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The Great Recession and the UK labour market

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Abstract

In line with most of the developed world, the United Kingdom experienced in 2008–09 its worst recession since the Great Depression of the 1920s and 30s: the Great Recession. But despite the 6% peak-to-trough fall in output (as measured by real gross value added at basic prices) the unemployment rate only rose from 5.2% in 2007 Q4 to 8.4 in 2011 Q3. This muted response is often attributed to the flexibility of the UK labour market and, in particular, the willingness of UK workers to see their real wages fall. This paper uses an estimated DSGE model of the UK economy to investigate this hypothesis, assessing which shocks were largely responsible for the Great Recession and the extent to which the effect of these shocks on unemployment would have been worse had the UK labour market responded less flexibly.

Key words: Labour market flexibility, Great Recession.

JEL classification: E24, E32.

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1 Introduction and motivation

During 2008 and 2009, the world economy was subjected to two large economic shocks that left most economies in recession: the reduction in the ability of the financial system to intermediate between lenders and borrowers, resulting from the sub-prime crisis, and a large fall in world trade, only partly a direct result of the fall in world output. Although the United Kingdom also experienced the Great Recession, with output (as measured by real gross value added at basic prices) falling by 6.0% (peak to trough), the UK unemployment rate only rose by 3.2 percentage points (from 5.2% in 2007 Q4 to 8.4 in 2011 Q3). This muted response is often attributed to the flexibility of the UK labour market and, in particular, the willingness of UK workers to see their real wages fall. This paper uses an estimated DSGE model of the UK economy to investigate this hypothesis, assessing which shocks were largely responsible for the Great Recession and the extent to which the effect of these shocks on unemployment would have been worse had the UK labour market responded less flexibly.

To answer this question, I estimate a macroeconomic model – that of Jakab and Konya (2009) – using UK data. I then use the estimated model to assess the main drivers of the Great Recession in the United Kingdom. Given these drivers, I construct some counterfactual experiments in which I alter some of the features of the UK labour market and ask what would have happened to nominal and real wage growth, employment and unemployment, output and inflation in response to these shocks if the UK labour market had shown less flexibility in different dimensions.

Other authors have estimated DSGE models for the United Kingdom. Di Cecio and Nelson (2007) and Kamber and Millard (2012) use a ‘minimum distance’ estimation approach to estimate the Smets and Wouters (2007) model on UK data and Kamber and Millard (2012) also estimate a version of the Gertler *et al.* (2008) model, which extends the Smets and Wouters model to allow for search and matching frictions. More recently, Villa and Yang (2011) use Bayesian techniques to estimate a model on UK data that adds financial frictions to the Smets and Wouters model and Faccini *et al.* (2013) do the same for a model that adds labour market frictions. However, unlike the current model, these models are all ‘closed economy’ and so might not be thought of as the best models to use when considering the ‘open’ UK economy. Other authors (eg, Harrison and Oomen (2010), Millard (2011) and Burgess *et al.* (2013)) have estimated open economy models on UK data but have not included search and matching frictions as in the current model; this means that their models are not really able to be used to assess the response of the unemployment rate to shocks as there is no properly-defined ‘unemployment’ variable within them.

I consider in particular shocks to financial intermediation, world demand and the exchange rate risk premium, where I follow Smets and Wouters (2007) and model the financial intermediation shock as a shock to the domestic ‘risk premium’, ie, the wedge between the official interest rate and the interest rate that consumers consider when making their consumption vs. savings decisions. I am particularly interested in these shocks as they were all key aspects of the Great Recession.

The structure of the paper is as follows. In the next section, I develop the model I am going to use to analyse the effects of these shocks. Section 3 discusses the estimation procedure and our estimation results. Section 4 discusses how I might have expected the UK economy to respond to the financial and world trade shocks and compares these responses with what actually happened. Section 5 carries out some counterfactual experiments in order to assess to what extent labour market flexibility in the United Kingdom was responsible for the muted reaction of unemployment to the Great Recession and Section 6 concludes.

2 The Model

In this section, I describe the open-economy model I am going to use to examine how the financial and world trade shocks might have affected the UK labour market. The model I use was developed in Jakab and Konya (2009). It is a small open economy model with search and matching in the labour market. Demand for exports will depend on their relative price and an exogenous world demand shock. Import prices in foreign currency are taken as given. Finally, following Schmitt-Grohe and Uribe (2003), the exchange rate is determined by a modified Uncovered Interest Parity condition.

2.1 Households

The representative household maximizes their intertemporal utility by selecting streams of consumption, investment and foreign bond holdings. Consumption is subject to external habits, and investment is subject to adjustment costs. Household members are either employed or unemployed, but are able to fully insure each other against the random fluctuation of employment. This implies that the representative household member's utility function includes the average disutility of labour, $\chi_t n_t$, where χ_t follows an AR(1) process with mean χ. I defer detailed discussion of the labour market to later. The representative households' problem can be written as

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(c_t - h\bar{c}_{t-1}\right)^{1-\vartheta}}{1-\vartheta} - \chi_t n_t \right]$$

$$\text{s.t.}\, c_t + i_t + \frac{a_0}{1+\varphi}\left(z_t^{1+\frac{1}{\varphi}} - 1\right)K_{t-1} + \frac{b_t}{p_t e^{\varepsilon_t^d} R_t} = \frac{b_{t-1}}{p_t} + \left(1-u_t\right)w_t + u_t b_u + r_t^k z_t K_{t-1} + d_t \qquad \textbf{(1)}$$

$$K_t = \left(1-\delta\right)K_{t-1} + \left[1 - \Phi\left(\frac{e^{-\varepsilon_t^I} i_t}{i_{t-1}}\right)\right] i_t,$$

where c_t is consumption, $\bar{c}_{t-1}$ is average consumption in the previous period, n_t and u_t are the employment and unemployment rates, respectively, i_t is investment, b_t is the level of nominal bonds held by the household, R_t is the risk-free nominal interest rate, p_t is the consumer price index, w_t is the real wage rate, r_t^k is the (real) rental rate on capital, K_{t-1} is the capital stock carried over from the previous period and z_t represents the intensity with which the capital stock is used in period t. If capital is over-utilised (ie, $z > 1$), then the household pays a 'capital utilisation cost' given by $\frac{a_0}{1+\varphi}\left(z_t^{1+\frac{1}{\varphi}}-1\right)K_{t-1}$. Finally, d_t is lump sum net income from other sources such as dividends and government transfers. I assume that the investment cost function is non-negative, and has the property that $\Phi(1)=\Phi'(1)=0$ and I let $\Phi''(1)=\phi$. Finally, $\varepsilon^i{}_t$ is an investment-specific technology shock that lowers the adjustment cost and hence make investment more productive.

The budget constraint captures the idea that households can invest in bonds that pay a gross return of $e^{\varepsilon_t^d}R_t$. We can think of these bonds as being issued by other households, so in equilibrium $b_t = 0\forall t$ and they are also 'risky' in the sense that they do not pay the risk-free rate of interest, *R*. Instead, I follow Smets and Wouters (2007) and assume that there is a shock, $e^{\varepsilon_t^d}$, that drives a wedge between the central bank (ie, risk-free) interest rate, *R*, and the interest rate households charge and face, ie, the interest rate on these risky bonds, $e^{\varepsilon_t^d}R_t$. This shock captures changes in the ability of the financial system to intermediate between lenders and borrowers. Many recent models explicitly incorporate financial frictions into DSGE models, using mostly variants of the Bernanke *et al.* (1999) financial accelerator mechanism.[1] Since our purpose here is not to explain what caused the crisis, I treat the increase in financial frictions as exogenous. Also, since I estimate the interest rate wedge, our approach can be thought of as a reduced form for many different explanations of financial frictions. Our goal is simply to explore the consequences of an increase of the interest rate spread on the real economy, so I do not need to take a stand on the particular mechanism that caused the increase. For a similar approach looking at the US economy, see Hall (2011).

The first-order conditions for this problem (leaving aside labour supply for now) will be given by:

$$
\begin{aligned}
(c_t - h\bar{c}_{t-1})^{-\vartheta} &= \lambda_t \\
\frac{\lambda_t}{P_t} &= \beta e^{\varepsilon_t^d} R_t E_t \frac{\lambda_{t+1}}{p_{t+1}} \\
1 &= Q_t\left[1-\Phi\left(\frac{e^{-\varepsilon_t^I} i_t}{i_{t-1}}\right)-\frac{e^{-\varepsilon_t^I} i_t}{i_{t-1}}\Phi'\left(\frac{e^{-\varepsilon_t^I} i_t}{i_{t-1}}\right)\right] \\
&\quad +\beta E_t \frac{\lambda_{t+1}}{\lambda_t} Q_{t+1} e^{-\varepsilon_{t+1}^I}\left(\frac{i_{t+1}}{i_t}\right)^2 \Phi'\left(\frac{e^{-\varepsilon_{t+1}^I} i_{t+1}}{i_t}\right) \qquad \textbf{(2)} \\
Q_t &= \beta E_t\left[(1-\delta)Q_{t+1} + r_{t+1}^k\right]\frac{\lambda_{t+1}}{\lambda_t} \\
a_0 z_t^{\frac{1}{\varphi}} &= r_t^k \\
k_t &= (1-\delta)k_{t-1} + \left[1-\Phi\left(\frac{e^{-\varepsilon_t^I} i_t}{i_{t-1}}\right)\right] i_t .
\end{aligned}
$$

[1] See, eg, Christiano *et al.* (2010) and Gertler and Karadi (2011).

The first equation defines the marginal utility of income, λ_t, the second equation is the household Euler equation, the third equation describes investment behaviour, the fourth equation is an arbitrage condition between investment into bonds and capital that defines the shadow value of capital, the fifth equation determines capital utilisation and the final equation defines the dynamic behaviour of capital.

2.2 Job flows

As is typical in the literature, I assume that new jobs are created when unemployed workers meet open job vacancies. The number of matches is described by a constant-returns-to-scale, Cobb-Douglas, matching function:

$$m_t = \sigma_m v_t^{\sigma} u_t^{1-\sigma}, \tag{3}$$

where m_t is the number of new matches, v_t is the number of open vacancies, u_t is the number of unemployed and σ_m is a constant that reflects 'matching efficiency'. I follow the timing convention of Gertler *et al.* (2008) and assume that employment n_t evolves according to the flow equation:

$$n_t = (1-\rho) n_{t-1} + m_t, \tag{4}$$

where ρ is the exogenous separation rate and in which matches become productive immediately.

I normalise the labour force to unity. Then unemployment will be given by

$$u_t = 1 - n_{t-1}. \tag{5}$$

Thus workers who lose their jobs have to wait one period to be able to search for a new one, but those who enter the workforce can search immediately. Finally, I can define the job filling rate by $q_t = m_t / v_t$, the job finding rate by $s_t = m_t / u_t$ and labour market tightness by $\theta_t = v_t / u_t$.

2.3 The wholesale sector

Firms within the wholesale sector produce a homogenous product, using capital, imported intermediates and labour. Capital and imported intermediates are acquired at competitive factor markets at factor prices r_t^k and p_t^m. The labour market, on the other hand, is subject to search-and-matching frictions. Each job is a firm-worker pair, subject to an exogenous job destruction probability ρ. The aggregate production function is given by the following Cobb-Douglas specification:

$$Y_t = e^{a_t} (z_t k_t)^{\alpha} \left(Y_{m,t}^{\alpha_z} N_t^{1-\alpha_z} \right)^{1-\alpha}, \tag{6}$$

where Y_t is the amount of output produced, a_t is an exogenous productivity shock, k_t is the firm's demand for capital services (equal in equilibrium to the aggregate capital stock multiplied by its rate of utilisation), $Y_{m,t}$ is imported intermediates, N_t is the number of workers employed, and as defined above, z_t stands for capacity utilization. I assume that each firm employs one worker, so I can rewrite the production functions in a per-worker form as:

$$y_t = e^{a_t}\left(z_t k_t\right)^{\alpha} y_{m,t}^{\alpha_z(1-\alpha)} \tag{7}$$

Given the Cobb-Douglas specification and the fact that the capital and import markets are competitive, demand for these inputs is given by the familiar conditions:

$$\begin{aligned} r_t^k z_t k_t &= \alpha p_{w,t} y_t \\ p_{m,t} y_{m,t} &= (1-\alpha)\alpha_z p_{w,t} y_t. \end{aligned} \tag{8}$$

This implies that the flow benefit of a job match for a firm is given by

$$\xi_t = (1-\alpha)(1-\alpha_z) p_{w,t} y_t. \tag{9}$$

I base my description of the wage setting process on Bodart *et al.* (2006). In particular, I distinguish between the wage of new hires, and wages in existing jobs. Both wage-setting processes are described by a Calvo (1983) probability. In particular, wages in existing jobs are bargained with a probability $1-\gamma_w$; otherwise the wage is left at last period's value. For new hires, the wage is negotiated with probability $1-\vartheta_w$, otherwise it is indexed to last period's average wage w_{t-1} (I discuss indexation below). I denote wages that are set optimally in period *t* by w_t^*.

When a wage is not bargained over, it may still be adjusted to inflation. I allow for the following rule-of-thumb when wages are not bargained over:

$$w_t = \frac{w_{t-1}}{\pi_t^{\xi_w}},$$

where $\pi_t = p_t / p_{t-1}$ is the inflation rate. Notice that since w_t is the real wage, the specification nests full real ($\xi_w = 0$) and nominal wage rigidity ($\xi_w = 1$).

Let V_t denote the value of a vacancy and let J_t denote the value of a filled job.[2] Since a vacancy is filled with probability q_t and the wage bargain takes place with probability ϑ, V_t is given by

$$V_t = -\frac{\kappa}{\lambda_t} + q_t\left[\vartheta_w J_t\left(w_{t-1}\right) + \left(1-\vartheta_w\right) J_t\left(w_t^*\right)\right] \tag{10}$$

[2] To save on notation, I will not explicitly indicate the indexation of past wages in the value functions. I make the indexation explicit whenever it is necessary in the formulas below.

I assume the usual free-entry condition in the market for vacancies, which implies that the value of vacancies is identically zero, $V_t \equiv 0$.

Let $J_t(w_t^*)$ denote the value of a job that was renegotiated at *t*, and is given by:

$$J_t(w_t^*) = \xi_t - w_t^* + \beta(1-\rho)E_t \frac{\lambda_{t+1}}{\lambda_t}\left[\gamma_w J_{t+1}(w_t^*) + (1-\gamma_w) J_{t+1}(w_{t+1}^*)\right] \quad \textbf{(11)}$$

Unemployed workers receive an income b_u while unemployed, and enjoy the monetized value of leisure χ/λ_t. Thus, the value function for an unemployed worker, U_t, can be written as:

$$U_t = b_u + \frac{\chi_t}{\lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\left\{s_t\left[\vartheta_w W_{t+1}(w_t) + (1-\vartheta_w) W_{t+1}(w_{t+1}^*)\right] + (1-s_t)U_{t+1}\right\} \quad \textbf{(12)}$$

The value of a job when the wage is just negotiated is given by:

$$W_t(w_t^*) = w_t^* + \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\left\{(1-\rho)\left[\gamma_w W_{t+1}(w_t^*) + (1-\gamma_w) W_{t+1}(w_{t+1}^*)\right] + \rho U_{t+1}\right\} \quad \textbf{(13)}$$

When wages are negotiated, I assume that they are set as a solution to the generalised Nash (1950) bargaining problem, as is standard in the literature.[3]

Thus the wage w_t^* solves:

$$\max_{w_t^*}\left[W_t(w_t^*) - U_t\right]^{\eta} J_t(w_t^*)^{1-\eta}, \quad \textbf{(14)}$$

where the parameter η measures the bargaining power of workers.

Using again equations **(11)**, **(12)** and **(13)**, I can rewrite the wage setting condition as follows:

$$\begin{aligned} w_t^* &= \eta\left(\xi_t + \frac{\beta\kappa}{\lambda_t}E_t\theta_{t+1}\right) + (1-\eta)\left(b_u + \frac{\chi_t}{\lambda_t}\right) \\ &+ E_t\sum_{j=1}^{\infty}\frac{\lambda_{t+j}}{\lambda_t}\left[\beta\gamma_w(1-\rho)\right]^j\left[w_{t+1}^* - \frac{w_t^*}{\pi_{t+1}^{\xi_w}} - \frac{s_{t+1}\vartheta_w}{(1-\rho)\gamma_w}\left(w_{t+1}^* - \frac{w_t}{\pi_{t+1}^{\xi_w}}\right)\right] \end{aligned} \quad \textbf{(15)}$$

Thus the wage that is set at time t is a combination of what it would be without any rigidity for existing jobs (the first two terms), and a term that captures the possibility that the newly set wage remains effective for some time period.

[3] See, Diamond (1982) for a clear exposition of how 'Nash Bargaining' can be applied in the context of bargaining over wages. As stated in the main text, Nash Bargaining over wages is an integral part of the standard Diamond-Mortensen-Pissarides approach to labour market modelling of which the current model is an example.

Recall that w_t^* is the wage rate that is bargained at period t. The evolution of the average wage depends both on the newly set wage and on those wages that are not allowed to reset. Let w_t denote the economy wide average wage, which evolves according to:

$$w_t = \frac{m_t}{n_t}\left[\vartheta_w \frac{w_{t-1}}{\pi_t^{\xi_w}} + (1-\vartheta_w)w_t^*\right] + \frac{(1-\rho)n_{t-1}}{n_t}\left[\gamma_w \frac{w_{t-1}}{\pi_t^{\xi_w}} + (1-\gamma_w)w_t^*\right] \tag{16}$$

Let us define the 'flexible wage' as:

$$\omega_t = \eta\left(\xi_t + \frac{\beta\kappa}{\lambda_t}E_t\theta_{t+1}\right) + (1-\eta)\left(b_u + \frac{\chi_t}{\lambda_t}\right), \tag{17}$$

which would be the wage under continuous Nash bargaining. Log-linearising these equations, and noting that in the steady state $\overline{m} = \rho\overline{n}$, leads us to the following real wage Phillips curve:

$$\hat{\pi}_t^w + \xi_w\hat{\pi}_t = \frac{\beta[(1-\rho)\gamma_w - \bar{s}\,\vartheta_w]}{\rho\vartheta_w + (1-\rho)\gamma_w}\left(E_t\hat{\pi}_{t+1}^w + \xi_w\hat{\pi}_{t+1}\right) + \frac{[1-\rho\vartheta_w - (1-\rho)\gamma_w][1-\beta\gamma_w(1-\rho)]}{\rho\vartheta_w + (1-\rho)\gamma_w}(\hat{\omega}_t - \hat{w}_t) \tag{18}$$

As the equation shows, wages are persistent, but real wage inflation is not. Wage persistence, intuitively, depends on three parameters: the exogenous Calvo (1983) probabilities γ_W and ϑ_W, and the job destruction rate ρ.

I can also derive the job creation condition:

$$\begin{aligned}\frac{\kappa}{\lambda_t q_t} =\ & \xi_t - w_t^* + \beta(1-\rho)E_t\frac{\kappa}{\lambda_t q_{t+1}} + \left[E_t\left(w_{t+1}^* - \frac{w_t^*}{\pi_{t+1}^{\xi_w}}\right) - \frac{\vartheta_w}{\gamma_w}\left(w_{t+1}^* - \frac{w_t}{\pi_{t+1}^{\xi_w}}\right)\right]\sum_{j=1}^{\infty}\frac{\lambda_{t+j}}{\lambda_t}[\beta\gamma_w(1-\rho)]^j \\ & + \vartheta_w\left(w_t^* - \frac{w_{t-1}}{\pi_t^{\xi_w}}\right)\sum_{j=0}^{\infty}\frac{\lambda_{t+j}}{\lambda_t}[\beta\gamma_w(1-\rho)]^j\end{aligned} \tag{19}$$

Notice that if there is no wage rigidity for new hires, ie, $\vartheta_W = 0$, the job creation condition is identical to the one under continuous Nash bargaining. This is the point made by Pissarides (2009): for job creation and hence unemployment volatility, only the wages of new hires matter. With wage rigidity for new hires, however, job creation responds not only to next period's shocks, but also to the evolution of the average wage.

2.4 The retail sector

The retail sector contains an infinite number of monopolistically competing firms, who buy the homogenous wholesale good and differentiate it. Consumers value the differentiated final goods according to the following CES utility function:

$$y_t^F = \left[\int_0^1 y_t^F(i)^{\frac{1}{1+\mu_t}} di\right]^{1+\mu_t}, \qquad \textbf{(20)}$$

where $y_t(i)$ is output of a typical variety in sector *i*, and μ_t is the time-varying desired mark-up. Demand for variety i is then given by:

$$y_t^F(i) = \left[\frac{P_t(i)}{P_t}\right]^{-1-1/\mu_t} y_t^F. \qquad \textbf{(21)}$$

Price setting follows the basic New Keynesian model, based on Calvo (1983). In each period, a retail firm can reset its price optimally with probability $1-\gamma_p$. If it cannot reset its price optimally, it partially indexes its price to lagged inflation with the indexation parameter denoted by ξ_p. As is well known, these assumptions lead to the (log-linearized) New Keynesian Phillips curve:

$$\hat{\pi}_t - \xi_p \hat{\pi}_{t-1} = \beta E_t\left(\hat{\pi}_{t+1} - \xi_p \hat{\pi}_t\right) + \frac{(1-\beta\gamma_p)(1-\gamma_p)}{\gamma_p}\hat{p}_t^{\,w} + \varepsilon_{p,t} \qquad \textbf{(22)}$$

where π denotes inflation (and I have assumed zero inflation in steady state), p_t^w denotes the log deviation of real marginal cost (the wholesale price) from its steady state value and ε_p is a mark-up shock.

2.5 Equilibrium

Retail goods are sold domestically and exported. I allow domestically sold and export goods to have different price setting parameters; I assume moreover that export prices are set in foreign currency (pricing to market).

The wholesale sector is composed of n_t firms producing y_t units of the wholesale good each. Let $n_{d,t}$ denote the number of firms (and workers) who serve the domestic retail sector, then domestic final sales are given by $n_{d,t} y_t$. These are used for consumption, investment, and government consumption. The latter is assumed to be exogenous and unproductive, described by an autoregressive process. The domestic equilibrium condition is then given by:

$$n_{d,t} y_t = c_t + i_t + g_t. \qquad \textbf{(24)}$$

Monetary policy is represented by a simple Taylor rule. The Central Bank sets the interest rate and reacts to deviations in inflation and output from their steady state values:

$$\hat{r}_t = \zeta_r \hat{r}_{t-1} + (1-\zeta_r)\left(\zeta_\pi \hat{\pi}_t + \zeta_y \hat{y}_t\right) + \varepsilon_t^m . \quad \textbf{(25)}$$

I also allow for interest rate smoothing as common in the literature.

I assume that a modified UIP condition holds, where the interest rate on home currency denominated foreign bonds is given by the constant world interest rate plus an endogenous risk premium:

$$\frac{e_t R_t}{E_t e_{t+1}} = \left[\frac{1}{\beta} + \psi\left(e^{-(B_t - \bar{B})} - 1\right)\right] e^{\varepsilon_t^{UIP}} . \quad \textbf{(26)}$$

Where e is defined as the amount of domestic currency needed to buy one unit of foreign currency and I follow Schmitt-Grohé and Uribe (2003) and make the risk-premium a function of the net foreign asset position B_t .

I also posit an ad-hoc export demand equation including a foreign demand shock. This is designed to capture the collapse in world trade I saw towards the end of 2008.

$$\left(n_t - n_{d,t}\right) y_t = \left(p_{x,t}^*\right)^{-\theta_x} Y^w e^{\varepsilon_t^x} . \quad \textbf{(27)}$$

Finally, I can rewrite the household budget constraint to get the current account:

$$\frac{b_t}{e_t R_t} - \frac{b_{t-1}}{e_t} = p_{x,t} n_{x,t} y_t - p_{m,t}^* n_t y_{m,t} . \quad \textbf{(28)}$$

I assume that the foreign currency price of imported intermediates is exogenously given. This implies that their price relative to the domestic price level is given by:

$$p_{m,t} = p_{m,t}^* \frac{e_t}{p_t} , \quad \textbf{(29)}$$

where e_t / p_t is the real exchange rate.

Finally, I need to specify processes for our shocks. I assume that the technology, a, investment specific, ε_i, domestic risk premium, ε_d, government spending, g, disutility of labour (labor supply), χ, UIP, ε_{uip}, export demand, ε_x and import price, p_m*, shocks all follow AR(1) processes whereas the monetary policy, ε_m, domestic mark-up, μ, and export mark-up, μ_x, shocks are all white noise.

3 Data and estimation

The model was estimated using Bayesian techniques on UK data over the period 1997 Q3 (the first quarter after the Bank of England was given independent control over monetary policy) to 2013 Q4. I use eleven data series to estimate the model: private consumption (ONS Code: *HFC1*), the sterling exchange rate index published by the Bank of England (*SERI*), government consumption (ONS Code: *NMRY*), total gross fixed capital formation (ONS Code: *NPQT*), the employment rate (ONS Codes: *MGRZ/MGSF*), the private consumption deflator inflation rate (ONS Codes: *(ABJQ+HAYE)/HFC1*), export prices in foreign currency (ONS Code: *IKBH*SERI/IKBK*), import prices in foreign currency (ONS Codes: *IKBI*SERI/IKBL*), the Bank of England's policy rate (ONS Code: *AMIH*), imports (ONS Code: *IKBL*) and exports (ONS Code: *IKBK*). So, I have eleven data series to estimate eleven structural shocks. I detrended the data for consumption, government spending, investment, employment, export and import prices, exports and imports using the HP filter with the smoothing parameter, λ, set to 1,600. Finally, for consumer price inflation and nominal interest rates, I simply demeaned the data.

Table A: Calibrated parameters

Parameter	Description	Value
β	Discount factor	0.99
ϑ	Coefficient of risk aversion	2
ψ	FX Portfolio adjustment cost	0.001
δ	Depreciation rate	0.025
α	Capital share of costs	0.3333
α_z	Import share of non-capital costs	0.3953
Φ/y	Mark-up	0.1
β_u	Unemployment benefit replacement rate	0.58
$\bar{s}$	Steady-state job finding rate	0.338
σ	Elasticity of job matching with respect to vacancies	0.5
ρ	Job destruction rate	0.0216
$\bar{g}$	Share of government spending in gross output	0.1644

Given the short time series I use, and more general identification issues, I calibrated some parameters that are easy to relate to steady state conditions. I set $\beta = 0.99$, which implies a real annual interest rate of 4% in steady state. I set $\delta = 0.025$, which implies an annual depreciation rate of 10%. I set the steady-state mark-up to 1.1, in line with Harrison *et al.* (2005). I then used data on the share of labour compensation and imports in gross revenue to calculate the implied cost shares for capital and imports. I set the foreign exchange portfolio adjustment cost term, ψ, to the small value of 0.001. This parameter ensures the existence of a unique steady state, see Schmitt-Grohe and Uribe. I set the ratio of government spending to gross output to our sample averages. Following Petrongolo and Pissarides (2001), I set the matching elasticity to 0.5. For the job finding rate I use the value of 0.34 reported in Hobijn and Sahin (2007) and for the unemployment benefit replacement rate I use the value of 0.54 reported in OECD (2007).

Finally, I set the steady-state unemployment rate to its sample average. I summarise the calibrated parameters in Table A.

Tables B and C detail the priors and posteriors for the parameters I estimate. The estimated parameters include the standard errors of the innovations to structural shocks, the AR(1) parameters of all shocks except the mark-ups of domestic and export prices (these are assumed iid), Calvo (1983) parameters in price and wage setting, parameters in the Taylor rule, parameters in the utility function, worker bargaining power and the export demand elasticity. As is now standard in the literature, I first estimated the mode of the posterior distribution by maximising the log posterior function, which combines the priors with the likelihood given by the data, and then used the Metropolis-Hastings algorithm (as implemented in *Dynare*) to obtain the full posterior distribution. I used a sample of 250,000 draws (dropping the first 50,000 draws), obtaining an acceptance rate of 18%.

Table B: Priors and posterior estimates

Parameter	Description	Prior distribution	Prior mean	Prior standard deviation	Posterior mean
h	Consumption habits	Beta	0.6	0.1	0.6193
ϕ	Elasticity of investment adjustment costs	Normal	5	2	5.6389
φ	Elasticity of capital utilisation costs	Beta	0.2	0.05	0.1746
γ_p	Calvo parameter: domestic prices	Beta	0.5	0.15	0.8905
ξ_p	Indexation: domestic prices	Beta	0.5	0.15	0.2499
γ_x	Calvo parameter: export prices	Beta	0.5	0.15	0.5038
ξ_x	Indexation: export prices	Beta	0.5	0.15	0.7046
ζ_r	Interest rate persistence in Taylor rule	Beta	0.75	0.15	0.8739
ζ_π	Coefficient on inflation in Taylor rule	Normal	1.5	0.15	1.2045
ζ_y	Coefficient on output in Taylor rule	Normal	0.125	0.05	0.096
θ_x	Elasticity of export demand	Beta	0.5	0.15	0.1261
γ_w	Calvo parameter: wages of existing workers	Beta	0.5	0.15	0.6594
ϑ_w	Calvo parameter: wages of newly-employed workers	Beta	0.5	0.15	0.6605
ξ_w	Indexation: wages	Beta	0.5	0.15	0.3471
η	Worker bargaining power	Beta	0.5	0.1	0.3529
χ	Relative utility of leisure	Beta	0.2	0.05	0.2305

Since the goal of this paper is not estimation *per se*, I only point out that most parameter estimates are reasonable. Concentrating on those parameters describing the labour market, I see that wages are fairly flexible, being reset about once every nine months or so. Wage-setting for newly-hired workers appears to be no more flexible with the wages of about two-thirds of them appearing to be tied to existing wages. There is also little evidence of wage indexation with about 34% of wages linked to past inflation. These results are important as many commentators have argued that it was the flexibility of wages in the United Kingdom that led to a smaller than expected rise in the unemployment rate. I investigate this further in Section 5, below.

Table C details the priors and posteriors for the shock processes I estimate. Our estimates suggest that none of the shocks are particularly persistent, ie, our model has enough endogenous propogation that I can generate the persistent responses of variables seen in the data without resorting to persistent shocks. The labour supply shock is much more volatile than any of the other shocks, though the mark-up and investment-specific technology shocks are also estimated to be fairly volatile.

Table C: Priors and posterior estimates, shock processes

Parameter	Shock	Prior distribution	Prior mean	Prior standard deviation	Posterior mean
Persistence parameters					
ρ_a	Productivity	Beta	0.5	0.15	0.5967
ρ_χ	Labour supply	Beta	0.5	0.15	0.3483
ρ_{UIP}	Foreign exchange risk premium	Beta	0.5	0.15	0.7927
ρ_x	Export demand	Beta	0.5	0.15	0.4528
ρ_{pm}	Import prices	Beta	0.5	0.15	0.6462
ρ_g	Government spending	Beta	0.5	0.15	0.5972
ρ_i	Investment-specific technology	Beta	0.5	0.15	0.2022
ρ_d	Domestic risk premium	Beta	0.5	0.15	0.7503
Standard deviations					
ν_a	Productivity	Inverse gamma	0.01	2	0.0077
ν_χ	Labour supply	Inverse gamma	0.01	2	1.6814
ν_{uip}	Foreign exchange risk premium	Inverse gamma	0.01	2	0.0044
ν_x	Export demand	Inverse gamma	0.01	2	0.0324
ν_{pm}	Import prices	Inverse gamma	0.01	2	0.0191
ν_g	Government spending	Inverse gamma	0.01	2	0.0088
ν_i	Investment-specific technology	Inverse gamma	0.01	2	0.0464
ν_m	Monetary policy	Inverse gamma	0.01	2	0.0017
ν_μ	Price mark-up	Inverse gamma	0.01	2	0.3783
ν_d	Domestic risk premium	Inverse gamma	0.01	2	0.0103
$\nu_{\mu x}$	Export price mark-up	Inverse gamma	0.01	2	0.0699

4 Effects of shocks

In this section, I use our estimated model to examine how the financial market turbulence of 2008-10, and the fall in worldwide demand over the same period, affected the United Kingdom. In trying to translate the observed data into the model I consider the financial turbulence to be picked up by our domestic and foreign exchange risk premium shocks and the worldwide fall in demand to be picked up by our foreign demand shock. I start by considering how large these shocks have been before discussing how I might have expected the UK economy to respond to them and comparing these responses with what actually happened.

4.1 Which shocks have been important?

Chart 1 shows our estimated time series for the domestic risk premium shock, which I think capture the effects of the financial crisis. It shows that since 2008, this shock has been persistently positive and large, with the risk premium shock reaching almost 20 percentage points in 2009 Q2 and again in 2011 Q1. Chart 2 shows our estimated export demand shock, which shows clearly the effects of the fall in world trade in 2009. Chart 3 shows that there is some evidence of a positive shock to the foreign exchange risk premium in the United Kingdom from late 2007 onwards. Other things equal, I would expect this to lead to a depreciation in sterling, exactly as occurred around about this time.

Chart 1: Domestic risk premium shock

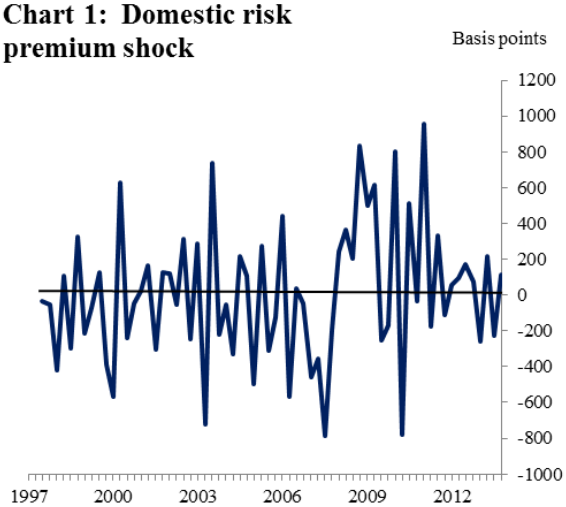


Chart 2: Export demand shock

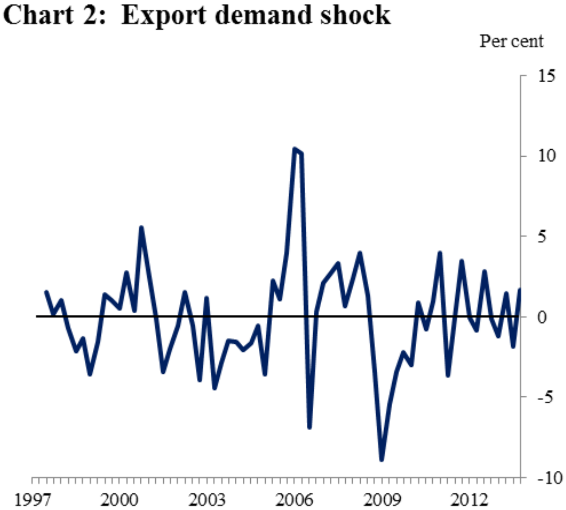
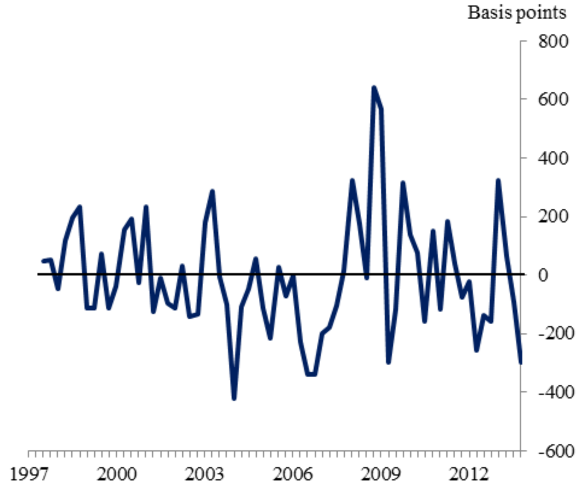


Chart 3: FX risk premium shock



Although these shocks were clearly important consequences of the financial crisis, there remains the question of how important they were for output, unemployment and real wages, our key variables of interest. Table D shows the variance decomposition for these variables in terms of the shocks over the whole period on which the model was estimated. As is common in these models, the vast bulk of the variance in unemployment and real wages is explained by the labour supply shock (ie, shock to the marginal utility of leisure). This is really a measure of the inability of the standard search and matching model to explain the volatility in unemployment seen in the data highlighted by Shimer (2005). Leaving these shocks aside, we can see that the domestic risk premium shock was an important explanator of output, unemployment and real wages; export demand and the foreign exchange risk premium seem to be less important. That said, it still seems a worthwhile exercise to assess how we might expect these shocks – that were particularly large at the time of the financial crisis – to affect output, unemployment and real wages.

Table D: Variance decompositions

	Percentage explained by each shock of the variance in:		
Shock	Output (ie, GDP)	Unemployment	Real wages
Productivity	24.83	0.29	0.10
Labour supply	19.17	94.03	96.29
Foreign exchange risk premium	1.47	0.19	0.07
Export demand	4.81	0.18	0.27
Import prices	8.79	0.11	0.04
Government spending	0.04	0.00	0.00
Investment-specific technology	20.95	1.85	0.59
Monetary policy	4.09	1.26	0.53
Price mark-up	2.43	0.46	0.74
Domestic risk premium	12.93	1.62	1.33
Export price mark-up	0.50	0.01	0.03

4.2 *How would we expect the UK economy to respond to these shocks?*

In this section I examine how we might have expected the UK economy to respond to the domestic risk premium, export demand and FX risk premium shocks. I do this by using the estimated model to work out the responses of various variables to each of our shocks.

Starting with the domestic risk premium shock, which I think captures the financial turbulence caused by the crisis, Charts 4 through 7 show the responses of the key endogenous variables in our model to this shock.

Now, I can use equation **(2)** to derive the IS curve:

$$\left(c_t - h\bar{c}_{t-1}\right)^{-\vartheta} = \beta e^{\varepsilon_t^d} R_t E_t \frac{\left(c_{t+1} - h\bar{c}_t\right)^{-\vartheta}}{1+\pi_{t+1}} \quad \textbf{(30)}$$

Clearly, a positive shock to ε_t^d will lead to a fall in consumption. As the shock is expected to persist, so will this fall in consumption. And the 'habit' term adds extra persistence the fall in consumption on top of this. The expected weakness in demand will also lead to a fall in investment and GDP. The real exchange rate depreciates leading to a fall in imports and a rise in exports. The labour market slackens as firms reduce vacancies and unemployment increases. This leads to a fall in real wages. The fall in real wages means that real marginal cost is lower and so inflation also falls. Finally, the central bank reacts to the falls in output and inflation by lowering interest rates.

Chart 4: Response to a domestic risk premium shock

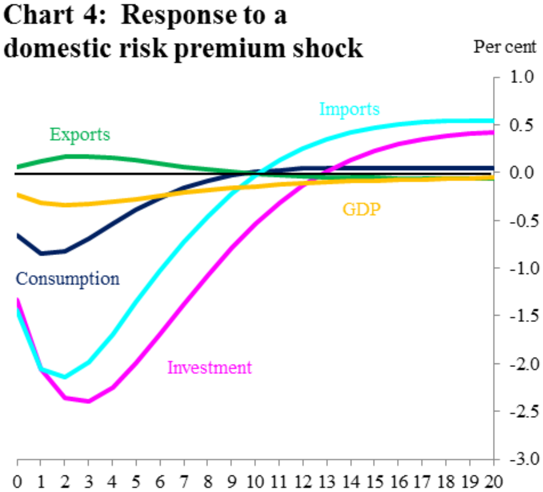


Chart 5: Response to a domestic risk premium shock

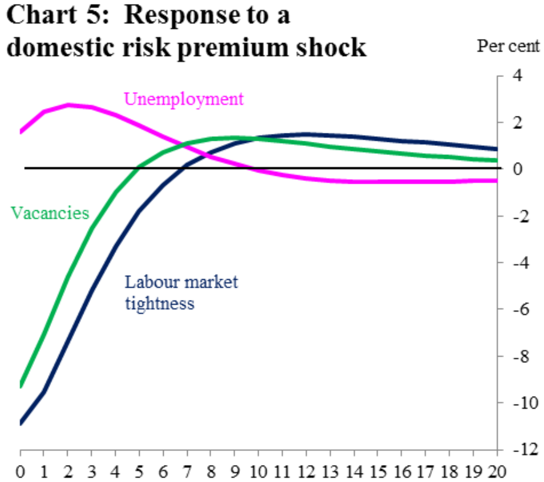


Chart 6: Response to a domestic risk premium shock

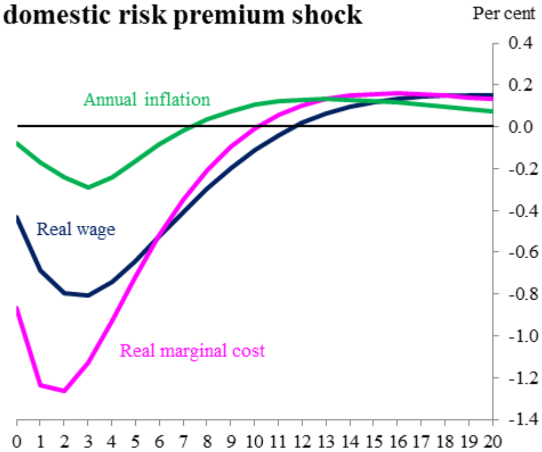
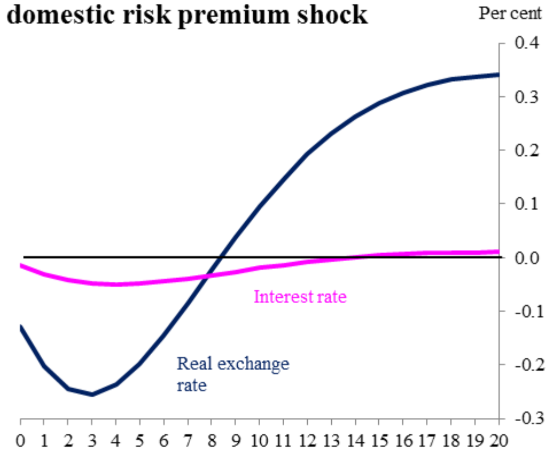


Chart 7: Response to a domestic risk premium shock



I next consider the effects of the shock to world demand. The responses of our endogenous variables to this shock are shown in Charts 8 through 11. Clearly a shock to world demand leads to a fall in exports (as shown in Equation **(27)**). This is partly offset through a depreciation of the real exchange rate, which also leads to a fall in imports. The net effect, though, is a worsening of the trade balance. The fall in export demand also results in a rise in unemployment and falls in labour market tightness, vacancies and real wages. With real wages falling, consumption also falls (though only very slightly), as does GDP, real marginal cost and inflation. Again, the central bank reacts by cutting interest rates.

Chart 8: Response to a world demand shock

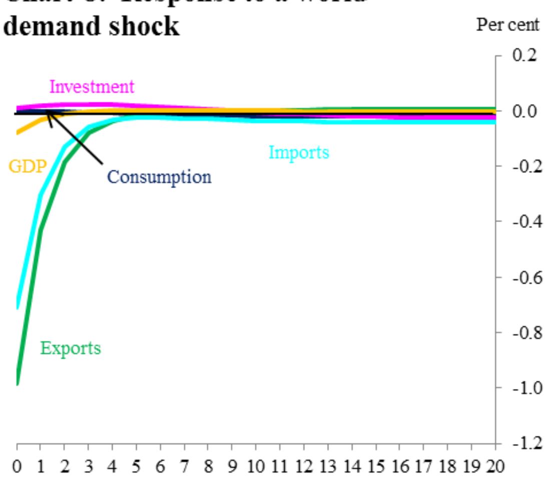
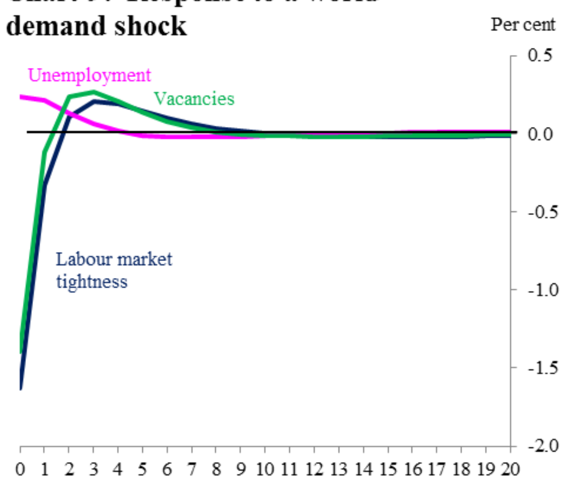
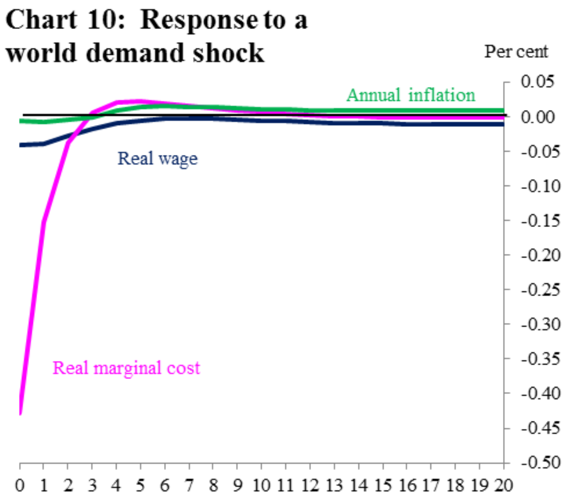
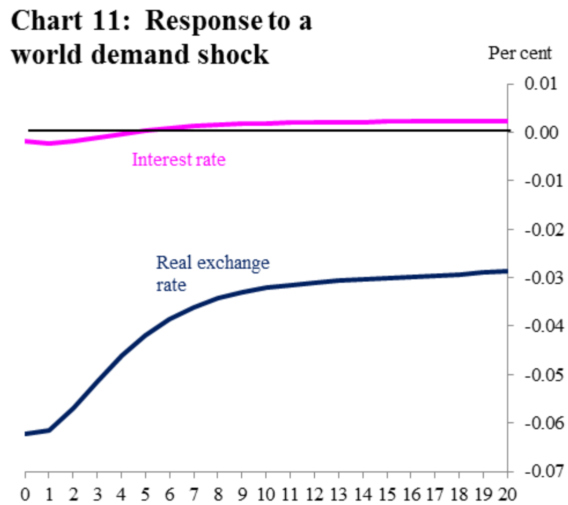


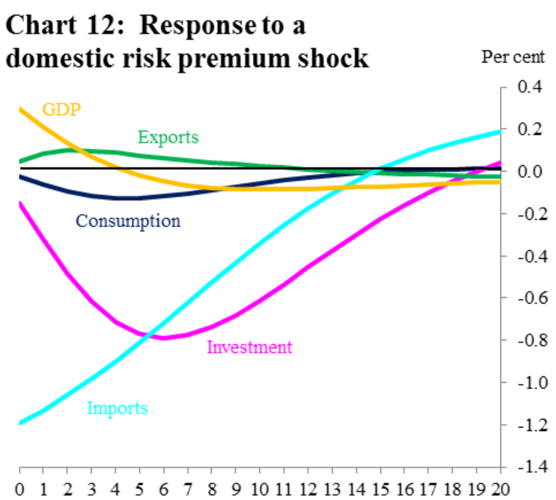
Chart 9: Response to a world demand shock







Finally, I consider the effects of the foreign exchange risk premium shock. These are shown in Charts 12 through 15. Now, the immediate effect of the shock is to cause the real exchange rate to depreciate. This raises exports and lowers imports, with the effect of raising GDP. Workers are moved from the domestic sector to the export sector so output for sale in domestic markets falls; with government spending unchanged, this means that consumption and investment fall. The labour market tightens as vacancies rise and unemployment falls. This results in an increase in the real wage, which coupled with an increase in real import prices, leads to a large rise in real marginal cost and a smaller rise in inflation. Interest rates hardly move.



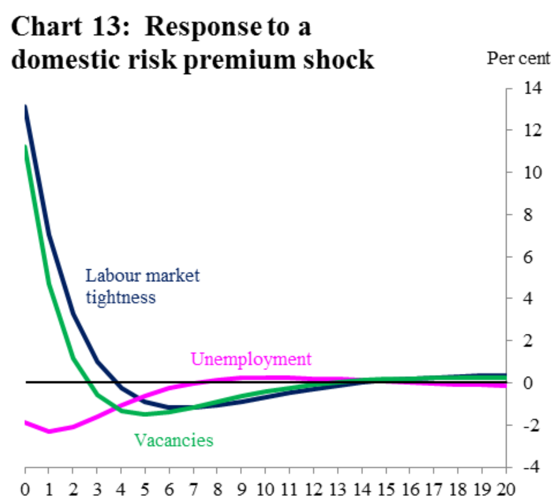


Chart 14: Response to a domestic risk premium shock

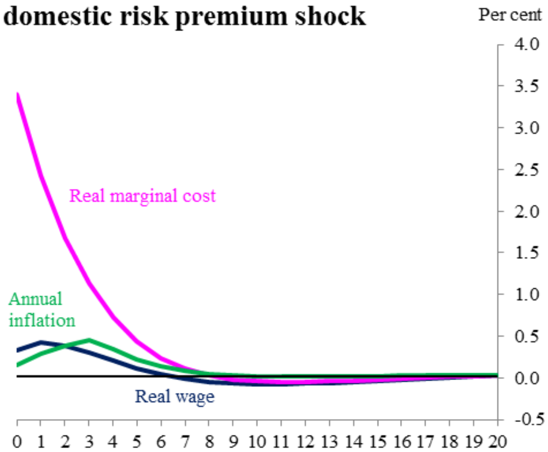
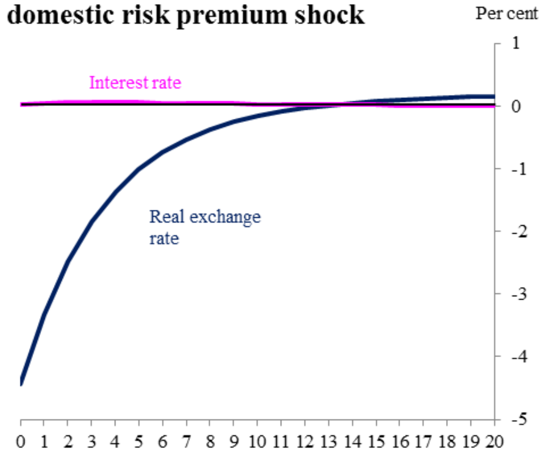


Chart 15: Response to a domestic risk premium shock



4.3 Can these shocks explain the responses of output, unemployment and wages since the financial crisis?

In this section, I examine to what extent the financial (domestic risk premium) shock and the world demand shock explain what happened to output, unemployment and real wages as a result of the financial crisis. I do this by taking the position of the economy in 2008 Q1 as a given and then simulating the model forward, but assuming that only these two shocks (and no others) had affected the UK economy.

Chart 16 shows annual GDP growth in the simulation and what happened in the actual data. The model suggests that these two shocks explain the fall in GDP growth, together with the recent recovery. Given just those two shocks, the model would have predicted lower growth in 2010-12 than actually happened. In other words, in order to understand the recovery in GDP growth in 2010-2012, we need to look at additional shocks. Chart 17 shows the unemployment rate in the simulation and what happened in the actual data. As expected, these two shocks lead to a rise in the unemployment rate within the model that is roughly in line with the actual rise in unemployment seen in the data. The question for the next section of the paper is whether or not the rise in unemployment might have been larger if the UK labour market had been less flexible. Finally, Chart 18 examines the response of real wages. Although the timing is different, the model suggests that these two shocks can explain the fall in real wages since the financial crisis. That said, it is clear that there have been other shocks affecting the UK economy over this period. Given the variance decomposition results reported earlier, it is possible that the labour supply shock can account for the behaviour of unemployment and wages, though it is not clear that this shock is particularly related to the financial crisis, whose effects this paper is interested in analysing.

So, the model suggests that the shocks were absorbed through wages rather than employment. The question is: is this a result of the flexibility of the UK labour market? I examine this proposition more thoroughly in the following section.

Chart 16: GDP growth

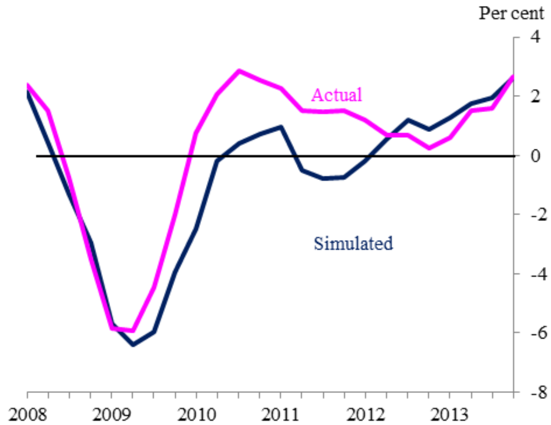


Chart 17: Unemployment rate

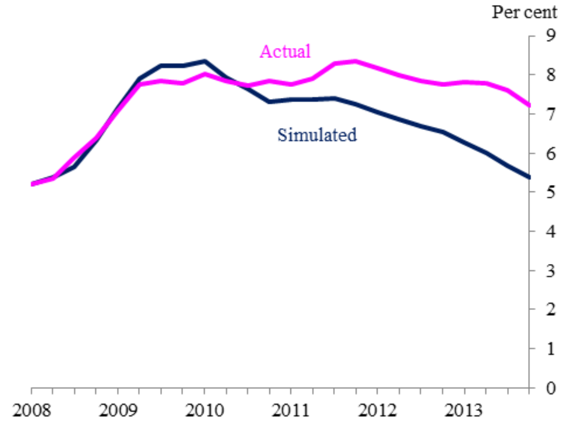
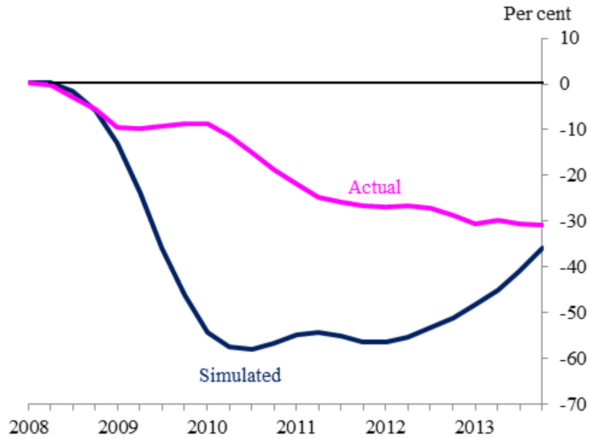


Chart 18: Real wages



5 How might the economy have responded with a less flexible labour market?

In this section, I ask the counterfactual question about how the UK economy might have responded to the financial crisis had the labour market not been as flexible as it turned out to be. In particular, I examine how the model predicts the economy would have responded to the financial crisis had wages for both existing and newly-hired workers been more rigid. More specifically, I suppose that the wages of existing employees are reset once a year on average and that three quarters of newly employed workers have their wage set at the same level as existing employees. This involves setting the parameters γ_w and ϑ_w,to 0.75 and leaving all other parameters in the model unchanged at their estimated values. I then simulate the model with the same two shocks from 2008 onwards and compare our results with what I found in Section 4, above.

Chart 19: Unemployment rate

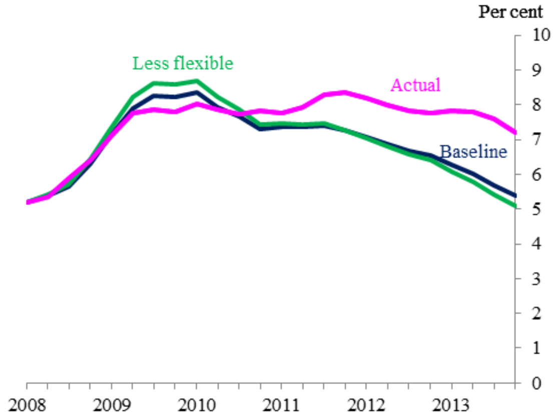
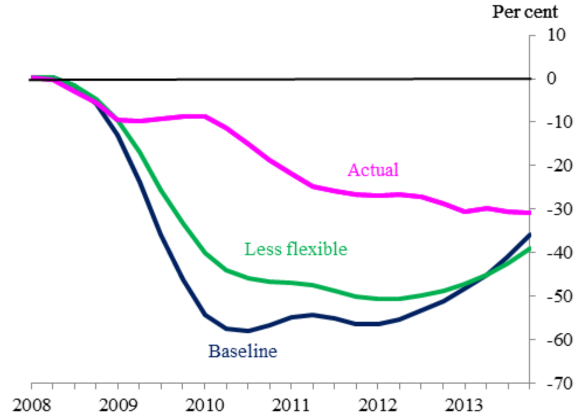


Chart 20: Real wages



Charts 19 and 20 suggest that, as expected, the rise in unemployment would have been higher and the fall in real wages less pronounced had wages in the UK labour market been less flexible than they actually were. That said, the model suggests that the effect on unemployment would not have been that marked, with unemployment peaking at 8.7% as opposed to 8.3% in the baseline model. The difference in the response of wages is more marked, though the key takeaway from Chart 20 is that other shocks mitigated against the fall in real wages that would have resulted from the financial shock and world demand shock on their own.

6 Conclusions

During 2008 and 2009, the world economy was subjected to two large economic shocks that left most economies in recession: the reduction in the ability of the financial system to intermediate between lenders and borrowers, resulting from the sub-prime crisis, and a large fall in world trade, only partly a direct result of the fall in world output. Although the United Kingdom also experienced the Great Recession, with output (as measured by gross value added at basic prices) falling by 6.0% (peak to trough), the UK unemployment rate only rose by 3.2 percentage points (from 5.2% in 2007 Q4 to 8.4 in 2011 Q3). This muted response is often attributed to the flexibility of the UK labour market and, in particular, the willingness of UK workers to see their real wages fall. In this paper, I have used an estimated DSGE model of the UK economy – specifically that of Jakab and Konya (2009) – to investigate this hypothesis.

I found that three shocks were particularly important during the financial crisis: a domestic risk premium shock, associated with the impaired ability of the financial sector to allocate savings effectively, a world demand shock, associated with the collapse in world trade in late 2008 and early 2009, and a foreign exchange risk premium shock, associated with the large depreciation of sterling seen in 2007 and 2008. Of these three shocks, it was the financial and world demand shocks that drove the fall in output and rise in unemployment. Given these shocks, I conducted a simple counterfactual experiment in which I made wages more sticky in order to see what would have happened to real wages and unemployment had the UK labour market been less flexible. I found that the rise in unemployment would have been greater, and the fall in real wages less pronounced, had the UK labour market not been as flexible, though the difference in the unemployment response would not have been that large.

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