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News-driven business cycles in small open economies *

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Abstract

The focus of this paper is on news-driven business cycles in small open economies. We make two significant contributions. First, we develop a small open economy model where the presence of financial frictions permits the replication of business cycle co-movements in response to news shocks. Second, we use VAR analysis to identify news shocks using data on four advanced small open economies. We find that expected shocks about the future Total Factor Productivity generate business cycle co-movements in output, hours, consumption and investment. We also find that news shocks are associated with countercyclical current account dynamics. Our findings are robust across a number of alternative identification schemes.

Key words: News shocks, business cycles, open economy macroeconomics, financial frictions, VAR.
J.E.L. codes: E32, F4

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1 Introduction

Does news about future Total Factor Productivity (TFP) generate business cycles in small open economies? A long tradition in macroeconomics and some recent empirical evidence suggests that news about the future might be an important driver of the business cycle.[1] There has been a lot of recent interest in incorporating this idea into modern business cycle models. One of the main challenges emerging from this literature is to develop equilibrium business cycle models that replicate data-congruent macroeconomic co-movement in response to news shocks.[2] The emphasis in most of this literature, particularly on the empirical side, is on the effect of news shocks in closed economies.

In this paper, we focus on the effect of news shocks in small open economies. We make two contributions. First, we put forward a novel mechanism through which news about future TFP causes business cycles. This mechanism is based on the presence of financial frictions. Specifically, the model incorporates financial frictions *à la* Jermann and Quadrini (2012) into an otherwise canonical small open economy model. The financial friction in this model arises because firms need to arrange a working capital loan prior to production taking place. Access to finance is constrained by the firm's net wealth position. News shocks interact with the financial friction by relaxing the borrowing constraint faced by firms. This allows firms to increase their demand for labour, which raises output and investment in anticipation of future increases in TFP. Greater investment and labour input today creates the expectation of higher dividends in the future, thus raising the share price in anticipation of future TFP.

Our second contribution is to identify and analyse the effects of news shock in a set of advanced small open economies. Specifically, we identify the dynamic macroeconomic effects of news shocks in four developed small open economies: Australia, Canada, New Zealand and the United Kingdom. The way news shocks are identified in the data is informed by the theoretical impulse responses of the model. In particular, our identi-

[1] See for instance Barsky and Sims (2011) Beaudry et al. (2011), Beaudry and Portier (2004, 2006), Schmitt-Grohé and Uribe (2012) and Fujiwara et al. (2011) and Khan and Tsoukalas (2012)

[2] See for instance Beaudry and Portier (2004, 2007), Jaimovich and Rebelo (2009), Beaudry et al. (2011).

fication strategy, based on Beaudry, Nam, and Wang (2011), imposes model consistent restrictions on the path of TFP, share prices and consumption. For TFP, this implies that news arrives not one, as is the convention in the literature, but two periods in advance. We also impose a restriction that at the end of the news horizon, TFP actually increases for a number of periods. Consistent with our model, we restrict share prices and consumption to rise in response to news.

We find consistent evidence that news shocks generate business cycles. As in our theoretical model, a news shock leads to positive co-movement between GDP, hours worked and investment as well as a counter-cyclical trade balance. Our results are robust across a number of alternative identification schemes, including an augmented Barsky and Sims (2011) identification. To our knowledge, this is the first account of the effect of news shocks in advanced small open economies.

The next section puts our contribution into the context of the literature analysing news shocks. We document the theoretical model and the transmission of the news shocks in section 3 and 4. In Section 5 we present our empirical results and perform a number of robustness tests around our baseline identification of news shocks.

2 Literature and model choice

News shocks in a standard open economy real business cycle model do not generate news-driven business or Pigou cycles. In this class of model, news about a future TFP improvement creates a positive wealth effect that raises both household consumption and leisure, thus reducing the supply of labour. In the absence of an actual increase in TFP labour demand remains unchanged and as a result output falls in response to news.

Jaimovich and Rebelo (2008, 2009) show that when preferences are such that the wealth effect on labour is small, hours worked do not decline following a news shock. Eliminating the wealth effect on hours is, however, not enough to generate an actual increase in labour demand when an increase in TFP is anticipated but not yet realised. Jaimovich and Rebelo (2009) show that in a closed economy setting, this can be achieved by a combination of investment adjustment costs and variable capital utilisation. The presence of investment adjustment costs causes firms to bring the anticipated increase in future investment, associated with the increase in future TFP, forward into the current period. In a closed economy model, the hump shaped response of investment causes current period Tobin's q to fall, which in turn raises the rate at which firms utilise capital. The rise in capital utilisation raises the marginal product and thus the demand for labour. This is enough to generate new-driven business cycles.

For a small open economy, the challenge of generating news-driven business cycles is slightly different. With real interest rates determined abroad, Tobin's q always rises following a news shock. As a result, adding variable capital utilisation does not help generate business cycles in response to news shocks. Jaimovich and Rebelo (2008) show that adding labour adjustment costs that penalise large changes in labour input, will cause firms to bring forward into the current period some of the expected future increase in labour demand.[3]

Our modelling approach relies not on costly adjustment in the labour market, but on a simple form of financial friction to increase the demand for labour following news about future TFP. This friction introduces a wedge between the marginal product of labour and the real wage. Following Jermann and Quadrini (2012), we assume that because of limited enforcement of financial contracts, firms face an enforcement constraint on working capital loans. Because firms have to borrow the wage bill, the 'tightness' of the enforcement constraint creates a wedge between the marginal product of labour and the real wage. In our model, good news about future TFP relaxes the enforcement constraint and increases the demand for labour.

The intuition behind our results is similar to Pavlov and Weder (2013) who consider a model with counter-cyclical mark-ups. In their model, mark-ups create a wedge between the marginal product of labour and the real wage. A news shock that lowers the mark-up also reduces the labour wedge, raising firms' labour demand.

[3] The literature offers several alternatives to overcome the negative co-movement between consumption and hours in response to news. See among others Beaudry and Portier (2004) and Den Haan and Kaltenbrunner (2009) for closed economy approaches and Beaudry, Dupaigne, and Portier (2011) and citedenhaanlozej2010 for open economy approaches.

Related to our analysis is Walentin (2012), who examines news shocks in a model with limited enforcement where firms face a collateral constraint when securing external finance. As in our model, the arrival of news relaxes the borrowing constraint and raises share prices, which leads to an accelerator type effect on investment. The key difference between our approach and that of Walentin (2012) is that in our model, the firm faces the enforcement constraint on working capital, whereas in Walentin (2012), the loan is inter-temporal. Financial frictions impact the business cycle via an accelerator type mechanism. This difference between our approaches matters, because only in our case does the financial friction create the aforementioned labour wedge that is helpful in generating a positive co-movement between consumption and hours.[4]

Two recent papers that set out to identify productivity shocks in open economies using sign restrictions are Fratzscher and Straub (2013) and Corsetti et al. (2013). Fratzscher and Straub (2013) use a canonical two-country new Keynesian model in which news shocks are used to identify changes in asset prices that are not related to current fundamentals. Related to our work, they analyse asset price shocks in small open economies, including the four in our sample. However, since the focus of their work is on asset price shocks, no effort is made to identify news-driven business cycles. Indeed, their baseline model shows a decline in investment following a news shock, and their empirical work does not report the response of investment or employment. In contrast, we identify news shocks as shocks that raise the share price as well as lead to a path of TFP that is consistent with news about future total factor productivity.

Corsetti et al. (2013) analyse the international dimension of contemporaneous sectoral productivity for the US economy. A contemporaneous increase in labour productivity of the manufacturing sector is shown to lead to a trade deficit as well as an appreciation of the real exchange rate. Nam and Wang (2013), using an identification method that divides TFP shocks into a contemporaneous as well as an anticipated component, suggest that for the US economy, anticipated TFP shocks are associated with a real appreciation, whereas contemporaneous shocks are linked to a depreciation. Both of these studies are

[4] In Walentin (2012), a positive response of labour to news shocks requires a relatively large degree of habit persistence in hours, in addition to the financial friction.

related to our work in the sense that they analyse TFP shocks in an open economy setting, but differ from ours by focusing mainly on the United States economy.

3 A simple small open economy model with financial frictions

We extend the flexible price version of the model presented in Jermann and Quadrini (2012) into a small open economy setting. To turn a closed economy real business cycle model into a small open economy model requires only a few changes to be made to the structure of the model. In an open economy, the savings of households do not have to equal the borrowing by firms. The gap between savings and investment equals the current account balance. Unlike a closed economy, the gross or pre-tax interest rate faced by households and firms is exogenous in a small open economy setting. This rate is determined instead by the world interest rate as well as a small risk premium to ensure a well defined steady state.[5] Firms and households produce and consume a homogeneous good. This good is a perfect substitute for output produced in the rest of the world. As a result, the terms of trade defined as the price of imports relative to exports are constant. We make the one-good assumption for two reasons. First, abstracting from terms of trade movements allows us to to focus more clearly on the role of financial frictions in the transmission of news shocks. Second, for commodity producers such as Australia, Canada and New Zealand, assuming an exogenous terms of trade is quite realistic, although this is probably not the case for the UK.

As in Jermann and Quadrini (2012), we introduce financial frictions into the environment in which domestic firms are operating. The household sector, on the other hand, faces a standard optimisation problem.

[5]See Schmitt-Grohe and Uribe (2003) for alternative ways to close small open economy models.

3.1 Borrowing constrained firms

At any time t, the representative firm combines hired labour, n_t and accumulated capital stock, k_{t-1} in a Cobb-Douglas production function $F(z_t, k_{t-1}, n_t) = z_t k_{t-1}^{\alpha} n_t^{1-\alpha}$. The variable z_t denotes the level of TFP. TFP is affected by both unanticipated and anticipated shocks and evolves as follows:

$$\ln z_t = \rho_z \ln z_{t-1} + \varepsilon_{z,t} + \varepsilon_{news,t-j} \tag{1}$$

Capital accumulation is subject to investment adjustment costs of the type proposed by Christiano et al. (2005)

$$k_t = (1-\delta)\, k_{t-1} + i_t \left(1 - \frac{\phi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right) \tag{2}$$

where i_t is investment, δ the depreciation rate of capita and ϕ a parameter capturing the curvature of the adjustment cost function.

As in Jermann and Quadrini (2012), firms can finance investment projects either by issuing equity, d_t, or debt, b_t^f. Reducing equity payouts to finance investment projects does not affect a firm's tax liabilities in the same way as issuing new debt. As a result, firms prefer debt to equity finance in this model. This preference for debt finance is captured by a constant tax benefit, or subsidy. The effective interest rate faced by firms is $R_t = 1 + r_t(1-\tau)$, where r_t is the world rate of interest (adjusted by a net-debt elastic risk premium) and τ captures the tax benefit on debt issuance.

The firm has to make its payments to its workers, shareholders, and creditors, as well as undertake investment before revenues are realised. To cover this cash flow mismatch, the firm has to secure an intra-temporal working capital loan equal to its production at the beginning of the period. After receiving the working capital loan, the firm can either pay its factors of production, produce and pay back the inter-temporal loan at the end of the period, or it can choose not to produce, abscond with the loan and default. To rule out the latter scenario, the firm is subject to the following enforcement constraint:

$$\xi\left(k_t - \frac{b_t^f}{1+r_t}\right) = F(z_t, k_{t-1}, n_t) \tag{3}$$

where ξ denotes the probability that the lender can recover the full value of the firm's capital stock in the case of a default.

A key feature that determines the effect of this enforcement constraint on the model economy is an assumed rigidity affecting the substitution between equity and debt. If we define total intra-temporal borrowing, l_t, as:

$$l_t = F(z_t, k_{t-1}, n_t) = w_t n_t + i_t + d_t + b_{t-1}^f - \frac{b_t^f}{R_t}$$

then the firm will always be able to keep the demand for intra-period loans, l_t, constant simply by changing the composition between debt and equity finance. In this case, shocks that affect the firm's ability to borrow intra-temporally will have no effect on the firm's choice of labour input or investment. To make sure the enforcement constraint is binding, we introduce a cost of adjusting equity payouts, as suggested by Jermann and Quadrini (2012)

$$\varphi\left(d_t\right) = d_t + \kappa\left(d_t - \overline{d}\right)^2 \tag{4}$$

where κ a positive adjustment cost parameter and $\overline{d}$ is the steady state level of dividend payouts. Given these adjustment costs, the firm's budget constraint can be written as:

$$F(z_t, k_{t-1}, n_t) - w_t n_t - i_t - b_{t-1}^f + \frac{b_t^f}{R_t} - \varphi(d_t) = 0. \tag{5}$$

The firm's optimisation problem consists of maximising equity payouts, subject to the budget (5), capital accumulation (2) and enforcement (3) constraints. The first order conditions for the optimal choice of labour, inter-temporal borrowing, capital and investment are:

$$\left(1 - \Delta_t \varphi'(d_t)\right) F_{n,t} = w_t \tag{6}$$

$$E_t\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{\varphi'(d_t)}{\varphi'(d_{t+1})}R_t+\Delta_t\varphi'(d_t)\frac{R_t}{1+r_t}\xi=1 \tag{7}$$

$$E_t\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{\varphi'(d_t)}{\varphi'(d_{t+1})}\left(F_{k,t}\left(1-\Delta_{t+1}\varphi'(d_{t+1})\right)+Q_{t+1}(1-\delta)\right)+\Delta_t\varphi'(d_t)\xi=Q_t \tag{8}$$

$$Q_t\left(1-\frac{\phi}{2}\left(\frac{i_t}{i_{t-1}}-1\right)-\phi\left(\frac{i_t}{i_{t-1}}-1\right)\frac{i_t}{i_{t-1}}\right)+E_t\beta Q_{t+1}\frac{\lambda_{t+1}}{\lambda_{t+}}\frac{\varphi'(d_t)}{\varphi'(d_{t+1})}\phi\left(\frac{i_{t+1}}{i_t}-1\right)\left(\frac{i_{t+1}}{i_t}\right)^2=1 \tag{9}$$

The variable λ_t denotes the marginal utility of consumption of households, who are the owners of the firm. The variables q_t, v_t and μ_t are the Lagrange multipliers on constraints (5), (2) and (3), respectively. These shadow prices are used to define the following composite variables: $Q_t=\frac{v_t}{\lambda_t}\varphi'(d_t)$, $\Delta_t=\frac{\mu_t}{\lambda_t}$, and $\frac{\lambda_t}{\varphi'(d_t)}=q_t$.

Because changing its financial structure is costly, the effective discount factor of the firm $\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{\varphi'(d_t)}{\varphi'(d_{t+1})}$ differs from that of the household. The first derivative of the dividend adjustment costs (4) is a positive function of the level of dividend payouts. A one-off decrease in dividend payments (where $\varphi'(d_t)$ decreases but not $\varphi'(d_{t+1})$) lowers the discount factor applicable to firms. A more gradual decrease of dividend payments, on the other hand (where $\varphi'(d_t)$ increases by less than $\varphi'(d_{t+1})$), raises the discount factor.

3.2 Households

The representative household maximises the expected utility function defined over

$$E_0\sum_{t=0}^{\infty}\beta^t\frac{(c_t-\psi n_t^{\theta}x_t)^{1-\sigma}-1}{1-\sigma} \tag{10}$$

where

$$x_t=c_t^{\gamma}x_{t-1}^{1-\gamma} \tag{11}$$

consumption, c_t, and labour effort, n_t. Following Jaimovich and Rebelo (2008), we choose a functional form for the utility function that allows utility to be both separable ($\gamma\approx 1$) and non-separable ($\gamma\approx 0$) over consumption and hours worked. The household's discount factor is denoted by β and has the usual properties that $0<\beta<1$. Expected utility is maximised subject to the following budget constraint:

$$w_t n_t + b_{t-1} + s_t(d_t + p_t) = \frac{b_t}{1 + r_t} + s_{t+1} p_t + c_t + T_t. \tag{12}$$

At the beginning of each period, the household receives wage income, $w_t n_t$, and a dividend payment, d_t. The household also holds a stock of internationally traded bonds, b_{t-1}. The household's income steam is used to purchase consumption goods, pay taxes, T_t, and purchase new bonds, b_t at a price of $1/(1+r_t)$ per unit, and purchase new shares, s_{t+1}, at price p_t. Taxation, which the household takes as given, is used to finance the tax benefit enjoyed by firms when borrowing: $T_t = b_t^f/R_t - b_t^f/(1 + r_t)$.

The representative household maximises expected utility, (10) subject to (11) and (12). The household's first-order conditions for the optimal choice of c_t, n_t, x_t, b_t and s_{t+1} are:

$$(c_t - \psi n_t^{\theta} x_t)^{-\sigma} + \omega_t \gamma c_t^{\gamma-1} x_{t-1}^{1-\gamma} = \lambda_t \tag{13}$$

$$(c_t - \psi n_t^{\theta} x_t)^{-\sigma} \theta \psi n_t^{\theta-1} x_t = \lambda_t w_t \tag{14}$$

$$(c_t - \psi n_t^{\theta} x_t)^{-\sigma} \psi n_t^{\theta} + \omega_t = \beta E_t \omega_{t+1} (1 - \gamma) c_{t+1}^{\gamma} x_t^{-\gamma} \tag{15}$$

$$\frac{\beta E_t \lambda_{t+1}}{\lambda_t} (1 + r_t) = 1 \tag{16}$$

$$\frac{\beta E_t \lambda_{t+1}}{\lambda_t} (d_{t+1} + p_{t+1}) = p_t \tag{17}$$

where ω_t and λ_t are the Lagrange multipliers associated with constraints (11) and (12), respectively.

3.3 Consolidated budget constraint

Combining the budget constraints of the representative firm (5) with that of the representative household (12) and aggregating over all individuals yields the economy-wide budget constraint[6]:

$$F(z_t, k_{t-1}, n_t) = c_t + i_t + \frac{(b_t - b_t^f)}{1 + r_t} - (b_{t-1} - b_{t-1}^f) + \varphi(d_t) - d_t \tag{18}$$

Where the net foreign asset position is defined as the difference between household savings and firm borrowing, $(b_t - b_t^f)$. The trade balance, which we assume to be zero in the steady state, is defined as:

$$TB_t = y_t - c_t - i_t - \varphi(d_t) + d_t \tag{19}$$

4 News about total factor productivity

In Figures 1 to 2 we assess the contribution of financial frictions to the generation of positive co-movement between consumption and hours worked in response to news shocks. To do this, we compare our baseline model to a version where the dividend payout cost is set to zero. This version of our model is similar to the model in Jaimovich and Rebelo (2008). The calibration of our model follows Jermann and Quadrini (2012) for the financial frictions part of the model, such that $\xi = 0.162$ and $\tau = 0.35$. We set $\kappa = 0.146$, which corresponds to the value in Jermann and Quadrini (2012). Sensitivity analysis shows that in our baseline calibration with non-separable preferences, we get news-driven business cycles for any positive value of κ. For separable preferences (when $\gamma = 0.999$), our model generates news-driven business cycles for any value of κ greater than 0.09.

For technology, we use standard parameters from the literature. The share of capital in output, the depreciation rate as well as the investment adjustment cost parameter are $\alpha = 0.3$, $\delta = 0.025$, $\phi = 1$, respectively. In terms of preferences, we assume a value for the risk free discount rate of $\beta = 0.985$. The parameters of the utility function are $\sigma = 1$, $\theta = 1.2$ and $\gamma = 0.001$. The value of ψ is set in such a was as to yield a steady state value of hours worked of $\overline{n} = 0.2$.

Figure 1 analyses the response of key macroeconomic aggregates to an increase in TFP that is expected to occur in period $t + 2$ and announced in period t.[7] In our

[6]The number of shares held by all households is normalised to unity.

[7]We follow business cycle tradition in analysing the responses of temporary rather than permanent

baseline model, hours worked and GDP both increase as soon as the news about future productivity becomes available. Without financial frictions, the agent's preferences over consumption and labour ensure that the wealth effect on hours worked is weak. However, given our value of γ, the wealth effect is small, but not zero, and hence hours worked decline on impact. Because the real interest rate stays constant in our small open economy model, share prices rise with the announcement of news.

In the baseline model, labour effort rises on impact because an anticipated shock to TFP drives a wedge between the marginal product of labour and the real wage. This wedge can be easily illustrated by combining the household's and the firm's first-order conditions for labour. For expositional purposes, we assume that $\gamma = 0$, such that the wealth effect on hours is absent.

$$F_n(z_t, k_{t-1}, n_t)(1 - \Delta_t \varphi'(d_t)) = \theta \psi n_t^{\theta-1}$$

Following a positive news shock about TFP the term $\Delta_t \varphi'(d_t)$ falls, which for a given marginal product of labour raises the real wage. The rise in the real wage causes agents to increase hours worked and thus output to rise.

Once TFP increases, the firm's borrowing constraint becomes more binding, Δ_t rises, due to more output needing to be financed in advance of production. A feature of the Jermann and Quadrini (2012) model is that a tightening of the borrowing constraint causes hours worked to decline. In the next subsection, we analyse why the borrowing constraint is relaxed during the news period, causing hours worked to rise.

4.1 Intuition

In Jermann and Quadrini (2012) a positive contemporaneous TFP shock causes firms to reduce their dividend payouts, d_t. The reason for the fall in dividends is as follows: A positive TFP shock raises the marginal products of both capital and labour, causing the firm to expand labour input and capital accumulation. Because of the aforementioned

shocks. In the news literature, there are examples of both.

mismatch in the timing of revenues and expenditure, the representative firm in this model requires a working capital loan. Limited enforcement ensures that the size of the working capital loan, l_t, is constrained by the net worth of the firm:

$$\xi\left(k_t - \frac{b_t^f}{1+r_t}\right) = l_t = w_t n_t + i_t + d_t + b_{t-1}^f - \frac{b_t^f}{R_t} \tag{20}$$

In order to raise the funds to increase $w_t n_t + i_t$ in response to a TFP shock the firm has to cut dividend payouts, d_t.

Without dividend adjustment costs, i.e. $\varphi' = 1$, dividends can be reduced sufficiently for labour demand and investment to rise, just as in the standard RBC model. In the presence of dividend adjustment costs, dividend payouts are reduced more gradually, causing labour input to decline. This mechanism explains the observed decline in hours worked once the anticipated increase in TFP materialises in Figures 1 to 2.

When the increase in TFP is anticipated and in the presence of adjustment costs, the firm finds it optimal to start reducing the flow of dividends before TFP actually increases. Thus dividends start to decline as soon as the news about future TFP becomes available. Dividend adjustment costs also affect the firm's stochastic discount factor.

$$\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{\varphi'(d_t)}{\varphi'(d_{t+1})}$$

When dividends are expected to fall over time, the firm's discount factor rises, which makes the firm want to hold less debt. Therefore, the firm's desire to gradually reduce dividend payments in order to expand investment and labour input also leads to a deleveraging of the firm.

The combination of a higher expected capital stock and lower inter temporal borrowing thus improves the firm's net asset position, which in turn relaxes the intra-temporal borrowing constraint. The less binding the constraint, the smaller Δ_t and the greater will be the firm's demand for labour (see Equation 6). This mechanism explains the role of financial frictions in generating news-driven business cycles in our model. Importantly, as we show in Figure 2, this mechanism can be strong enough to off-set the wealth effect on hours worked.

4.2 Separable preferences

In this section, we examine whether the mechanism identified above is strong enough to overcome the negative wealth effect on hours that one finds in models with separable preferences over consumption and labour. The utility function put forward by Jaimovich and Rebelo (2008) nests both non-separable (when γ is close to zero) and separable preferences (when γ is close to unity) over consumption and labour. Figure 2 shows the response to a news shock when $\gamma = 0.99$ for an otherwise unchanged calibration. Even with largely separable preferences, GDP and its components display typical business cycle behaviour, with output, consumption and investment and hours all rising on impact. As in the non-separable case, there is a reduction in labour demand once TFP actually increases. This is because as output rises, so does the demand for intra-period finance, which in turn causes the the enforcement constraint to tighten.

5 News shocks in open economies

Having analysed the effects of news shocks in a theoretical small open economy, we now compare the predictions of this model to the data. We are interested in analysing the effects of news shocks in four industrialised small open economies: Australia, Canada, New Zealand and the United Kingdom. In this section, we first present the data used in the empirical exercise. We then describe our time series model and discuss the results under alternative identification schemes. To our best knowledge this is the first rigorous attempt of identifying news shocks in advanced small open economies. In a recent paper, Nam and Wang (2013) investigate the effect of news shock on international trade but their contribution remains focused on the US economy.

5.1 Data

We estimate the VAR model using data on total factor productivity, stock prices and five macroeconomic aggregates: output, consumption, investment, total hours worked and net trade. For each country our data is from OECD and obtained via HAVER. Our sample period is mainly dictated by data availability and covers 1989Q3 to 2011Q3.

5.1.1 A measure of Total Factor Productivity

Our identification scheme is based on the assumption that TFP is exogenous. Basu, Fernald, and Kimball (2006) argue that because of sectoral heterogeneity in the marginal product of factors, one should ideally measure TFP at the sectoral level and then aggregate across sectors to derive an aggregate measure of TFP. Furthermore, unobserved variations in factor utilisation must also be accounted for. They proxy the unobserved changes in capital utilisation and labour effort by observed changes in hours worked per capita.

Fernald (2014) derives a quarterly measure of TFP that does not require annual sectoral data, but does rely on the annual estimates for utilisation from Basu, Fernald, and Kimball (2006).

Unfortunately, there are no corresponding studies for the small open economies in our sample. Instead, we construct our own series of TFP using readily available quarterly data. As in Basu, Fernald, and Kimball (2006) and Fernald (2014), we use a growth-accounting approach. Assume that quarterly per capita output growth is modelled by Cobb-Douglas production function:

$$dy_t = da_t + \alpha(du_t + dk_t) + (1 - \alpha)(de_t + dn_t) \tag{21}$$

where y_t is output a_t is total factor productivity, u_t is capital utilisation rate, k_t is physical capital input, n_t is total hours worked, e_t is effort and α is the capital share.

Whereas data on capital utilisation, hours worked, output and total labour force are available for our sample of countries at quarterly frequency, we have to construct quarterly data for effort and the capital stock. We follow Basu, Fernald, and Kimball (2006) and proxy the change in effort by the change in average hours, $de_t = \zeta dn_t$. To construct a quarterly series of the capital stock, we use annual capital data from the OECD and transform it to quarterly frequency using information on quarterly investment. Our approach consists of allocating capital into each quarter proportionally to the investment on that particular quarter.

Consistently with the calibration of our model we set α to 0.3. The coefficient that links changes in effort to hours worked, ζ is set to 1. We have experimented with values between 0.1 and 10 and found that our results are robust provided ζ is non-zero.

5.1.2 Country-specific shocks

It is likely that TFP growth in small open economies has both a domestic as well as a foreign component. To take account of this, we would ideally adjust our TFP series by a measure of global TFP to allow us to isolate country-specific shocks to TFP. There is, however, no obvious measure of world TFP available, hence we take the quarterly TFP series by Fernald (2014), for the United States as a proxy.

5.1.3 Stock prices and macroeconomic aggregates

Stock prices are stock market indexes deflated by CPI for each country. Output and consumption correspond to gross domestic product and private consumption in real prices, respectively. Investment refers to private non-residential fixed capital formation in real prices. Total hours for each country is constructed as a product of employment and hours worked per employee. All macroeconomic aggregates are divided by the working age population and are therefore expressed in per capita terms. Net trade is the the difference between exports and imports of goods and services divided by output.

5.2 The Time Series Model

In this section we describe the structure of the time-series model and explains its estimation details. Our empirical model is a vector autoregressive model of order K –

VAR(K)

$$\tilde{y}_t = \sum_{i=1}^{K} \Theta_i \tilde{y}_{t-i} + u_t \tag{22}$$

where u_t is the $N \times 1$ vector of reduced-form errors that is normally distributed with zero and Σ variance-covariance matrix. It is helpful to re-express the VAR model in the following format

$$Y = X\Psi + V$$

where $Y = [\tilde{y}_{h+1}, .., \tilde{y}_T]$ is a $N \times T$ matrix containing all the data points in $\tilde{y}_t$, $X = Y_{-h}$ is a $(NK) \times T$ matrix containing the h-th lag of Y , $\Theta = \begin{bmatrix} \Theta_1 & \cdots & \Theta_K \end{bmatrix}$ is a $N\times$ (NK) matrix, and $U = [u_{h+1}, .., u_T]$ is a $N \times T$ matrix of disturbances.

The number of lags has been selected using information criteria (likelihood ratio test statistic, final prediction error and Akaike's information criterion). All selection criteria suggest that a VAR model with two lags is sufficient to capture the dynamic properties of the macroeconomic data and this is the case for all countries. In order to ensure that our inference is not driven by the selection of a particular lag length we repeat the same analysis using lag choices (VAR(1), VAR(3) and VAR(4)) and the results remain unchanged.

For the estimation of the empirical model we rely on Bayesian inference techniques as the large dimension of the observable vector (seven variables) and the small time span of the macroeconomic data set cause Classical (OLS) estimates to be subject of considerable uncertainty. In this case data is combined with prior information about the reduced-form parameter vector in the form of a probability density function. Similar to Beaudry et al. (2011) we employ a flat Normal-Wishart conjugate prior that leads (after being combined with the likelihood of the model) to a closed-form posterior probability distribution for the VAR parameter vector[8].

[8]See Kadiyala and Karlsson (1997) for a detailed discussion

5.3 Identification

As in Beaudry et al. (2011), we identify news TFP shock using a combination of zero type and sign restrictions (Uhlig (2005)). To be precise, the TFP shock anticipated in $t+h$ period is identified by imposing zero restrictions on TFP for periods t, $t+1$,..., $t+h-1$ and sign restrictions on the responses of a set of variables in the system.

Our theoretical model suggests that news shocks are associated with positive co-movement between macroeconomic aggregates and share prices as well as a counter-cyclical current account. Based on this analysis, we impose that stock prices and consumption increase after a positive news about future TFP. [9]

Our methodological strategy also enables us to consider, in a VAR framework, news shocks beyond the first period (see, Barsky and Sims (2011) and Beaudry et al. (2011)). That makes the VAR identified responses more comparable to DSGE ones so the former responses can serve a useful device to either assess the empirical predictions of the structural model about new shocks and/or to calibrate the structural parameter vector in order for the DSGE model to replicate the responses estimated in the data. This closes an important gap in the literature since so far the comparison was achievable only for DSGE model with only one quarter anticipation period (see Barsky and Sims (2011), Kurmann and Otrok (2013), Theodoridis and Zanetti (2013) and Pinter et al. (2013)).

In order to make the paper self contained we describe in this section the mechanics of the identification process starting from the vector moving average representation of the system (22). Under relatively weak restrictions (see Lutkepohl (2007)) the reduced-from model (22) has the following moving average representation

$$\tilde{y}_t = B(L)\, v_t. \tag{23}$$

[9] We have also considered alternative sign restrictions by restricting the sign of the response of (i) only stock prices, (ii) stock prices and investment and (iii) stock prices, consumption and investment. We also considered various durations of zero restrictions on TFP. The results appear robust to alternative schemes and across countries. We summarise these in Figure 5.

The mapping between the reduced-form errors and the structural shocks is given by

$$v_t = A\varepsilon_t, \tag{24}$$

with $AA' = \Sigma$. For any arbitrary orthogonalization of Σ such as the Cholesky decomposition $\Sigma = \tilde{A}\tilde{A}'$ and an orthonormal matrix such that $DD' = I_{dy}$ (where I_{dy} is the $dy \times dy$ identity matrix) the mapping between the reduced-form and structural errors can be re-expressed as

$$v_t = \tilde{A}D\varepsilon_t \tag{25}$$

Having identified the structural shocks, the response of variable j to shock i in period h can be obtained as

$$R(j,i,h) = J_j\breve{\Theta}^{h-1}\left(\mathbf{1}_K \otimes \tilde{A}D\right)J_i' \tag{26}$$

where $\breve{\Theta}$ is the companion matrix of the system (22), $\mathbf{1}_K$ is a $(K \times 1)$ vector of ones, $\otimes$ denotes the Kronecker product and J_v is a selection $(1 \times Kdy)$ vector of one in position v and zeros everywhere else.

As discussed earlier, the identification of the news shock requires – in addition to some zero type restrictions – the response of a set of variables indexed by $\mathcal{R}_+$ to be positive and these restrictions can last for a number of periods $\mathcal{H}_+$. Beaudry et al. (2011) achieve the identification of the news shock by employing the procedure developed by Uhlig (2005) and Mountford and Uhlig (2009), known as a penalty function approach. This framework allows the user to easily combine zero and sign restrictions by solving the following minimisation problem

$$d^* = \arg\min \sum_{j\in\mathcal{R}_+} \sum_{h_j=\tilde{h}_j}^{\mathcal{H}_{j,+}\in\mathcal{H}_+} f\left(-\frac{J_j\breve{\Theta}^{h-1}\left(\mathbf{1}_K \otimes \tilde{A}d\right)}{\sigma_j}\right) \tag{27}$$

s.t.

$$\begin{aligned} d'd &= 1 \qquad (28)\\ R\left(1,2,\tilde{h}\right) &= 0 \qquad (29)\end{aligned}$$

where $d = De_i'$, $\tilde{h} = 1, 2, 3$, e_i denotes the column i of I_N, σ_j is the standard deviation of $R(j, i, h)$ and $f(x) = \begin{cases} 100x \text{ if } x \geq 0 \\ x \text{ otherwise} \end{cases}$. Expression (28) indicates that d^* must be a column of an orthonormal matrix D, while equation (29) says that the news shock ($i = 2$) cannot have an effect on TFP ($j = 1$) for periods $\tilde{h}$. Finally, the objective function (27) is scaled by the standard deviation of impulse response $R(j, i, h)$ to make it comparable across different variables.

In summary, the identification puts restrictions on the responses of TFP, consumption and share prices. TFP is restricted to remain at zero for two quarters and positive for the following two quarters. Consumption and share prices are restricted to increase for four quarters following a positive news shock.

5.4 Testing the identification technique on simulated model data

In this section, we perform a Monte-Carlo experiment to compare the true impulse responses to news shocks from the model presented in the previous section and those from a VAR using our identification scheme.

In order to estimate a VAR with as many variables as we have in the empirical section, we introduce additional structural shocks into our model. In addition to news about TFP, we also consider a standard contemporary TFP shock plus five additional shocks. These are shocks to investment specific technology, financial shocks as in Jermann and Quadrini (2012), government spending shocks and preference shocks and a shock to the world real interest rate. The standard deviation of the two unanticipated technology shocks (TFP and investment specific) is set to 0.75 percent, the standard deviation of the news shock is set to 0.25 percent and the standard deviation of all other shocks is set to 0.15 percent. All shocks are assumed to have an AR(1) coefficient of 0.95.

We generate 2000 artificial data sets from the model under our calibration corresponding to Figure 1. The sample size of each data set is 86, corresponding to the number of observations of the actual data. Using the artificial data sets, we estimate VARs with TFP, output, consumption, investment, total hours worked, net trade and stock prices as observables. The VARs include two lags. We then identify impulse responses using the same identification restriction employed in the empirical section.

Figure 3 displays the theoretical and the range of estimated impulses responses over the Monte-Carlo repetitions. Model based impulse responses are dashed blue and the shaded area represents ± one standard deviation confidence intervals for the estimated impulse responses. The VAR based impulse responses are able to capture the model based dynamics following a news shock. Output and its components, total hours as well as share prices, are all estimated to respond positively while the VAR correctly identifies the negative response of net trade. The VARs somewhat underestimate the magnitude of macroeconomic effects of a news shock, particularly at longer horizons. This bias is probably related to the truncation of the empirical model, as we only use two lags. When we expand the lag order to 4, this bias almost disappears. Nevertheless, the theoretical impulse responses almost always lie within the range of estimated impulse responses. These result suggest that our identification successfully recovers news shocks.

As in Barsky and Sims (2011), we argue that our Monte Carlo results suggest that the invertibility or 'fundamentalness' issue raised by Fernndez-Villaverde et al. (2007) is not a major cause for concern for our work.

5.5 Empirical results

In this section, we discuss impulse responses and forecast error variance decompositions obtained from the structural VAR. Figure 4 shows the estimated impulse responses in four countries for TFP, output, consumption, total hours, investment, net trade and stock prices. The grey shaded area represents 16th and 84th quantiles. As per our identification restrictions, TFP remains constant for two periods and increases after the zero restrictions end, and consumption and stock prices increase on impact. After the identification restriction, the impact of the news shock is significantly positive for all these three variables. The quantitative impact of the news shock is similar for TFP and consumption in all countries. Possibly reflecting their volatility, the impact response of stock prices are one order of magnitude higher than the response of TFP.

Now consider the response of other variables which are not subject to any identification restrictions. A first robust finding is that in all countries, output is estimated to increase on impact, before the realisation of the news shock. This is, for example, contrary to Barsky and Sims (2011) who find that, in the US, the output response to a news about future TFP tracks, but does not anticipate the movements in the estimated path of TFP. In our sample of small open economies, positive news about future TFP creates an economic boom on impact and its positive effects on output are estimated to be persistent. Second, total hours and investment are also estimated to persistently increase after a news shock. There is, however, somewhat more heterogeneity in the response of these two variables. In the case of the United Kingdom, in particular, the response of these two variables seem to be building up over time and less front loaded than in the other countries. The impulse responses described so far imply that, for the small open economies we consider, news shock generate a positive co-movement between output, consumption, investment and total hours. Third, net trade is countercyclical in all four countries following a positive news shock, with some differences in the initial responses. Except for Canada, the initial response of net trade is small and is followed with further deteriorations.

Comparing Figures 1 and 4 shows that the estimated impulse responses are qualitatively similar to those of our model. In both cases, there is co-movement between GDP, consumption, investment and hours as well as a counter-cyclical trade balance. Model and data do, however, differ with respect to the persistence of GDP, consumption and hours as well as with respect to the magnitude of the response of share prices. Compared to the data, the model predicts a more persistent response for GDP, consumption and hours and a less volatile one for share prices.

To show that our empirical results do not depend on a particular identification restriction or the lag choice in the VAR, we have considered a large number of alternative identification schemes and VARs. First, regarding sign restrictions, we have considered less as well as more restrictive identification restrictions. Accordingly, we have identified news shock by just restricting the response of stock prices to be positive and also by restricting the responses of stock prices, consumption and investment all together. Second, we considered an identification scheme in which TFP is restricted to be zero for only 1 period. Third, we have also considered shorter (one period) and longer (12 periods) positive restrictions in all the alternative identification schemes. Finally, we have used a VAR with four lags of each variable. Figure 5 summarises impulse responses from this battery of models (twenty four in total) by plotting the median impulse response from each model against our baseline impulse responses. Focusing on the general pattern of impulse responses from this exercise, our baseline results appear to be robust across alternative identification schemes. In all cases, news shocks generate an economic boom on impact and, except in a few cases, a positive co-movement across macroeconomic aggregates and countercyclical net trade dynamics.

Overall a consistent picture emerges regarding macroeconomic dynamics conditional on news shocks in small open economies. Our results suggest that positive news shocks about future TFP are associated with impact increases in output, consumption, investment, total hours, stock prices and are associated with countercyclical net trade dynamics. These results appear to be in contrast with the recent empirical work focusing on the effect of TFP news shock on the US economy.

We now turn to the relative importance of the identified news shocks in shaping the business cycle dynamics in our set of small open economies. Table 1 reports the share of the news shock in the forecast error variance decomposition for the seven variables in the VAR. The news shock accounts for between 9% to 47% of the 20-quarter ahead forecast error variance of GDP. For consumption, the figures are between 15% and 50%, and for investment between 13% and 45%. The shock also accounts for between 10% and 39% of the 20-quarter ahead forecast error variance of net trade.

The large range of these results reflects heterogeneity between countries. In the United Kingdom, the contribution of new shocks to the 20-quarter ahead forecast error variance of GDP is much greater than in Australia, Canada or New Zealand. In New Zealand, news shocks appear to play only a minor role. Whereas in the UK, they account for around 47% of the 20-quarter ahead forecast error variance of GDP, in New Zealand these shocks only contribute around 9%. The role of news shocks in Australian and Canadian GDP is more important than in New Zealand, but in both of these countries the forecast error variance is still only about a third of that of the UK. That country-specific news shocks are somewhat less important in the smaller and more open economies in our sample is in line with the well documented importance of foreign shocks for these economies, see for instance Justiniano and Preston (2010).

5.6 Robustness under an alternative identification scheme

In Figure 5, we summarise the impulse responses for a battery of alternative sign and zero restrictions using our baseline identification scheme. In this section we undertake further robustness checks and illustrate that our empirical results are unchanged when an alternative and very different news identification procedure proposed by Barsky and Sims (2011) is employed. The scheme relies on the model consistent assumption that productivity is driven by two shocks: the unanticipated productivity shock, $\varepsilon_{z,t}$, and the anticipated news shock, $\varepsilon_{news,t-j}$, where j indicates the anticipation horizon. Hence, technology z can be expressed as

$$\ln z_t = \rho_z \ln z_{t-1} + \varepsilon_{z,t} + \varepsilon_{news,t-j} \tag{30}$$

This assumption also implies that $\varepsilon_{z,t}$ and $\varepsilon_{news,t-1}$ account for all variation in productivity at different horizons (h), which yields:

$$FVD_{z,\varepsilon_z}(h) + FVD_{z,\varepsilon_{news}}(h) = 1 \tag{31}$$

where $FVD_{z,\varepsilon_z}(h)$ denotes the forecast variance contribution of ε_z in z at horizon h. However, it is unlikely that equation (31) holds at all horizons in a multivariate VAR model. Hence, Barsky and Sims (2011), select the column of the VAR identification matrix $\tilde{A}D$ that corresponds to the new shocks to come as close as possible to making equation (31) hold over a finite set of horizons.

This is achieved by solving the following optimization problem:

$$D^* = \arg\max \sum_{h=0}^{H} FVD_{z,\varepsilon_{news}}(h) \tag{32}$$

subject to the following set of restrictions

$$\begin{aligned} \tilde{A}(1,j) &= 0 \; \forall \; j > 1, & (33)\\ D(1,j) &= 0 \; \forall \; j > 1, & (34)\\ D'D &= I_{dy} & (35)\\ \tilde{A}D &\in \mathcal{R}_+ & (36) \end{aligned}$$

where

$$FVD_{z,\varepsilon_{news}}(h) = \frac{e_1'\left(\sum_{\tau=0}^{h} B_\tau \tilde{A} D e_2 e_2' D' \tilde{A}' B_\tau'\right) e_1}{e_1'\left(\sum_{\tau=0}^{h} B_\tau \Sigma B_\tau'\right) e_1} \tag{37}$$

and e_i denotes the selection vector with one in the i-th place and zeros elsewhere. Conditions (33) and (34) ensure that productivity responds contemporaneously only to ε_z, while condition (35) implies that D^* is an orthonormal matrix. Finally, condition (36) ensures that the impact matrix satisfies the sign-restrictions discussed earlier.[10] In the empirical exercise H is set equal to 40, which is the same value used by Barsky and Sims (2011). In line with our baseline identification scheme, we also impose a two-period zero restriction on TFP and sign restrictions for 4 periods. Intuitively, this alternative identification scheme is adding an additional constraint in the identification procedure. Now we are searching for the impulse responses satisfying not only the sign and zero restrictions but also maximising the share of contemporaneous and news TFP shocks in the forecast error decomposition of TFP.

In Figure 6, we superimpose the ± one standard deviation error bands of the impulse response using the Barsky and Sims (2011) identification onto that of our baseline identification scheme. Comparing these two identification schemes suggests a high degree

[10]The method discussed in this section is an extension proposed by Pinter et al. (2013) that allows the user to impose sign-restrictions and identify multiple shocks. A detailed discussion of the algorithm and implementation steps is provided by the authors.

of conformity across the two approaches. Only in the case of Australian net trade do we observe a significant qualitative difference. In the separate appendix, we report the median response as well as the error bands associated with these impulse responses, for both this case (VAR(2)) as well as for a VAR(4).

6 Conclusion

News about future TFP can be a source of business cycle fluctuations in small open economies. For a set of advanced small open economies, we show that news about future TFP causes positive co-movement between GDP, hours, consumption and investment. News shocks are also associated with counter-cyclical current accounts. This is in contrast with previous studies focusing on the US economy in which news about future productivity are not associated with economic booms. We also find that the contribution of country specific news shock in the forecast error variance decomposition of macroeconomic variables is modest. This is possibly due to larger share of foreign variables in driving business cycle dynamics in these small open economies.

In addition to our empirical contribution, we also put forward a theoretical small open economy model that is able to generate business cycles from news shocks to TFP. We introduce financial frictions, akin to those in Jermann and Quadrini (2012) as a mechanism to generate the positive co-movement between hours worked and consumption that is a challenge for canonical small open economy models.

Our approach is deliberately parsimonious in order to put forward a particular channel in generating news-driven business cycles. In future work, we plan to address both the theory and empirics of the movements in international relative prices in generating news driven business cycles in open economies.

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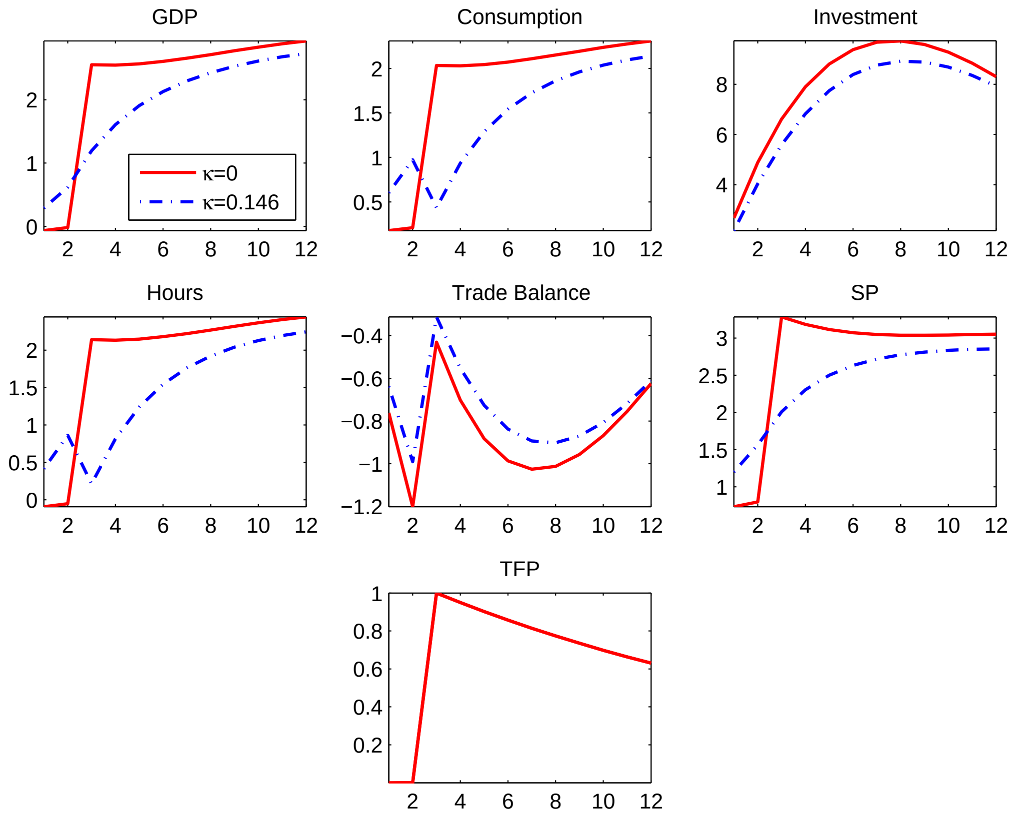
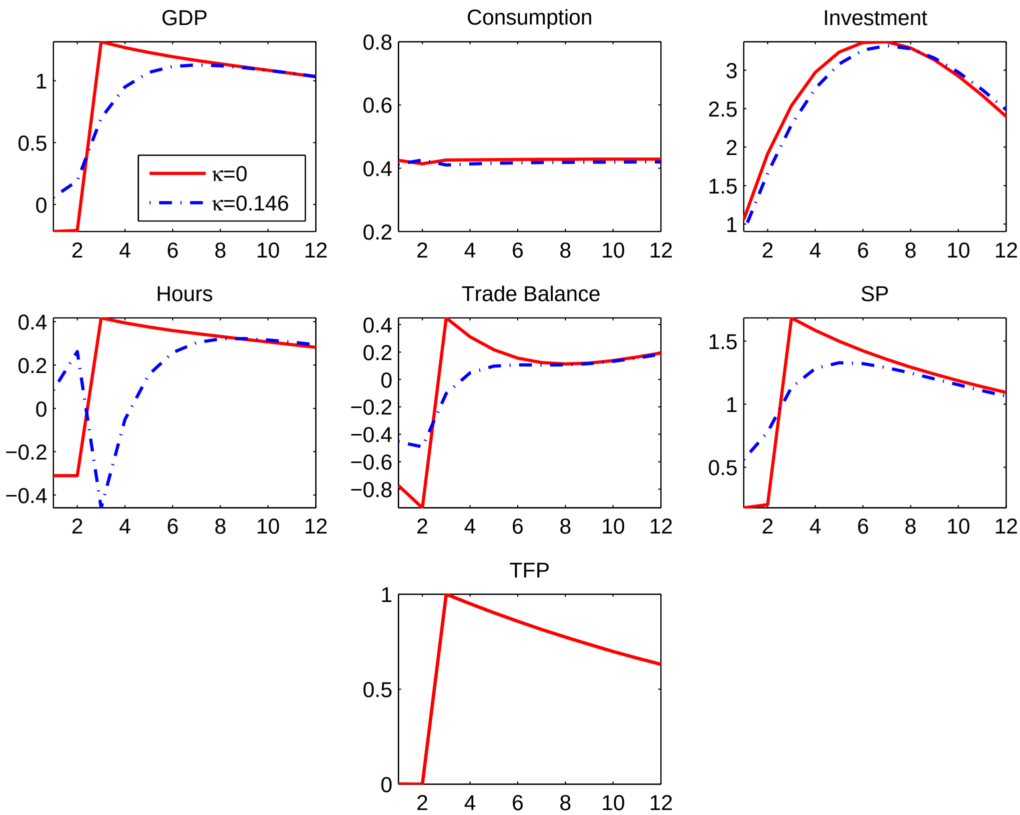
A Figures and Tables

Figure 1: News about total factor productivity



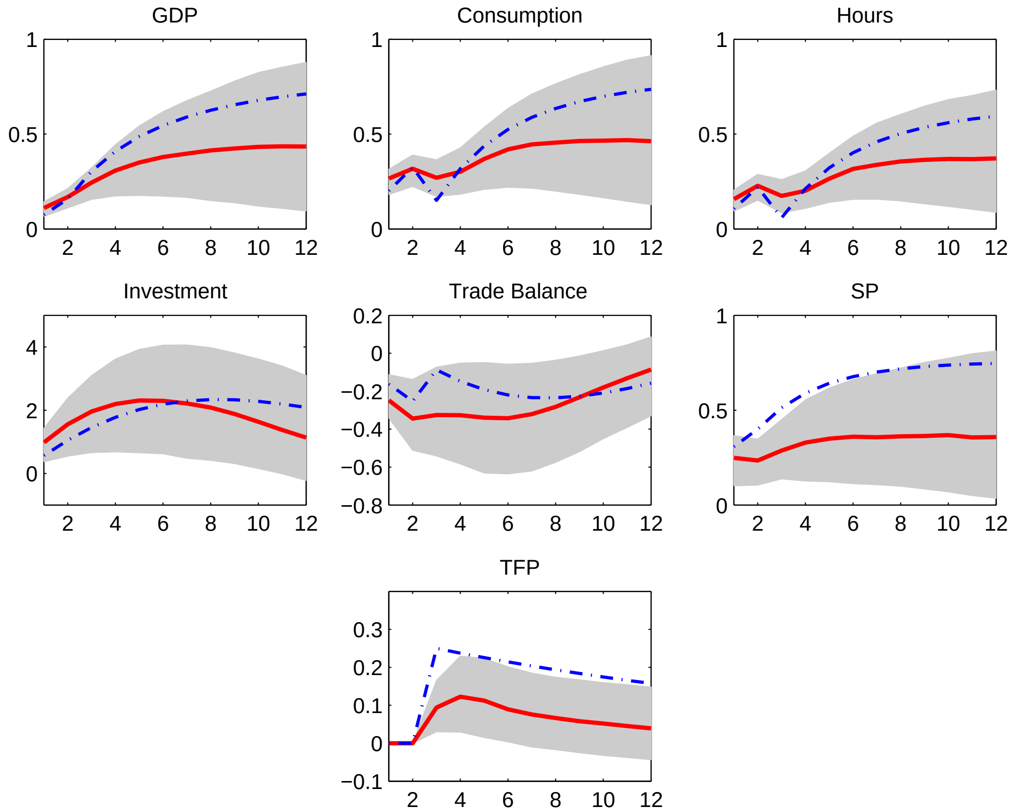
Note: The response of to news about productivity that is expected to occur two periods after the announcement of the news. The solid lines show the impulse responses generated by a model akin to Jaimovich and Rebelo (2008). The dashed lines show the impulse responses of our baseline model, which augments the JR model by financial frictions as in Jermann and Quadrini (2012). The calibration used is as follows. Technology: $\alpha = 0.3$, $\delta = 0.025$, $\phi = 1$. Preferences: $\beta = 0.985$, $\sigma = 1$, $\theta = 1.2$, $\gamma = 0.001$, $\overline{n} = 0.2$. Financial frictions: $\xi = 0.162$, $\tau = 0.35$, κ=varied, Bond holding cost: 0.001.

Figure 2: News about total factor productivity - nearly separable preferences.



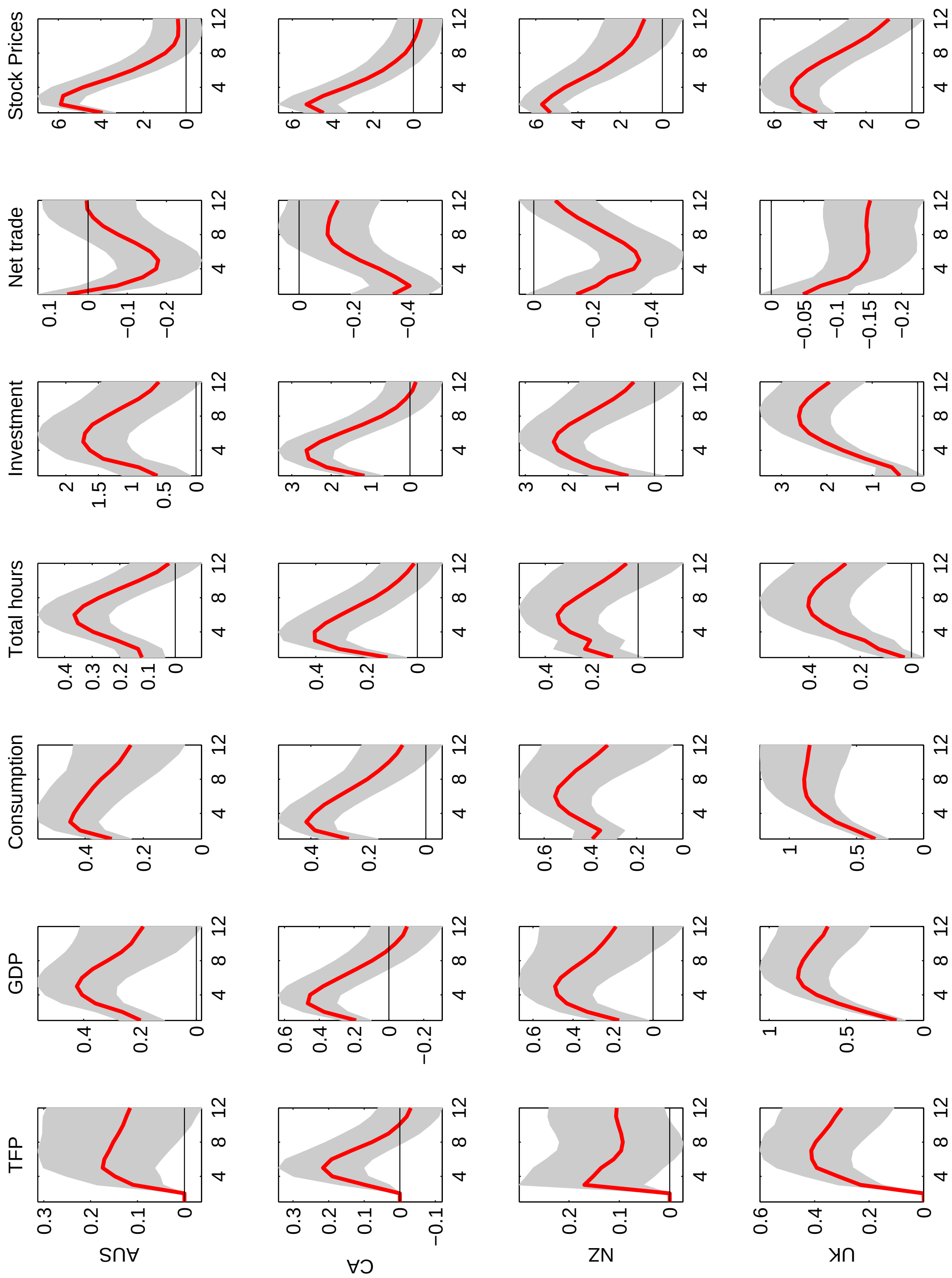
Note: The response of to news about productivity that is expected to occur two periods after the announcement of the news. The solid lines show the impulse responses generated by a model akin to Jaimovich and Rebelo (2008). The dashed lines show the impulse responses of our baseline model, which augments the JR model by financial frictions as in Jermann and Quadrini (2012). The calibration used is as follows. Technology: $\alpha = 0.3$, $\delta = 0.025$, $\phi = 1$. Preferences: $\beta = 0.985$, $\sigma = 1$, $\theta = 1.2$, $\gamma = 0.99$, $\overline{n} = 0.2$. Financial frictions: $\xi = 0.162$, $\tau = 0.35$, κ=varied, Bond holding cost: 0.001.

Figure 3: Model and Monte Carlo estimated impulse responses to a $t+2$ news shock.



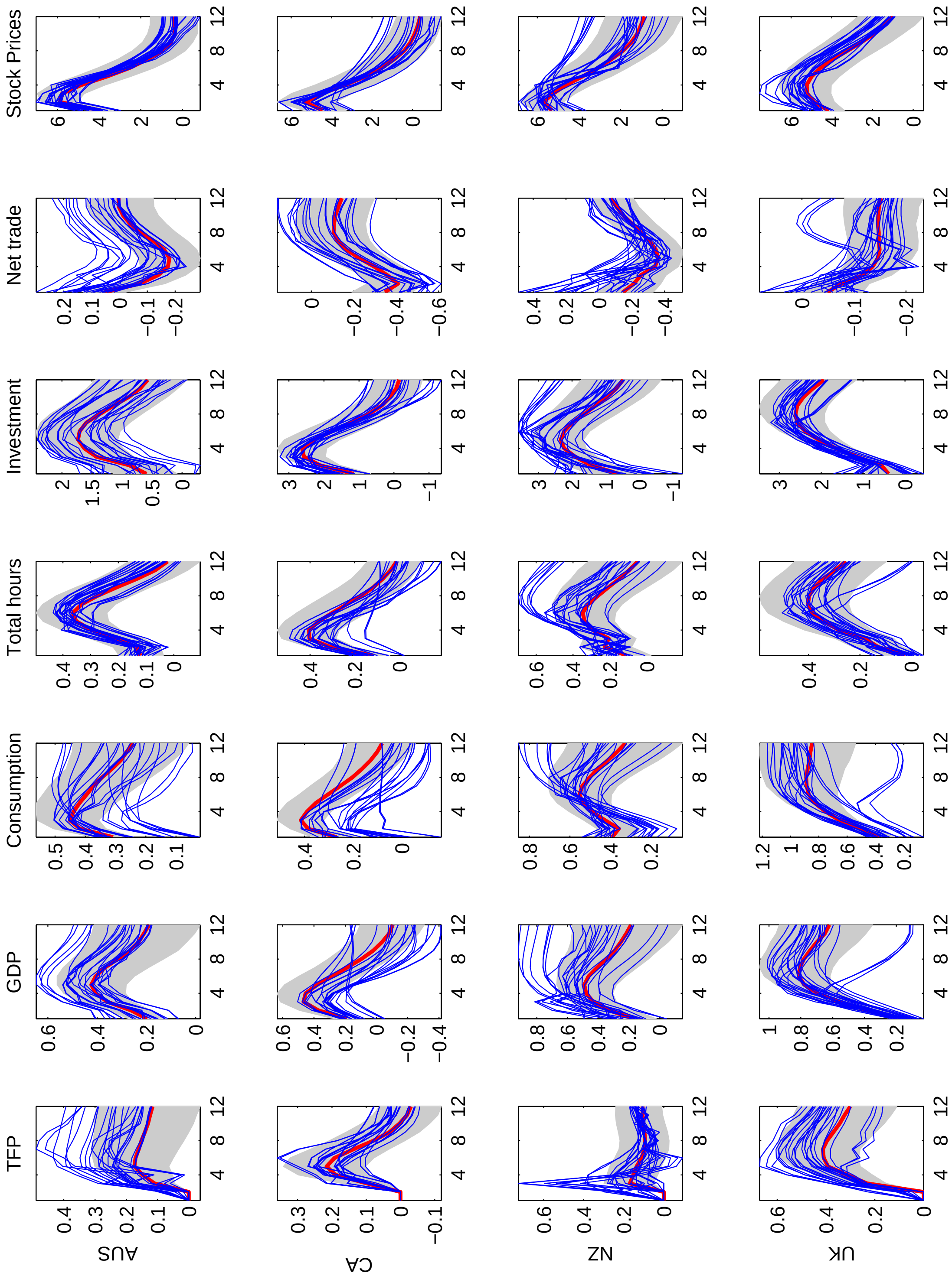
Note: The dashed line shows the theoretical impulse responses from the model. The solid line is the median impulse responses estimated from 2000 Monte-Carlo simulations. There are 86 observations in each simulation. The shaded areas represents ± one standard deviation confidence bands from the 2000 Monte-Carlo simulations.

Figure 4: News about Relative TFP in open economies - t+2 shock



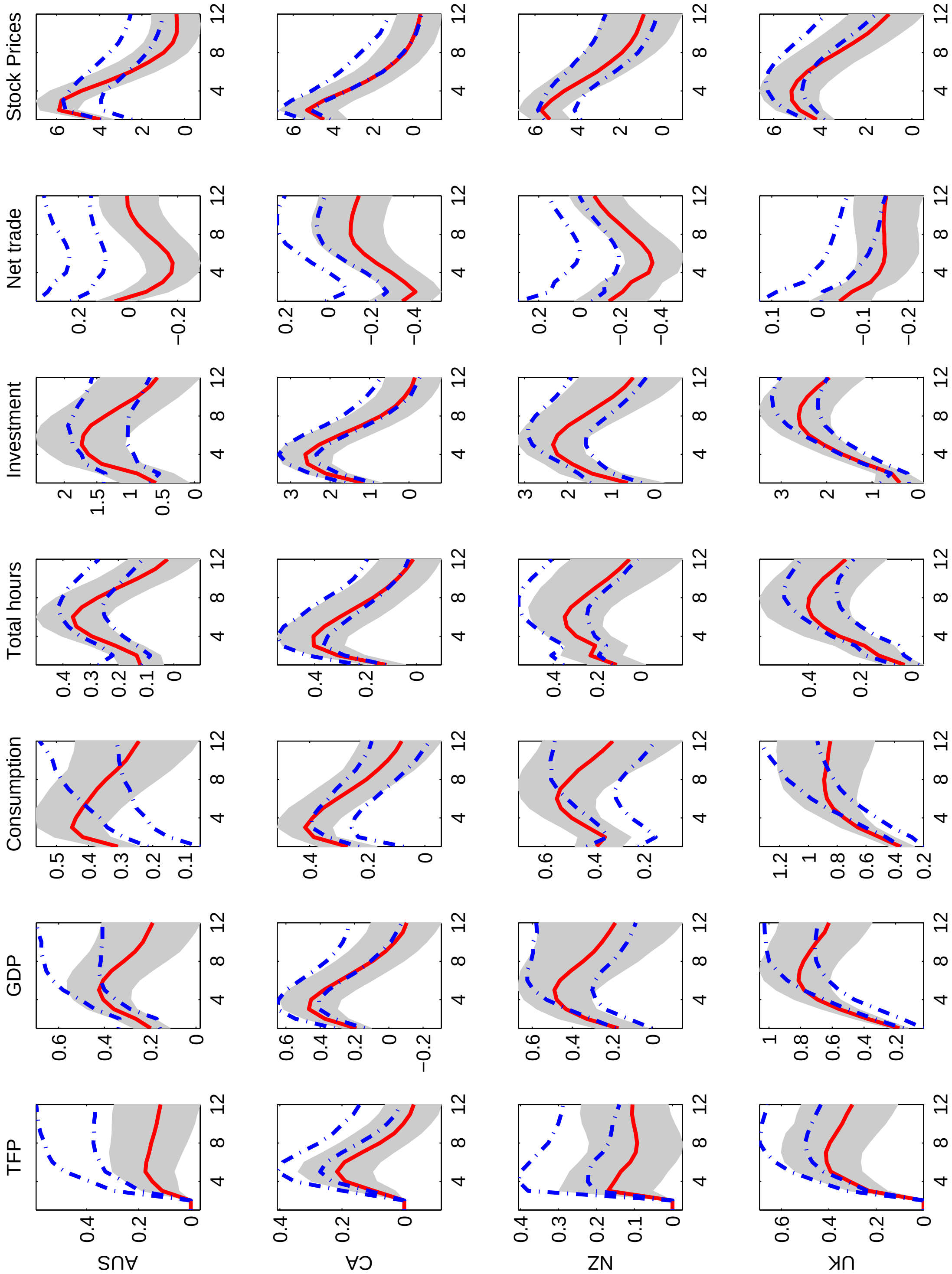
Note: Beaudry identification method with relative TFP. TFP is restricted to be zero for 2 quarters and consumption and stock prices are restricted to increase on impact.

Figure 5: News about Relative TFP in open economies - alternative identification schemes



Note: Beaudry et al identification method with relative TFP. Baseline as well as several alternative sign and zero restrictions, for VAR(2) and VAR(4) models. Lines correspond to the median IRF response to news shocks identified using fewer and more sign restrictions with one and two zero restrictions.

Figure 6: News about Relative TFP in open economies - Alternative identification scheme - t+2 shock



Note: The dashed lines show the ± one standard deviation error bands of the impulse responses of 1000 VARs using the modified Barsky and Sims identification method with relative TFP. TFP increases in period t+2. TFP is restricted to be zero for 2 quarters and then be positive until the 4th quarter. Consumption and stock prices are restricted to increase for 4 quarters.

Table 1: Forecast error variance decomposition

	AUS			CA			NZ			UK		
	h=1	h=10	h=20	h=1	h=10	h=20	h=1	h=10	h=20	h=1	h=10	h=20
TFP	0.00	6.54	7.47	0.00	8.13	9.53	0.00	3.26	4.83	0.00	22.63	26.54
	[0.00, 0.00]	[1.51, 16.67]	[2.39, 18.34]	[0.00, 0.00]	[2.48, 17.45]	[3.62, 18.39]	[0.00, 0.00]	[0.91, 8.08]	[1.59, 10.93]	[0.00, 0.00]	[9.02, 39.06]	[10.50, 44.33]
Output	12.15	25.09	17.41	21.05	20.96	14.77	5.64	13.97	8.65	18.46	53.99	46.94
	[3.93, 22.23]	[11.16, 41.88]	[6.62, 34.17]	[6.85, 40.83]	[9.82, 37.13]	[7.27, 25.77]	[0.72, 14.89]	[4.93, 27.80]	[3.69, 21.21]	[8.76, 31.07]	[33.58, 69.45]	[24.97, 65.13]
Consumption	36.30	41.45	26.28	28.68	41.31	22.52	40.61	33.45	15.43	41.05	56.03	50.03
	[23.40, 50.73]	[24.26, 57.81]	[12.86, 45.74]	[10.67, 49.17]	[23.50, 57.66]	[12.58, 35.61]	[22.69, 54.89]	[18.98, 48.65]	[7.52, 30.08]	[20.64, 57.08]	[33.08, 72.78]	[26.23, 70.02]
Hours	4.50	28.11	25.68	7.17	29.95	24.85	1.27	9.75	8.68	1.53	31.47	30.68
	[0.69, 11.51]	[15.31, 41.54]	[14.37, 39.05]	[1.18, 18.38]	[13.27, 48.56]	[11.56, 39.57]	[0.13, 4.58]	[3.60, 20.06]	[3.99, 17.94]	[0.11, 6.25]	[13.00, 49.81]	[12.20, 50.16]
Investment	4.66	26.78	22.06	25.17	38.62	28.29	2.33	18.58	13.19	3.89	53.90	44.99
	[0.53, 16.44]	[11.33, 43.92]	[9.87, 39.65]	[8.79, 46.94]	[20.76, 55.27]	[15.43, 43.86]	[0.21, 9.16]	[9.47, 31.36]	[6.92, 24.57]	[0.37, 16.15]	[35.50, 67.91]	[26.52, 61.87]
Net trade	2.26	10.01	9.84	23.79	20.76	19.21	2.48	17.74	16.47	2.78	27.25	38.81
	[0.18, 8.56]	[3.86, 21.34]	[4.18, 22.38]	[7.79, 43.75]	[9.57, 39.06]	[7.90, 36.45]	[0.23, 9.18]	[8.68, 29.22]	[8.63, 26.49]	[0.24, 10.85]	[11.74, 45.56]	[19.86, 55.46]
Stock prices	56.26	56.79	50.47	46.24	34.92	28.80	56.69	32.98	22.49	64.02	54.59	43.70
	[41.15, 68.90]	[43.95, 69.35]	[36.61, 64.19]	[25.31, 69.71]	[18.36, 51.34]	[15.34, 42.73]	[39.79, 71.50]	[21.26, 46.21]	[13.50, 35.32]	[43.63, 77.36]	[34.55, 69.07]	[26.62, 59.17]

Notes: Each column corresponds to the contribution of a particular structural shock to the variance of observables. The values in square brackets are 90% Bayesian confidence intervals.