & \cdot \\ \cdot & \cdot & \cdots & 1 & 0 \\ a_{n1,t} & \cdot & \cdots & a_{n(n-1),t} & 1 \end{pmatrix}$$

Let $\sigma_t = (\sigma_{1,t}, \sigma_{2,t}, \ldots, \sigma_{n,t})'$ and $a_t = (a_{21,t}, a_{31,t}, a_{32,t}, \ldots, a_{n(n-1),t})'$. These are allowed to evolve according to the following state equations:

$$\log(\sigma_t) = \log(\sigma_{t-1}) + u_t \tag{5}$$

and

$$a_t = a_{t-1} + v_t \tag{6}$$

where $u_t \sim \text{i. i. d. } N(0, W)$, $v_t \sim \text{i. i. d. } N(0, C)$, and u_t and v_t are independent to each other with all the leads and lags. As discussed in Primiceri (2005), this specification is a flexible one, allowing both error variances and covariances to evolve over time.

Our empirical work considers VARs, homoskedastic TVP-VARs and heteroskedastic TVP-VARs. We use the Bayesian information criterion (BIC) to compare these models. This can be interpreted as an asymptotic approximation to the log of the marginal likelihood (the conventional Bayesian model comparison metric). Note that BIC does not involve the prior, which is potentially an advantage in high-dimensional models such as VARs and TVP-VARs where marginal likelihoods can be sensitive to prior choice. Following Carlin and Louis (2000, Section 6), we calculate the BIC using the posterior expectation of the log-likelihood.

Additional technical details, including discussion of posterior simulation and the priors used in our Bayesian estimation procedure, are given in the online appendix. The reader is referred to Koop and Korobilis (2009) for complete details regarding Bayesian estimation of VARs and TVP-VARs.

The online appendix also gives details of how the sign-restricted impulse responses are calculated. We use the same methods as Uhlig (2005) and Fujita (2011). These require the specification of restrictions and we use the same restrictions as in Fujita (2011), which identify an aggregate shock using the following restrictions:

1. A negative aggregate shock will causes changes in unemployment to be non-negative for k quarters.
2. A negative aggregate shock will not raise vacancies in the impact quarter.

In line with Fujita (2011), in this paper we set $k = 2$. In the online appendix, we also present results for $k = 1, 3, 4$ and find results to be fairly robust to choice of k. We present impulse responses for the three variables in y_t (i.e. the separation and job-finding hazards and the vacancy rate). We also present a variance decomposition arising from the sign-restricted impulse response approach. Defined as in Fujita (2011), this measures the proportion of the forecast error variance at different horizons which can be attributed to the identified aggregate shock.

3. DATA

We use quarterly data from the USA (1951:Q1–2009:Q4), Canada (1981:Q1–2003Q1), France (1995: Q1–2007:Q2), Spain (1987:Q3–2005:Q1) and the UK (1983:Q3–2007:Q2). We use the first 20 quarters of data from each country as a training sample and the remaining data to estimate our models.

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The separation and job-finding hazards for France, Spain and the UK were obtained from Petrongolo and Pissarides (2008). The US data were obtained from Elsby *et al*. (2010) and include the separation and job-finding hazard series, which were computed using data from the Current Population Survey (CPS). The Canadian separation and job-finding hazard series were originally computed in Campolieti (2011) using the public release files of the Labour Force Survey (LFS), which is collected by Statistics Canada and is comparable to the US CPS. The separation and job-finding hazard rates measure the flows into unemployment and out of unemployment. Details on the computation of the separation and job-finding hazards can be found in Elsby *et al*. (2009, 2010), Campolieti (2011) and Petrongolo and Pissarides (2008).

For the USA we use the vacancy series created by Barnichon (2010). This series combines information in the help-wanted index collected by the Conference Board, which is based on help-wanted ads in 51 prominent newspapers in the USA, and the US Job Openings and Labor Turnover Survey (JOLTS).[1] For Canada we use the help-wanted index created by Statistics Canada, which is obtained from Statistics Canada's CANSIM database.[2] The Canadian help-wanted index is based on the number of job ads in newspapers and is comparable to the US help-wanted index data collected by the Conference Board.[3] The vacancy rates (number of vacancies divided by number of openings) for France and Spain were based on data obtained from the OECD statistics portal, while the vacancy rate for the UK was computed based on data collected from the OECD statistics portal and ILO website.

Elsby *et al*. (2010) computed their hazard rate series beginning in 1948, but the vacancy series in Barnichon (2010) begins in 1951, so our US sample period includes 1951:Q1–2009:Q4. While Campolieti (2011) computed hazard rate series for Canada from 1976:Q1 to 2008:Q4, the help-wanted index for Canada begins in 1981:Q1 and ends in 2003:Q1, because Statistics Canada terminated the help-wanted index for Canada in April 2003. The hazard rate series in Petrongolo and Pissarides (2008) are available for Spain from 1987:Q3 to 2006:Q3, for France from 1991:Q1 to 2007:Q2 and for the UK from 1983:Q3 to 2007:Q2. The lack of availability of more recent Spanish data for the vacancy rate limits our sample period to 1987:Q3–2005:Q1. We were also only able to obtain a vacancy rate for France beginning in 1995:Q1, so that limited our sample for that country to 1995:Q1–2007:Q2. For the UK we were able use the whole period covered by the Petrongolo and Pissarides (2008) hazard rate series.

We present plots of the raw data for the USA, Canada, France, Spain and the UK in the online appendix. These plots indicate that there is some evidence of low-frequency trends in the data. Fujita (2011) argues that theoretical search/matching models are not associated with low-frequency trends and, accordingly, takes out such low frequency trends. Following Fujita (2011), we detrend all our series using deterministic quadratic trends.[4]

4. EMPIRICAL RESULTS

We divide our empirical results section into two subsections. The first discusses modelling choices and volatility estimates. The second subsection presents impulse responses and variance decompositions.

[1] The Job Openings and Labor Turnover Survey, which began to be collected during December 2000, contains information on the actual number of vacancies.

[2] This help-wanted index was introduced during 1989 and was computed back to the first quarter of 1981.

[3] The help-wanted index we use counts the number of job ads in Canada's 20 largest newspapers. There was also an earlier help-wanted index that was available from 1962 to 1988. This index was proportional to the space occupied by job ads in Canada's 18 major newspapers, so it was sensitive to changes in fonts and column widths as well as paper size in the newspaper industry.

[4] Results using non-detrended data are available in the online appendix. In general, results are similar to those presented in this paper. However, the impulse response functions for the non-detrended data tend to show more persistence in the shocks as well as bigger role for the separation hazard in the unemployment adjustment process in some of the countries we consider.

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4.1. Model Comparison

The BIC chooses VAR models with lag length 2 for the USA, Canada and Spain, but lag length 1 for France and the UK. We adopt these choices for all of our VARs and TVP-VARs. With regard to the degree of time variation in VAR coefficients and error variances, Table I presents BICs for three models. For notational convenience, we use 'Homo TVP-VAR' to denote TVP-VAR models with constant error covariance matrix, and 'Hete TVP-VAR' to denote TVP-VAR models with time-varying error covariance matrix. Table I indicates moderately strong support for time variation in both VAR coefficients and the error covariance matrix. That is, for all countries that we study the Homo TVP-VAR has a substantially lower BIC than the VAR, and the heteroskedastic TVP-VAR in turn has a substantially lower BIC than the TVP-VAR. Accordingly, in the remainder of this paper we will focus mainly on the heteroskedastic TVP-VAR. However, a complete set of results for all models is available in the online appendix.

With regard to the role of stochastic volatility,[5] we note the following patterns. For Canada and the USA there is evidence of time variation in volatilities, but the patterns are quite different. For the longer US series, there are more peaks and troughs in the volatilities. For Canada, the time variation reveals itself largely through a spike around 1997. Campolieti (2011) noted that there is a spike in the separation hazard around 1997 and examined some other data sources for similar patterns. Campolieti (2011) concluded that the spike in the separation hazard was most likely related to a change in the wording of the temporary layoff question that was phased in between September 1996 and January 1997 (Sunter *et al*., 1997) that would classify more individuals as unemployed in the Canadian Labour Force Survey that occurred around this time, since the spike is not present in other data. Campolieti (2011) also observed an increase in the Canadian job-finding hazard around 1997. This increase in the rate at which the unemployed find jobs is equivalent to a decrease in unemployment duration, which is also seen in Macklem and Barillas (2005). However, as noted in Campolieti (2011), the reasons for this increase in the job-finding rate from unemployment are unclear.

For France there is a very little evidence of stochastic volatility because the standard deviations take values in a very tight band for both hazard rates and the vacancy series. There is more evidence of stochastic volatility for Spain. In particular, the error in the vacancy rate equation exhibits a number of spikes and troughs. The error in the job-finding hazard equation also exhibits some stochastic volatility, but this is more pronounced in the first half of the study period. For the UK the standard deviations for the separation and job-finding hazards fluctuate in a relatively narrow range. However, the UK vacancy rate exhibits more stochastic volatility.

4.2. Impulse Response Functions and Variance Decompositions

For each country, we calculate impulse responses and variance decompositions for various time periods, choosing periods near troughs and peaks of the business cycle as well as including a period near the end of the sample. Choices of peaks and troughs are taken from the OECD recession indicators. For the USA we choose 1982:Q4, 1992:Q3, 2003:Q2 (troughs), 1989:Q2, 2000:Q4 (peaks) and 2008:Q2 (near the end of the sample). For Canada we choose 1992:Q4, 2002:Q1 (troughs), 1989: Q3, 2000:Q2 (peaks) and 2003:Q1 (end of sample). For the short French time series we only consider 2001:Q1, 2003:Q1 (troughs) and 2007:Q1 (peak, near the end of the sample). For Spain we choose 1995:Q4, 2001:Q1 (troughs), 1997:Q1 and 2004:Q4 (peaks, with the latter also being near the end of

[5] Figures which plot the posterior means of the standard deviations of the errors in the three equations of the TVP-VAR for the USA, Canada, France, Spain and the UK are available in the online appendix

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Table I. BIC for various models

	USA	Canada	France	Spain	UK
VAR	7.54	6.65	11.79	4.81	5.48
Homo TVP-VAR	−1.64	−0.43	−1.49	1.95	−0.36
Hete TVP-VAR	−9.20	−8.02	−9.86	−5.64	−7.74

the sample). For the UK we choose 1990:Q4, 2001:Q1 (troughs), 1999:Q4 and 2007:Q1 (peaks, with the latter also being at the end of the sample).

4.2.1. Variance Decompositions

Before presenting impulse responses, we provide information that the sign restrictions used to calculate them are reasonable. Tables II–VI present a summary of the variance decompositions for our five countries.[6] The variance decompositions were calculated up to a horizon of 20 quarters. The tables present the average of the point estimate over all horizons. These tables indicate that the aggregate shock we have identified accounts for an appreciable amount of the variability in all three of our variables. For the USA it accounts for roughly 38–44% of the variability in all three series. For Canada comparable numbers are about 36–39%. In France the variance decompositions are a little lower and lie between 27% and 32%. In Spain and the UK the variance decompositions are always above 40%, which is slightly higher than for the USA. These numbers are in line with those reported by Fujita (2011) in his constant coefficient VAR and are much larger than those in Uhlig (2005) in a different empirical application.[7]

Another diagnostic on the sign restriction approach is the percentage of draws that satisfy the identification restrictions. These are presented in Tables VII–XI. Paustian (2007), in his critique of the sign restriction approach, argued that the higher this percentage of draws is, the greater the likelihood that the correct signs of impulse responses are recovered. The acceptance rates we report in Tables VII–XI indicate that about 30% of the draws (and in some cases more) of the draws satisfy the restrictions.

4.2.2. Impulse Response Functions

Figures 1–15 present impulse responses for the USA, Canada, France, Spain and the UK. All of these figures are responses to the negative aggregate shock identified using the sign restrictions. The three figures for each country are responses of three variables (separation hazard, job-finding hazard and vacancy rate) to this shock at the time periods specified above. In all these figures the solid line is the posterior median and the dashed lines are the 16th and 84th percentiles of the posteriors. We present results only for the heteroskedastic TVP-VAR but occasionally refer to results for other models. These latter results are available in the online appendix.

The USA. The response of the separation hazard (Figure 1) to the aggregate shock dies off steadily and fairly quickly (in about eight quarters). In contrast, the job-finding hazard and vacancy rate impulse responses exhibit hump-shaped patterns (Figures 2 and 3, respectively). These impulse responses tend to be near zero after about 12 quarters. These general patterns hold for most of our time periods and also hold for the VAR and homoskedastic TVP-VAR.

[6] Figures containing a full set of variance decompositions, including credible intervals, are available in the online appendix.

[7] Uhlig (2005) has been criticized by some for using weak restrictions and tended to find variance decompositions in the 5–15% range.

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Table II. Average variance decomposition rates for Hete TVP-VAR, USA

Time	1982:Q4	1989:Q2	1992:Q3	2000:Q4	2003:Q2	2008:Q2
Separation hazard	0.3777	0.3752	0.3725	0.3758	0.3781	0.3810
Job-finding hazard	0.4326	0.4321	0.4267	0.4146	0.4154	0.4128
Vacancies	0.4440	0.4361	0.4328	0.4270	0.4272	0.4262

Table III. Average variance decomposition rates for Hete TVP-VAR, Canada

Time	1989:Q3	1992:Q4	2000:Q2	2002:Q1	2003:Q1
Separation hazard	0.3633	0.3659	0.3828	0.3659	0.3766
Job-finding hazard	0.3649	0.3675	0.3826	0.3675	0.3773
Vacancies	0.3696	0.3726	0.3892	0.3726	0.3833

Table IV. Average variance decomposition rates for Hete TVP-VAR, France

Time	2001:Q1	2003:Q1	2007:Q1
Separation hazard	0.2991	0.3002	0.3027
Job-finding hazard	0.3099	0.3112	0.3142
Vacancies	0.2752	0.2764	0.2793

Table V. Average variance decomposition rates for Hete TVP-VAR, Spain

Time	1995:Q4	1997:Q1	2001:Q1	2004:Q4
Separation hazard	0.4513	0.4197	0.4513	0.4086
Job-finding hazard	0.4495	0.4173	0.4495	0.4063
Vacancies	0.4486	0.4189	0.4486	0.4078

Table VI. Average variance decomposition rates for Hete TVP-VAR, UK

Time	1990:Q4	1999:Q4	2001:Q1	2007:Q1
Separation hazard	0.4623	0.4466	0.4435	0.4291
Job-finding hazard	0.4660	0.4535	0.4493	0.4394
Vacancies	0.4524	0.4378	0.4333	0.4201

Table VII. Acceptance rate for the number of draws, USA

Time	1982:Q4	1989:Q2	1992:Q3	2000:Q4	2003:Q2	2008:Q2
Hete TVP-VAR	0.4143	0.4090	0.4065	0.4034	0.4042	0.4048

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Table VIII. Acceptance rate for the number of draws, Canada

Time	1989:Q3	1992:Q4	2000:Q2	2002:Q1	2003Q1
Hete TVP-VAR	0.3589	0.3612	0.3721	0.3686	0.3667

Table IX. Acceptance rate for the number of draws, France

Time	2001:Q1	2003:Q1	2007:Q1
Hete TVP-VAR	0.2760	0.2769	0.2783

Table X. Acceptance rate for the number of draws, Spain

Time	1995:Q4	1997:Q1	2001:Q1	2004:Q4
Hete TVP-VAR	0.2844	0.2790	0.2774	0.2609

Table XI. Acceptance rate for the number of draws, UK

Time	1990:Q4	1999:Q4	2001:Q1	2007:Q1
Hete TVP-VAR	0.3584	0.3525	0.3444	0.3311

The signs of the responses for all the series we consider are unambiguous (i.e. the initial response to the shock has an error band that does not include zero), which provides support for the restrictions we use in the data. In other words, despite using weak restrictions, we observe the adjustment process in the US labour market quite clearly. The separation hazard (separation rate) reaches its peak quickly and then declines slowly. The job-finding hazard (job-finding rate) and vacancies (see Figures 2 and 3) take a few quarters to reach a trough before starting to fade. The patterns in these series are like those in Fujita (2011). Moreover, they also support the conclusions in Elsby *et al*. (2009) and Fujita and Ramey (2009) that unemployment dynamics in the USA are driven by fluctuations in both the separation and job-finding hazard. However, the job-finding hazard does look to play a larger role than the separation hazard.

Overall, the differences across time periods do not appear to be too great, except for 2008:Q2. However, there are some variations over time and differences with standard VAR results which are worth noting.

For the separation hazard, the impact impulse response found using the heteroskedastic TVP-VAR is larger than what is provided by the VAR. In addition, the impulse responses in 1982:Q4 and 2008:Q2 begin at a higher level and die away more steeply than for the other time periods.

For the job-finding hazard, the point estimate for the impulse responses is similar in each time period, but the credible interval between the 16th and 84th percentiles becomes wider over time, with the 2008:Q2 interval being very wide.

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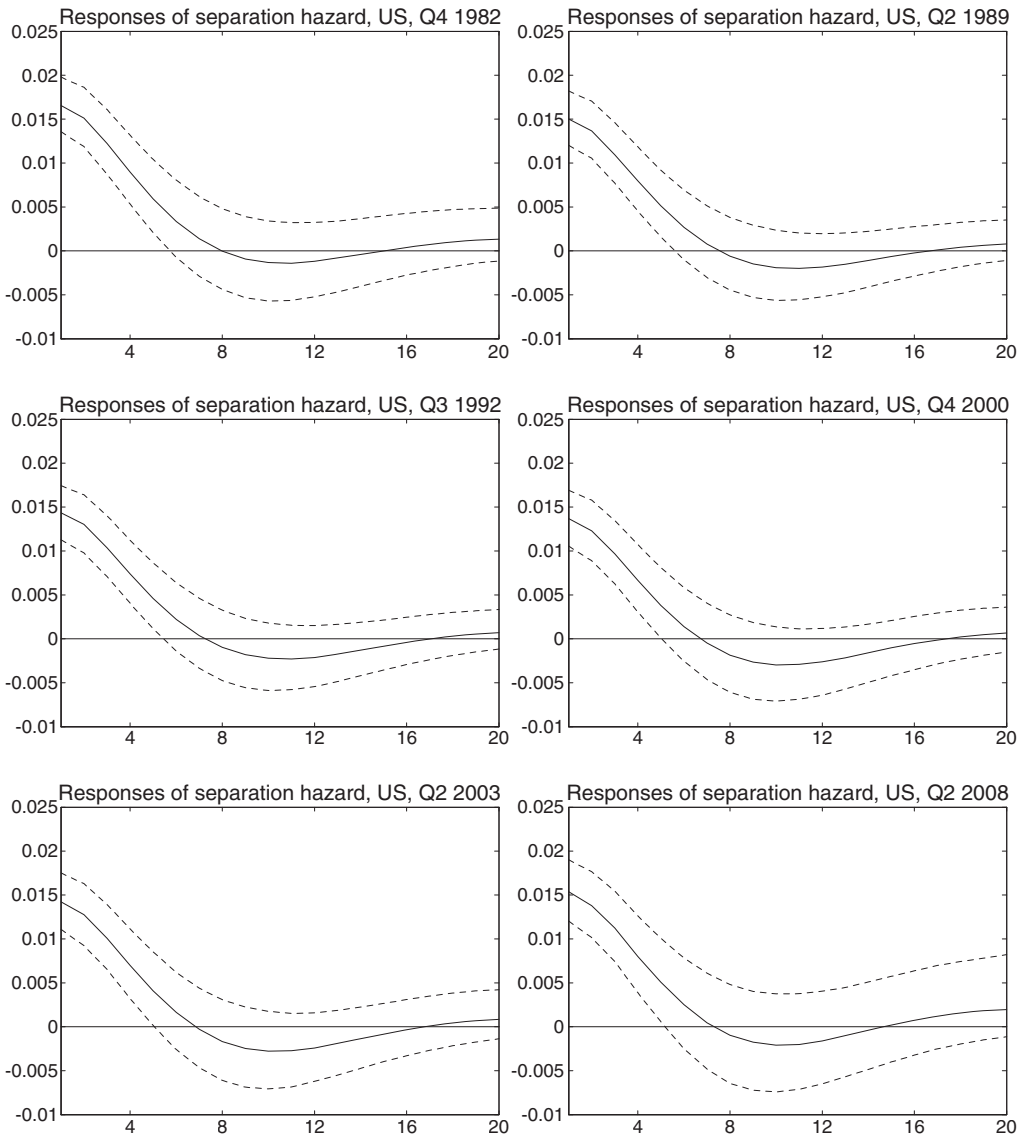

Figure 1. Impulse responses of separation hazards: Hete TVP-VAR, USA

For the vacancy rate, this pattern of wide credible intervals in 2008:Q2 and a tendency of the impulse response function to take a long time to move towards zero is also found. Other than this, impulse responses for this variable are quite similar in each time period and also similar to what is found for the standard VAR or homoskedastic TVP-VAR. Most of the time variation in the impulse responses is revealed in the initial response to a shock in 2008:Q2, which is larger than that in the other time periods we consider.

The time variation in impulse responses is most visible in the impulse responses of the separation and job-finding hazard for 2008:Q2. This is worth elaborating on since it provides some new insights into changes in the process of labour market adjustment in the USA. We find that the impulse responses for the job-finding hazard for most of the periods we consider fade to zero,

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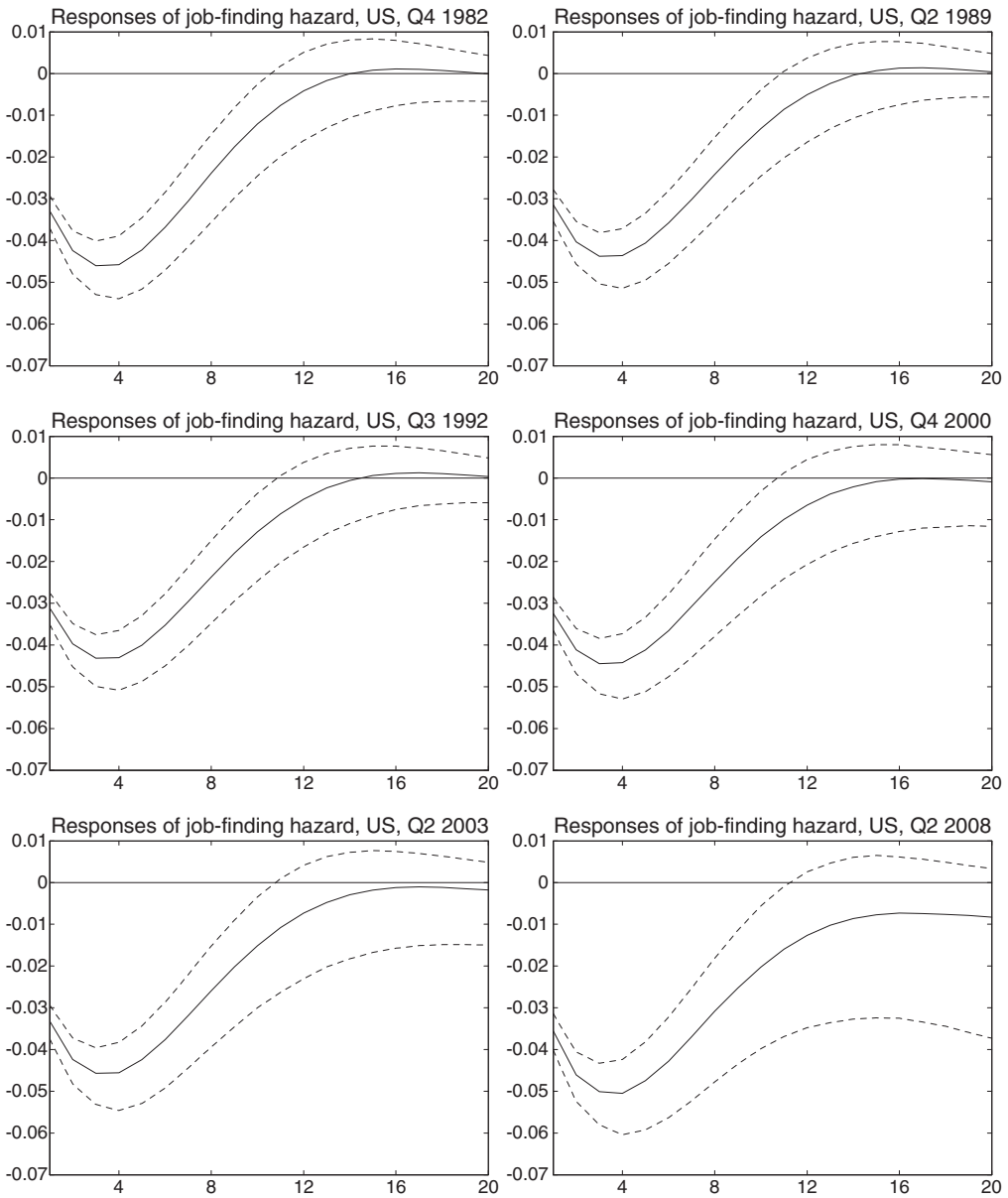

Figure 2. Impulse responses of job-finding hazards: Hete TVP-VAR, USA

but the impulse responses for 2008:Q2 are still large after 20 quarters. Elsby *et al*. (2010) noted that there was an increase in the half-life of a deviation from steady-state unemployment during the Great Recession relative to estimates of the half-life of a deviation from steady-state unemployment obtained with data before the Great Recession (see also Elsby *et al*., 2008, 2009). In addition, Elsby *et al*. (2010) also highlighted that there was an overall slowdown in the rate of exit from unemployment during the Great Recession, resulting in an accumulation of long-term unemployed people. This accumulation of the long-term unemployed reduced the ability of the job-finding hazard in the USA to rebound. Our impulse response functions for

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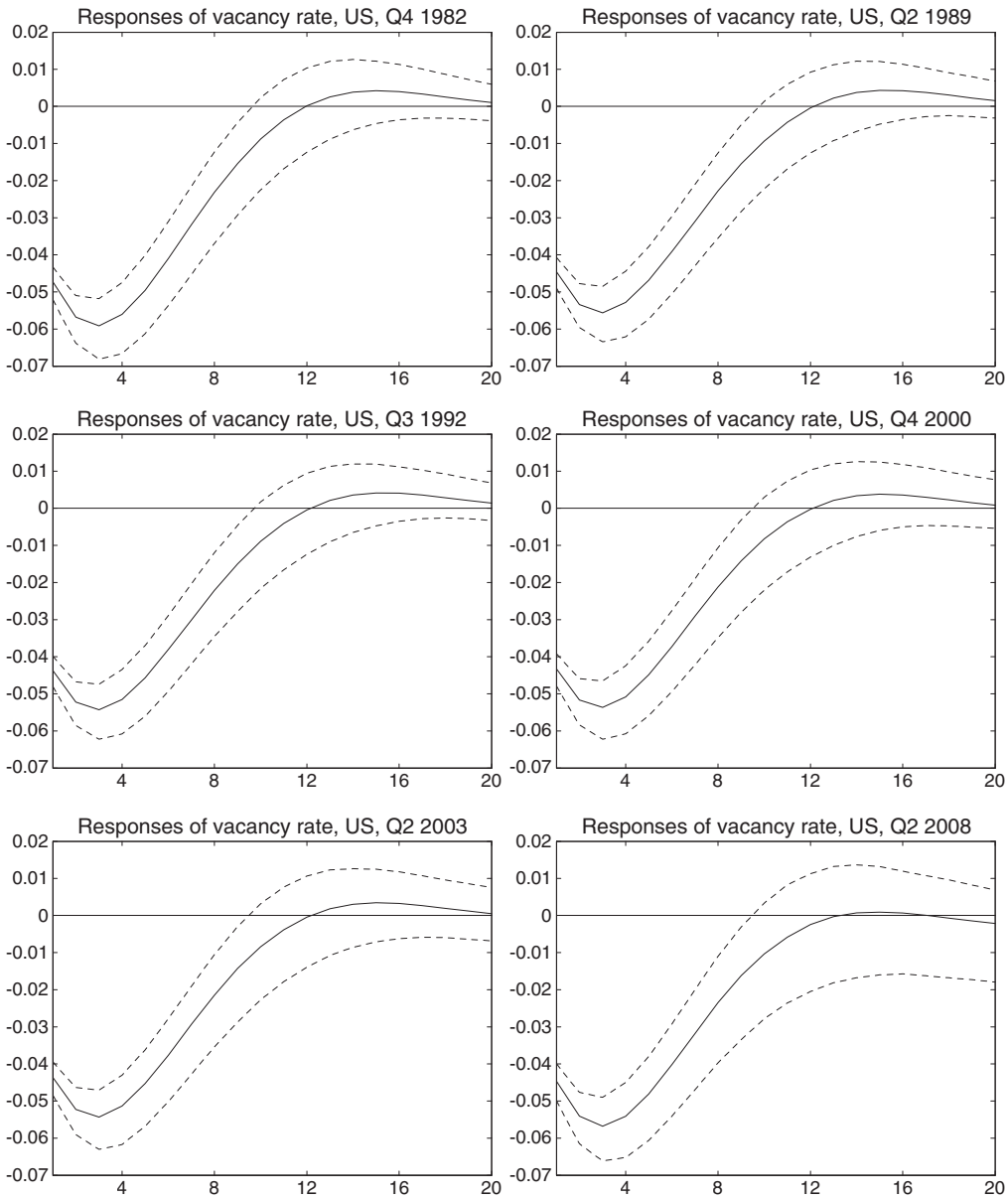

Figure 3. Impulse responses of vacancies: Hete TVP-VAR, USA

the job-finding hazard from 2008:Q2 are consistent with these observations, while those from a conventional VAR model would not capture these effects. The impulse response for the separation hazard from 2008:Q2 also tends to be larger than those for earlier periods and also takes longer to fade away. Elsby *et al.* (2010) also found some evidence of elevated levels of job loss, relative to earlier recessions, during the Great Recession. In particular, they found evidence of more separations due to layoffs during the Great Recession. Our impulse responses for 2008:Q2 would be consistent with this changed pattern observed by Elsby *et al.* (2010).

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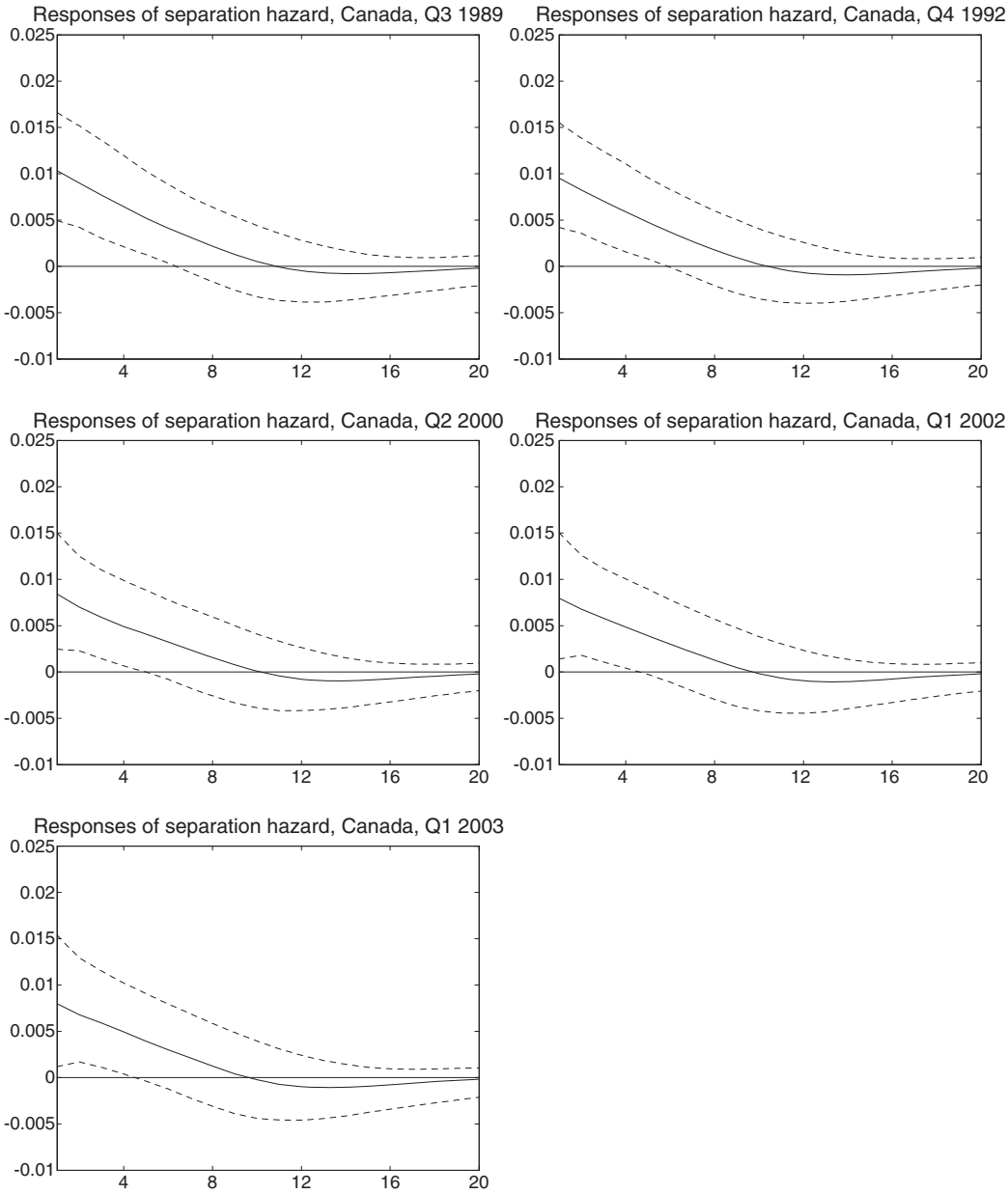

Figure 4. Impulse responses of separation hazards: Hete TVP-VAR, Canada

The online appendix presents results for various priors and different choices for k, and these are found to be of the same pattern as those presented here.

Canada. The general patterns found in the impulse responses using the Canadian data in Figures 4–6 are similar to those for the USA. Impulse responses for the separation hazard do indeed die off in a similar manner to what we found for the USA. The impulse responses for the job-finding hazard and vacancies have a hump-shaped pattern, like their counterparts in the USA, but tend to oscillate a little

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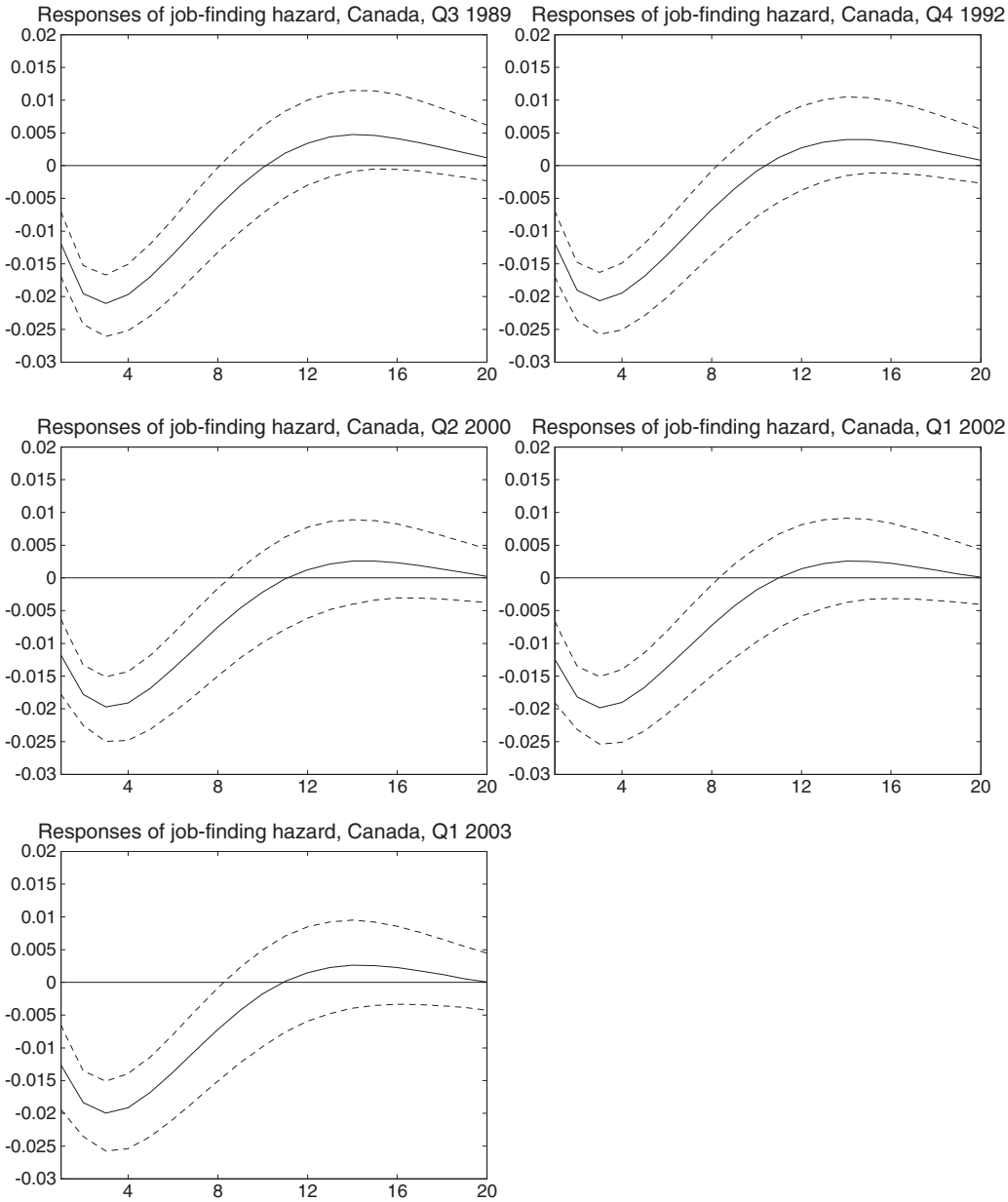

Figure 5. Impulse responses of job-finding hazards: Hete TVP-VAR, Canada

before fading. The previous statement holds for the point estimates of the impulse response, although the credible intervals are fairly wide and include the hump-shaped pattern. In addition, relative to the USA, the impulse responses for the job-finding hazard do not have a trough that is as deep, but they do take longer to recover. The patterns in the impulse responses for the job-finding hazard, relative to the USA, is interesting in the context of the difference in unemployment rates that has existed between the two countries since the early 1980s (Riddell, 2005). For most of the period we are

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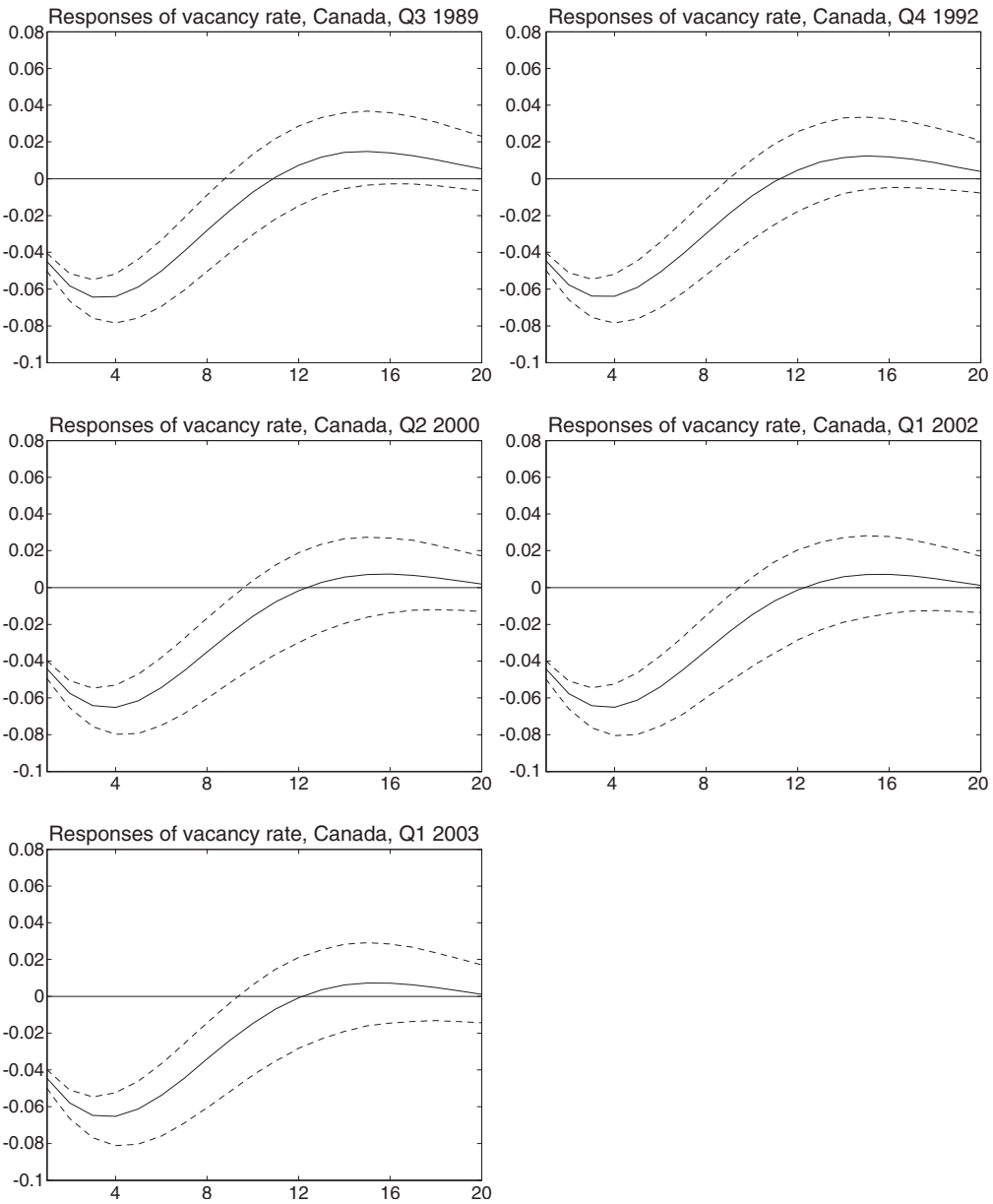

Figure 6. Impulse responses of vacancies: Hete TVP-VAR, Canada

considering the Canadian unemployment rate was higher than the US unemployment rate. The impulse responses for Canada, relative to the USA, suggest that there could be lower exits from unemployment at longer horizons. This is consistent with observations made by Campolieti (2012), who found that changes in the job-finding hazard were responsible for a large part of the Canadian–US unemployment rate gap.

In general, with Canadian data there is less evidence of time variation in impulse responses for the separation and job-finding hazards and the vacancy rate, although, for the separation hazard, there is

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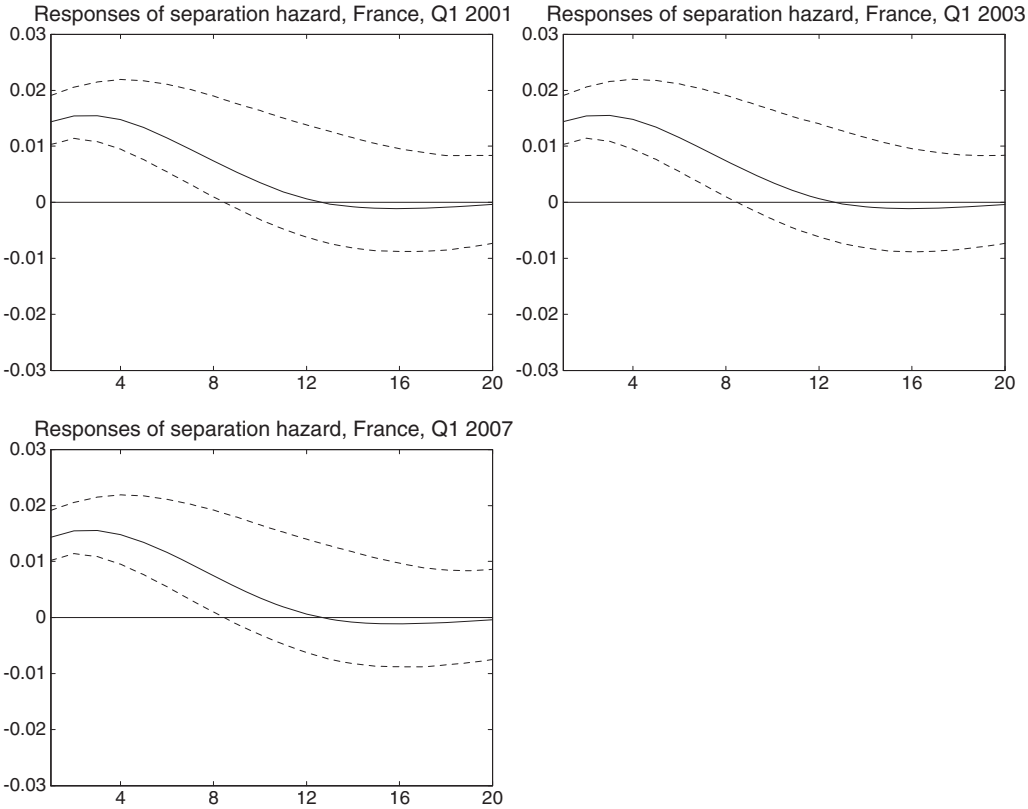

Figure 7. Impulse responses of separation hazards: Hete TVP-VAR, France

some weak evidence that the effect of the negative aggregate shock is getting weaker over time. That is, impact responses are slightly less in 2002:Q1 and 2003:Q1 than in earlier years.[8]

The similarity of the impulse responses for the periods we consider is like the pattern we observe in the USA, except for 2008:Q2.[9] The Canadian estimates suggest that the response to a shock is similar across time and the business cycle. Also, like the USA, the separation and job-finding hazards both play a role in the adjustment of the labour market, but the job-finding hazard effect is larger.

Results using different values for k are similar to those presented here (see the online appendix). However, the results using the VAR or homoskedastic TVP-VARs do differ from those included here in some minor ways (e.g. the VAR results do not exhibit the same oscillatory responses noted above). Furthermore, the results are more sensitive to the prior than was found with the US data (although this is not unexpected, due to the shorter data span). The reader is referred to the online appendix for full empirical results relating to these points.

[8] We present impulse responses for the unemployment rate in the online appendix. These show that the impulse response in 1992:Q4 for the unemployment rate is substantially different from those in other years. The impact and maximum responses are higher in this trough year than at other periods. While 1992:Q4 is contained in the 1990–1992 recession, the period covered by the time horizon for the impulse responses corresponds to the period referred to as the 'The Great Canadian Slump' (Fortin, 1996), which was a prolonged period of slow growth for the Canadian economy that extended into the mid 1990s following the end of the 1990–1992 recession.

[9] The Canadian data end in 2003:Q1, so we are not able to investigate the Canadian experience during the recession following the financial crisis of 2008.

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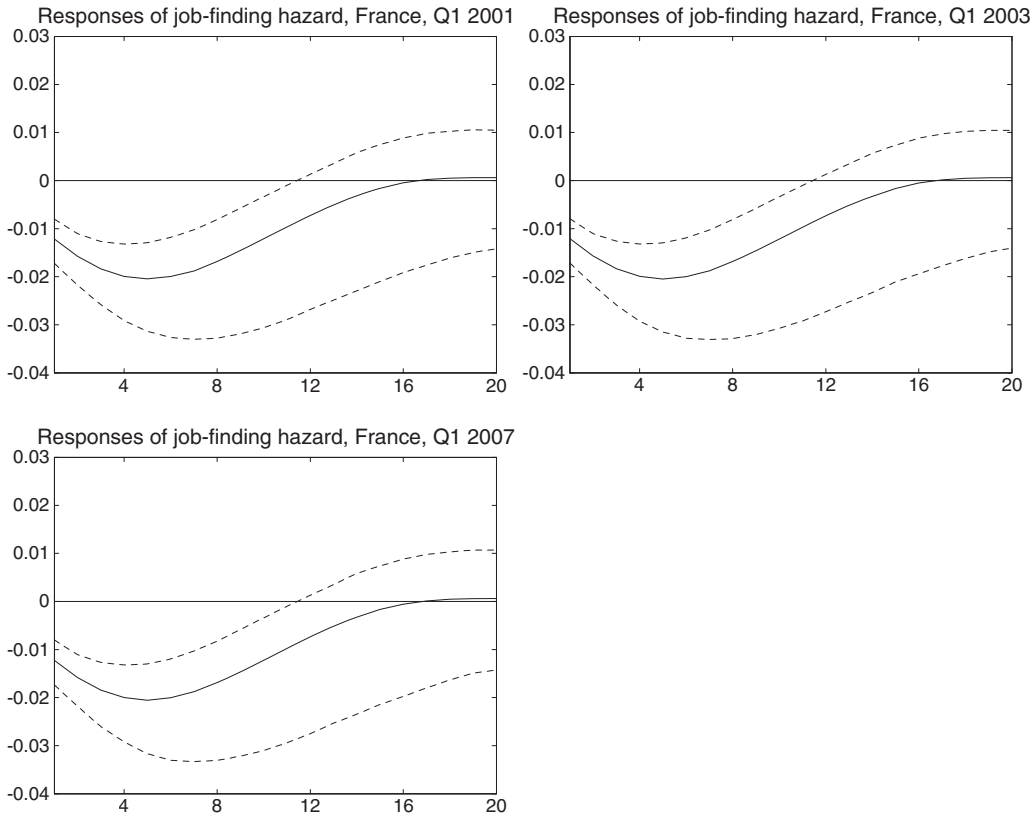

Figure 8. Impulse responses of job-finding hazards: Hete TVP-VAR, France

France. The impulse response functions for France are presented in Figures 7–9. The impulse responses for the separation hazard do not display a great deal of time variation in the three periods we consider for France. The impulse responses for separation hazards from France differ from those for the USA and Canada in two ways. First, the impulse responses for the separation hazard have a bit of a hump-shaped pattern, in that they increase slightly before beginning to decline. In contrast, for the USA and Canada the impulse responses begin to decline after the initial period. Second, the impulse responses for France tend to take longer to fade away.

The impulse response functions for the job-finding hazard for France in Figure 8 also do not display much time variation, but our data come from a relatively short window that does not include any deep recessions. Like those for the USA and Canada, the impulse responses for the job-finding hazard have a hump-shaped pattern. However, the impulse responses in France take longer to decline than those in Canada and the USA: about 16 quarters versus 12 quarters for most of the periods (except for 2008:Q2 in the USA, which is during the Great Recession).

The impulse responses for the vacancy rate for France also differs from those in the USA and Canada. These impulse responses do not have a hump-shaped pattern in France like in the USA and Canada, and tend to fade relative quickly (about eight quarters, relative to Canada and the USA, which take 10–12 quarters to decline in most of the periods we consider).

Spain. The impulse responses for Spain are presented in Figures 10–12. The separation hazards display some time variability, which is revealed in the impulse response function at trough times tending to be quite different from those at peaks. The general pattern of the impulse responses also differ from those

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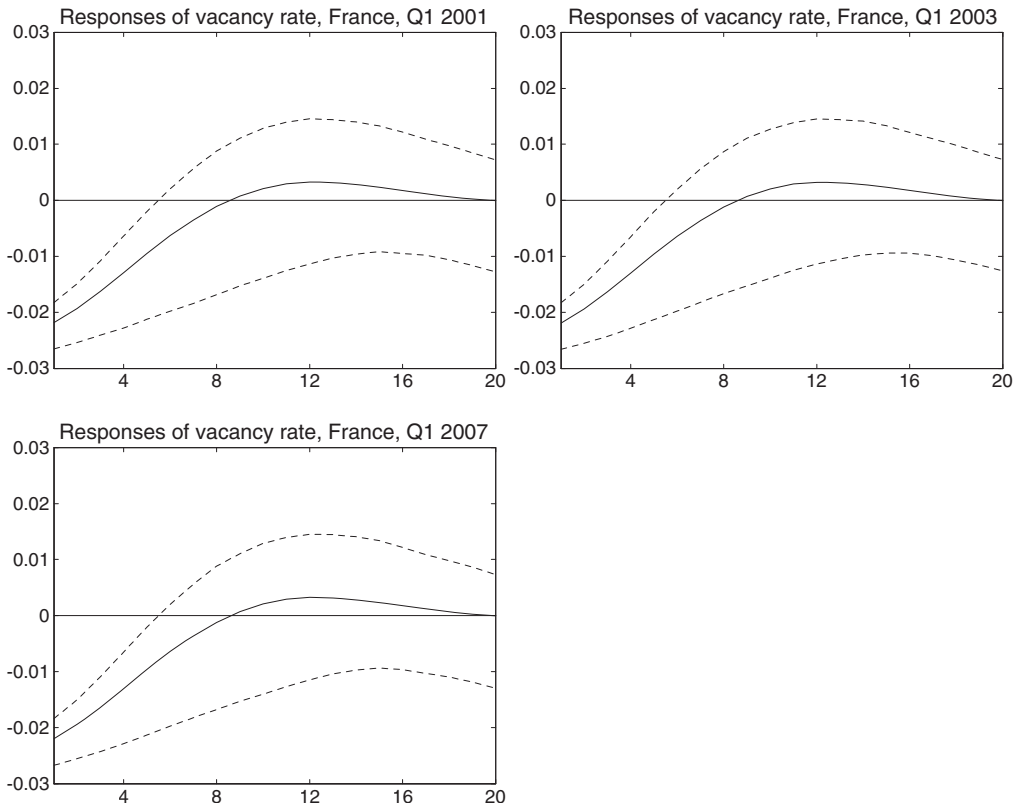

Figure 9. Impulse responses of vacancies: Hete TVP-VAR, France

in other countries. For instance, in Spain, during trough periods the impulse response for the separation hazard increases initially in response to a shock and then declines slowly. The impulse response functions from trough periods are also quite persistent, since they are still relatively large after 20 quarters. In contrast, during peak periods the impulse responses decline after the initial shock and the decline occurs more quickly than during trough periods.

The impulse response functions for the job-finding hazard tend to start small before they reach a minimum and then recover. However, after about six quarters the impulse responses tend to plateau and the rate of decline is very slow, so that the impulse responses are still relatively large after 20 quarters. This suggests, not surprisingly, that there is a great deal of persistence in unemployment duration. As with the impulse response function for the separation hazard, the time variation in the impulse response for the job-finding hazard is most apparent in the results for 1995:Q2 and 2001:Q1, where the troughs in the impulse responses are much deeper and the level at which they plateau are much lower than in the other periods we consider.

The impulse response functions for the vacancy series also differ substantially from those in the USA and Canada as well as France. In Spain the shock to the vacancy rate is negative initially, but it does not decline a great deal because the impulse response is relatively stable through most of the 20-quarter horizons we consider. The impulse responses in Figures 10–12 suggest that there are significant differences between the process and dynamics of labour market adjustment in Spain relative to those in the other countries we consider. In particular, shocks to the labour market tend to be much more persistent and in many cases are still quite large 20 quarters out. This indicates that the process of labour market adjustment is much slower in Spain, relative to the other countries we consider.

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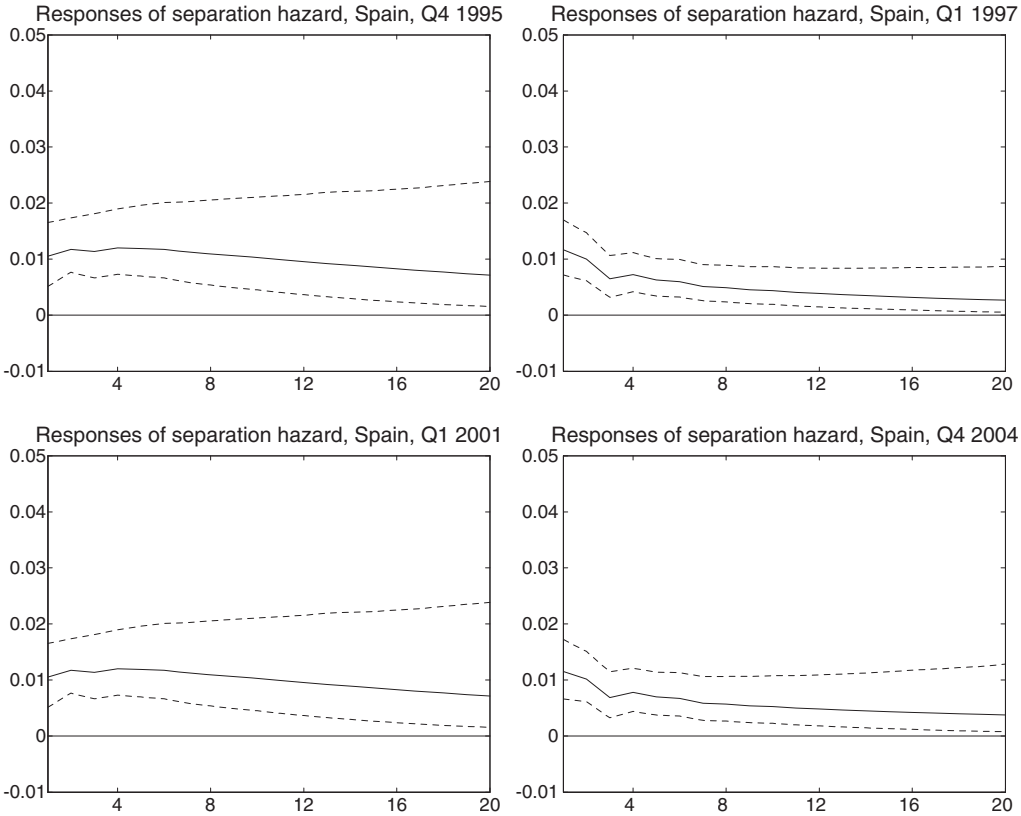

Figure 10. Impulse responses of separation hazards: Hete TVP-VAR, Spain

The UK. The results for the UK are presented in Figures 13–15. There is some time variability in the point estimates of the impulse responses for the UK. The impulse responses for separation hazard from the UK are slightly humped shaped, although the hump is very shallow. The decline in the impulse responses for the separation hazard from the UK is similar to that for Spain, since the decline is very slow. Even after 20 quarters impulse responses tend not to have returned to zero. The time variability in the separation hazard is revealed through a more pronounced hump shape during the cyclical trough periods we consider (1990:Q4 and 2001:Q1).

The impulse response functions for the job-finding hazard for the UK decline slightly before beginning a slow recovery. This pattern is most clearly seen during 1990:Q4 and 2001:Q1, i.e. the cyclical troughs. The impulse responses for the job-finding hazard also decline very slowly and are still quite sizeable after 20 quarters.

The impulse responses for the vacancy rate display their variability via the initial response to a shock, which is much larger during the cyclical troughs. However, one common feature of the impulse responses for the vacancy rate during all the periods we consider is the amount of time it takes the shock to decline. Like the impulse responses for the separation and job-finding hazards in Figures 13 and 14, the impulse responses for the vacancy rate are still quite large after 20 quarters.

5. DISCUSSION

The impulse response functions show that there are some cross-country differences in terms of how labour markets adjust. Elsby *et al*. (2008), in their analysis of unemployment inflows and outflows

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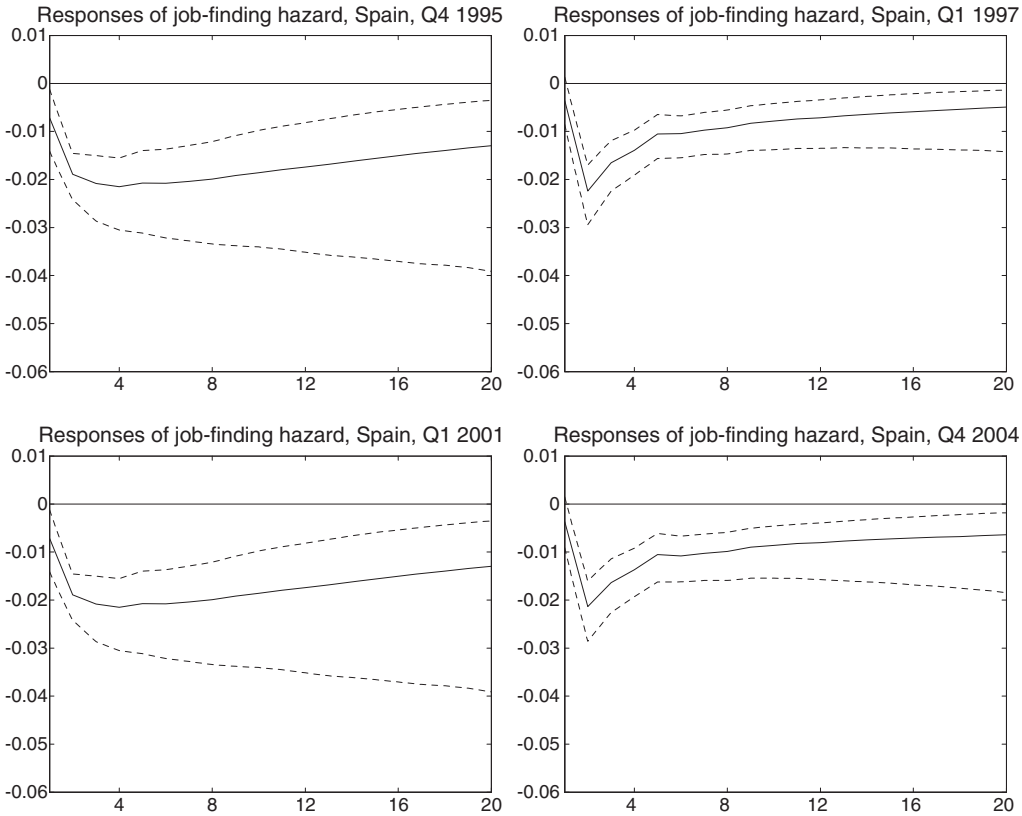

Figure 11. Impulse responses of job-finding hazards: Hete TVP-VAR, Spain

in OECD countries, divided their study group into three blocks: Anglo-Saxon countries, which exhibit high separation rates and high job-finding hazards; Continental Europe, which has much lower separation and job-finding hazards relative to the Anglo-Saxon countries; Nordic economies, with fairly high separation and job-finding hazards; and a few intermediate cases, such as the UK, which has hazard rates that lie about halfway between those in Continental European and Anglo-Saxon economies.[10] Using this classification we see differences between the Anglo-Saxon countries in Elsby *et al.* (2008), i.e. Canada and the USA, and Continental European economies, i.e. France and Spain, in our study and the UK. Our findings also suggest that the UK is not very similar to the USA and Canada in terms of the process of labour market adjustment, despite having some similarities in the levels of the hazard rates to Canada and the USA. Our findings also suggest that each of the European countries has its own distinctive features in terms of the process of labour market adjustment, which might be a reflection of the different institutional features of each country's labour market, such as differences in social insurance programs, laws governing labour standards, employment protection laws, trade union power and minimum wages (Machin and Manning, 1999; Nickell and Layard, 1999; Blanchard and Wolfers, 2000).

[10] The classification in Elsby *et al.* (2008) listed the Anglo-Saxon countries as Australia, New Zealand, Canada and the United States; the Continental European economies included, France, Spain, Germany, Italy and Portugal.

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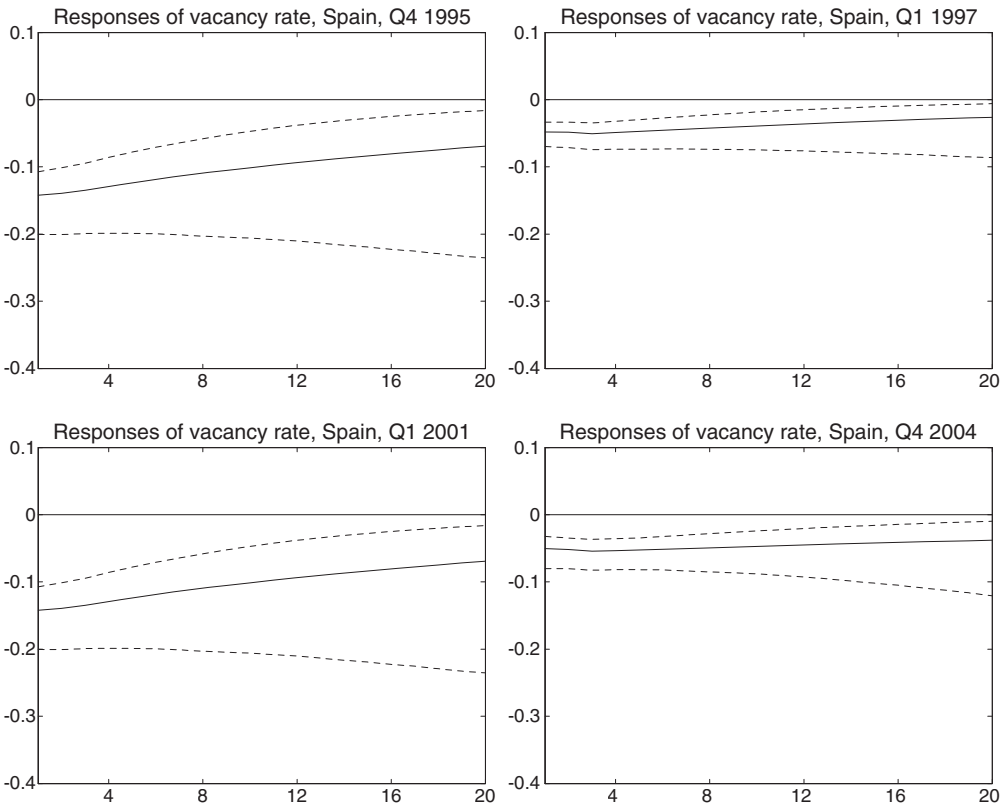

Figure 12. Impulse responses of vacancies: Hete TVP-VAR, Spain

Our results clearly indicate that there are some important differences in how labour market adjustments occur in the countries we include in our study. In the USA and Canada, the impulse response functions for the job-finding hazard and vacancies have a hump-shaped response, while separation hazard decreases after the initial shock. In Europe, we see differences in the impulse responses both relative to Canada and the USA as well as across countries. As we noted above, these differences could reflect differences in the labour market institutions in each country. For example, in France the impulse responses for the job-finding hazard have a hump shape, while in the UK the impulse responses for the job-finding hazard tend to dip and then recover gradually (for the most part) and in Spain the impulse responses decline sharply, recover for a few quarters and then reach a semi-plateau, where they decline quite slowly. Our results indicate that there are also differences in the persistence of shocks in Europe, with shocks declining more quickly in France than in Spain or the UK. In fact, in Spain and the UK these shocks are still quite large even 20 quarters out. We also observe much more time variability in the impulse responses for the European countries, since shocks can have much larger impacts during cyclical downturns. Another important difference between Europe and the USA (except for the period we consider in the US Great Recession) as well as Canada is that impulse responses for shocks to all the series we consider are more persistent in Europe. This is especially true for Spain and the UK, where shocks to the job-finding hazard are much more protracted and take a very long time to fade away, especially during recessions. These findings are consistent with observations others have made about the persistence of European unemployment (among others, Blanchard and Summers, 1986; Nickell and Layard, 1999; Nickell *et al*., 2005).

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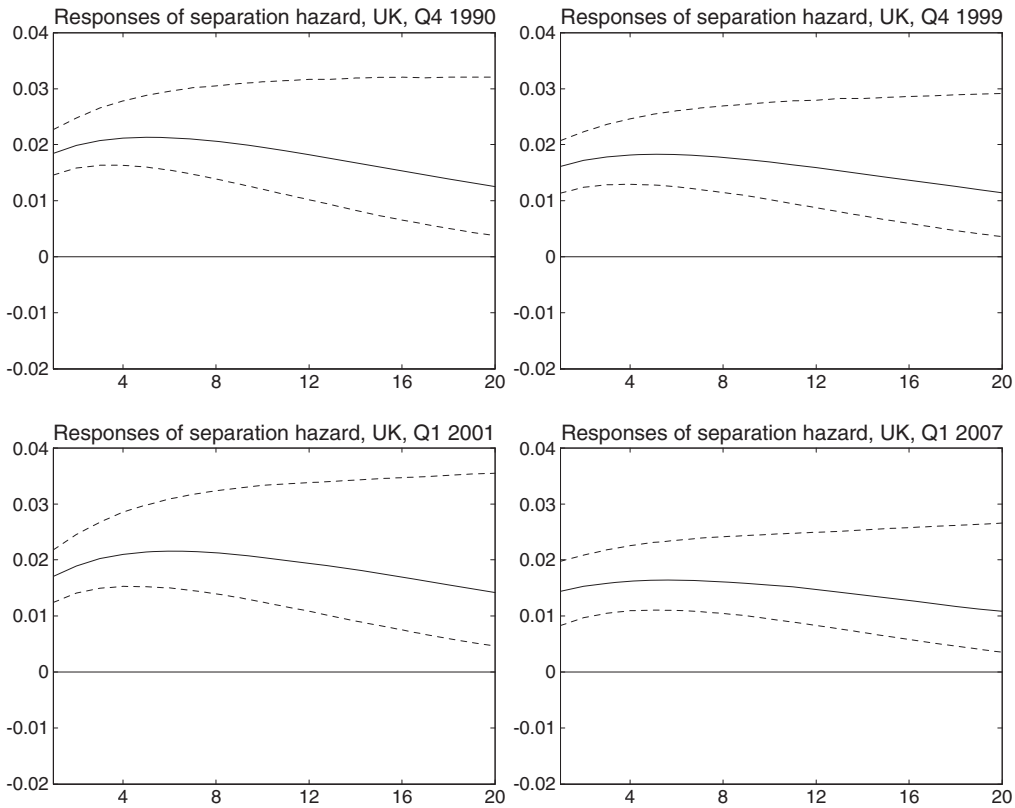

Figure 13. Impulse responses of separation hazards: Hete TVP-VAR, UK

We also find some interesting differences in the magnitude of the impulse responses for the separation and job-finding hazard, which imply differences in the contributions of unemployment incidence and duration to changes in unemployment across countries. Elsby *et al.* (2008) in their analysis of the separation and job-finding hazards in the OECD countries found that the job-finding hazard has a larger contribution to changes in unemployment rates in the Anglo-Saxon economies (i.e. the USA and Canada in our study), while the job separation hazard plays a larger role in continental Europe. We find that in the USA and Canada the impulse responses for the job-finding hazard suggest that unemployment duration accounts for most of the changes in unemployment and this portion tends to increase as the impulse response horizon increases. The patterns we observe in Europe are very different. In France there is a fairly even split between the impulse responses for the separation and job-finding hazards until about four to six quarters, after which the job-finding hazard effects tend to dominate more. In the UK, the impulse responses for the separation and job-finding hazard tend to be similar in the first few quarters, but the job-finding hazard is more dominant after that. In Spain the impulse responses for the job-finding and separation hazards vary much more over time and the business cycle. During cyclical troughs, the impulse responses for the separation and job-finding hazards are fairly similar, but the job-finding hazard becomes more dominant after a few quarters and remains so. In contrast, during cyclical peaks, the impulse responses for the separation hazard effects are larger for the initial few quarters, after which the job-finding hazard effects would become much larger for about four quarters. However, as the impulse responses for the job-finding hazard decline, they become similar in magnitude to the responses for the separation hazard, which suggests that they would account for similar shares of changes in unemployment at longer

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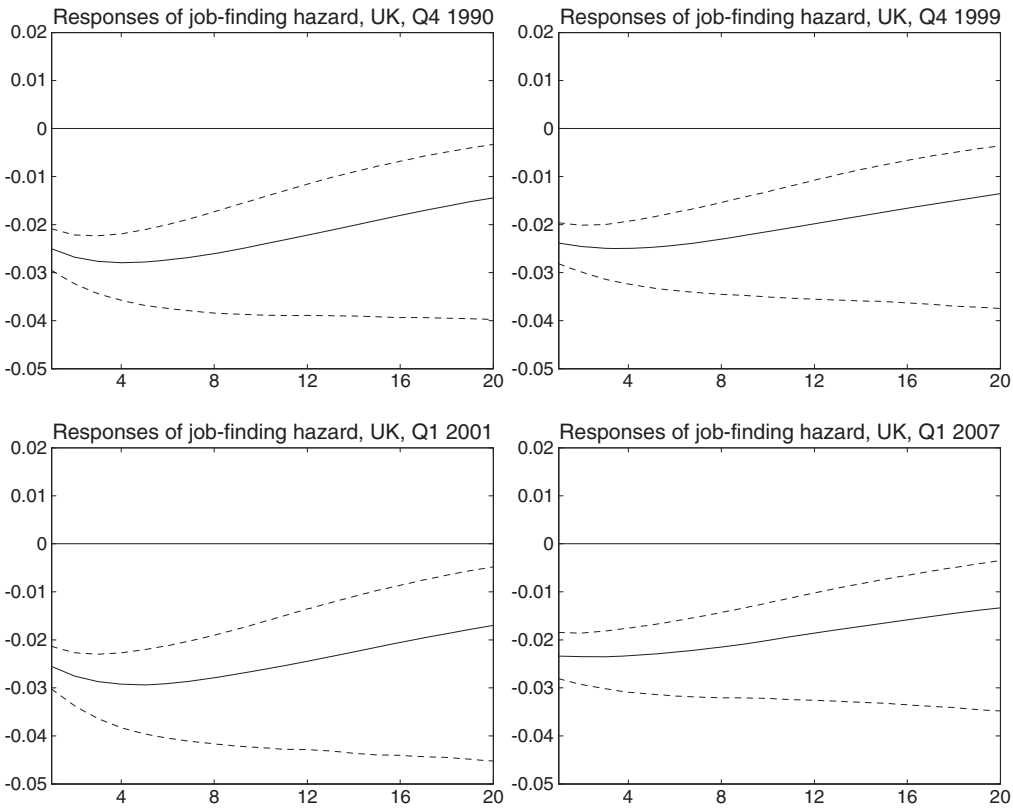

Figure 14. Impulse responses of job-finding hazards: Hete TVP-VAR, UK

horizons. Our results for the USA and Canada are in line with the conclusions in Elsby *et al*. (2008) on the relative contributions of the separation and job-finding hazards to changes in unemployment. However, our TVP-VAR models allow us to observe two patterns that have not been noted before in the literature for Europe. First, our estimates indicate that there is time variation in these effects across countries and in most countries the job-finding hazard effects play a larger role in the intermediate and longer runs. Second, we observe some variation in these effects across the business cycle.

6. CONCLUDING REMARKS

In this paper we have built on the existing literature which uses VAR methods for investigating the relationship between inflows and outflows into unemployment by using TVP-VAR methods. We use data from the USA, Canada, France, Spain and the UK. Our analysis allows us to examine the extent of the cross-country differences in how labour markets respond to shocks as well as whether these relationships are changing over time.

While we find that the process of labour market adjustment is similar in the USA and Canada, we find that Europe is very different. Moreover, we find that the process for labour market adjustment also differs a great deal across the European countries we consider; i.e. each country has its own unique patterns in how adjustments occur. However, the common element across the European countries we consider is the much longer time for shocks to decline, relative to the USA and Canada. We also find much more time variability in Europe, i.e. Spain and the UK. Interestingly, our analysis of the USA

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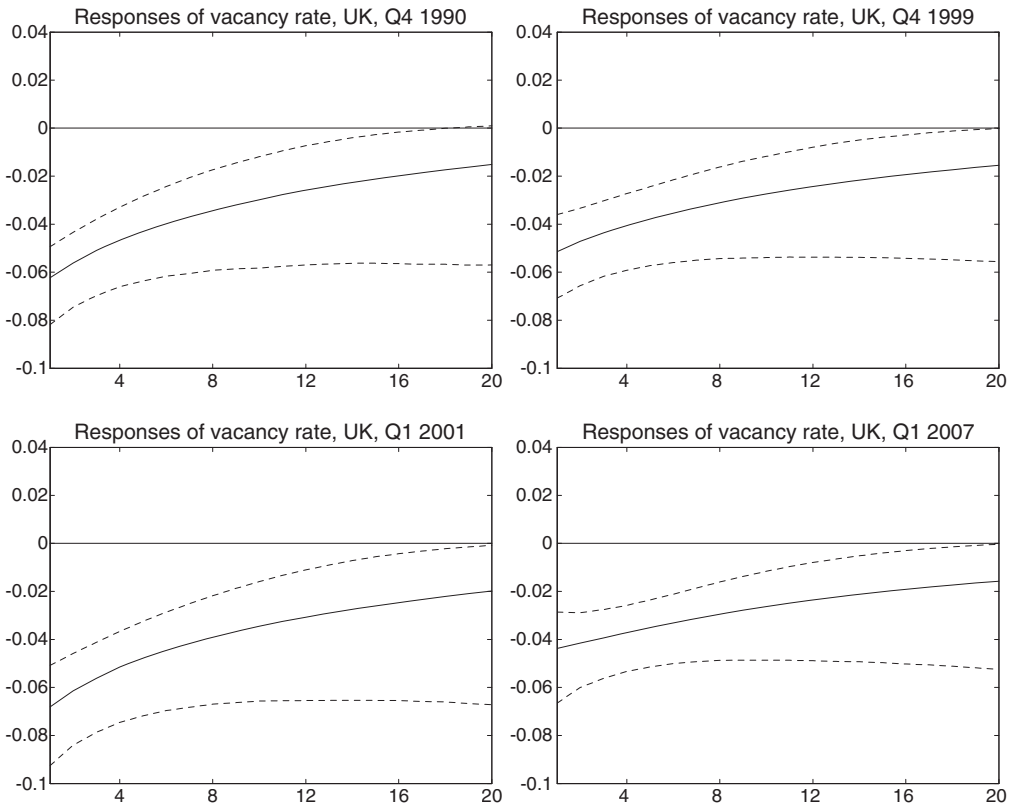

Figure 15. Impulse responses of vacancies: Hete TVP-VAR, UK

during the Great Recession resembles some of the patterns we observe in the European economies we study, in terms of the time it takes for shocks to disappear. Our estimates highlight the importance of using TVP-VAR models that can incorporate time variation since they reveal some features of the labour market adjustment process (particularly during severe economic downturns) that would not be captured by standard VAR models or more descriptive methods.

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