ILO Research Paper No. 11

International Labour Office

Beggar or prosper-thy-neighbour?

The international spillovers of labour cost

Matthieu Charpe
Stefan Kühn

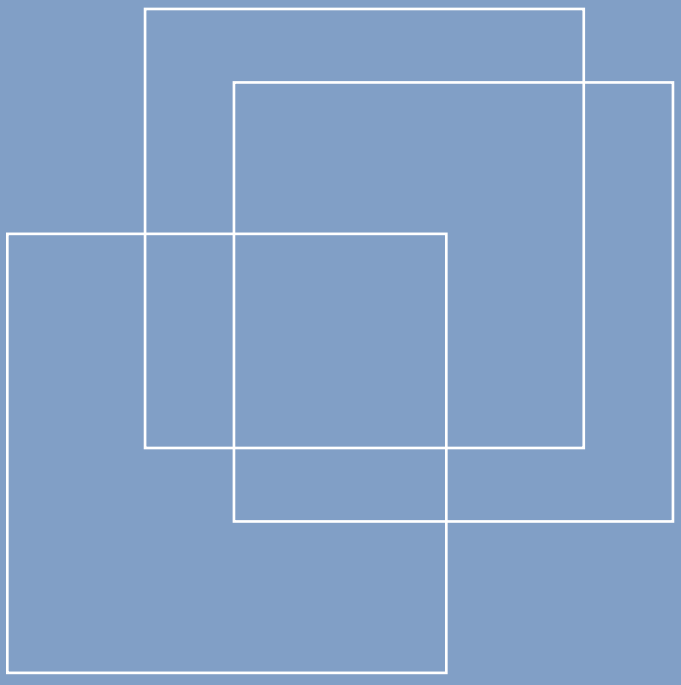

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Table of contents

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Abstract

This paper presents a two-country DSGE model with frictions in the labour market and constrained households to assess the international spillovers of a decline in labour costs. Lower labour costs have ambiguous effects on domestic and foreign output in the presence of a transmission channel linking real wages with consumption and savings decisions of households. This transmission channel takes place via credit constrained households. The main result is that lowering labour costs in the home country has a positive impact on the domestic economy as the competitiveness effect dominates the lower labour income/lower domestic consumption effect. However, lower labour costs may produce a significant beggar-thy-neighbour effect in the open economy case for a large set of parameters. The relative strength of the beggar-thy-neighbour effect depends in particular on the relative size of the two households' populations, on home bias and the substitution between home and foreign goods, as well as on the reaction of monetary policy to inflation. Lastly, lowering labour costs in the home country is detrimental to both the home country and the foreign country in the presence of a zero lower bound in the nominal interest rate.

Keywords: real wage, search and matching, two country, zero lower bound

JEL classification: E24; E32; E62

1 Introduction

Reducing labour costs in order to improve trade competitiveness is often seen by policy makers as a requirement for economic recovery in times of crisis. Political will to reduce labour costs becomes even more pressing when traditional counter-cyclical policies are less effective. In many high income countries for instance, fiscal policy is limited by the level of indebtedness and monetary policy is constrained by the zero lower bound. This may put social partners under pressure to accept a temporary decline in labour cost to maintain jobs. However, improved competitiveness at home may have adverse effects on trading partners.

This paper assesses the impact of a temporary decline in real wage on the domestic economy as well as on its trading partners. After discussing the impact on the domestic economy, the paper evaluates whether a decline in labour costs in the domestic economy has a beggar-thy-neighbour effect or a prosper-thy-neighbour effect on the trading partner. A beggar(prosper)-thy-neighbour is defined as a decline(increase) in foreign output following the reduction in labour costs in the domestic economy.[1]

This assessment is conducted using a two-country New-Keynesian DSGE model with frictions in the labour market.[2] Lower labour costs are proxied by a temporary decline in the bargaining power of workers[3], which leads to a decline in real wages.[4] The distinctive feature of this New-Keynesian model is to highlight a direct link between labour costs and aggregate demand via the presence of constrained households.

In a closed economy New-Keynesian DSGE model with labour friction,[5] a fall in the real wage has positive effects on both output and employment. A decline in real wage raises the surplus of firms from an additional match, creating an incentive for firms to post vacancies. This leads to higher employment and output, which are further enhanced by monetary policy as prices decline with labour costs.

In a two-country New-Keynesian DSGE model, the impact of lower labour costs on trading partners depends on the relative size of the income effect and the substitution effect associated with lower prices.[6] The substitution effect is associated with lower domestic prices, which improve exports of the domestic economy at the expense of the foreign country. Contrastingly, the income effect is related to the acceleration of growth in the domestic economy, which translates into potentially higher export demand in the foreign economy. The relative size of these two effects depends on the parameters for home bias and the elasticity of substitution between home and foreign goods.

The presence of constrained households affects the international spillovers of lower labour costs. Lower consumption of constrained households reduces imports from the domestic economy and enhances the beggar-thy-neighbour effect on the foreign economy. This is in contrast to a model with a single

[1] See Tille (2000) for a discussion of the beggar-thy-neighbour effect associated with exchange rate adjustment.
[2] Dynamic stochastic general equilibrium model
[3] Bargaining power shocks have been discussed in theoretical models as in Cahuc et al. (2008) in a model with intra-firm bargaining or in Kumhof et al. in a model with debt leverage
[4] There is increasing empirical evidence that labour market shocks and shocks in the bargaining power of workers in particular are important determinants of business cycles. Justiniano and Michelacci (2011) point to the importance of matching shocks and job destruction shocks in European countries. Galí et al. (2011) emphasize that wage markup shocks are a major determinant of output and employment fluctuations, while Christoffel et al. (2009) emphasize the central role played by bargaining shocks.
[5] An example of DSGE model with search and matching in the closed economy case includes Hall (2005), Shimer (2005), Ravenna and Walsh (2008), Gertler and Trigari (2009), Sala et al. (2008).
[6] An example of a two-country model with search and matching is Hairault (2002) or Campolmi and Faia (2011).

representative household in which a change in real wage has no direct impact on consumption and savings decisions of households.

Lastly, in the case of two large and open economies, an important transmission channel between the two countries works via imported price inflation and monetary policy. Lower real wages in the home country reduce inflation in the foreign country through lower prices of imported goods. This leads to a decline in the interest rate in the foreign country, which stimulates employment and output. However, lower prices raise the real interest rate when monetary policy is at the zero lower bound. A decline in real wages in the home country reduces output and employment in both the home country and the foreign country.

Constrained households are modelled using rule-of-thumb households as in Galí et al. (2007). Iacoviello (2005) proposes an endogenous borrowing constraint, which in fact enhances the impact of demand and reduces the impact of supply shocks compared to a model with an exogenous borrowing constraint.[7] However, this paper uses the rule-of-thumb framework to maintain clarity of this proposition and to allow the analytical study of the principal spill-over channels in section 4. The negative impact of lower labour incomes on the consumption of constrained households is equivalent to a negative demand shock. In such a framework, a reduction in real wage has a similar impact on aggregate demand than a deleveraging effect in an economy with household debt overhang, see Eggertsson and Krugman (2012).

The main results of this paper can be summarized as follow. First, it is possible to find a significant beggar-thy-neighbour effect under both the stylized model and the New-Keynesian model with nominal and real rigidities. Second, constrained households play a central role with respect to the size of the effect as well as the substitution between domestic and foreign goods or the degree of home bias. Third, a reactive monetary policy is very important for the positive supply side effects of lower bargaining power to materialize. Consequently, lower real wage is detrimental to both the home country and the foreign country in crises time when the interest rate is at the zero lower bound. Finally, the exchange rate regime is of importance through its determination of the interest rate, showing that the beggar-thy-neighbour effect disappears in a currency union.

There is a growing concern amongst economists about the pros and cons of wage flexibility as a buffer to negative shock. For instance, Galí and Monacelli (2013) discuss the impact on employment of wage flexibility in a small open economy framework. The paper highlights that the reaction of employment to a temporary decline in labour tax is determined to a great extent by monetary policy and that wage flexibility may be welfare reducing. Similarly, Decressin et al. (2015) discuss the impact on growth of a temporary decline in nominal wage in a multi-country/monetary union model when monetary policy is at the zero lower bound.[8] The main result is that reducing nominal wage may be detrimental to growth when the policy is applied simultaneously by all union members. Eggertsson et al. (2014) show in a two country model of a monetary union with a labour agency market that reductions in labour and goods taxes may have short run contractionary effects in the presence of a lower zero bound in the nominal interest rate.

This paper is also related to the literature looking at the importance of search and matching in the labour market and the international business cycle. In two companion papers, Dao (2013a) and Dao (2013b) look at the employment effect in country 1 of a reduction in labour cost in country 2 proxied by either a permanent decline in payroll taxes or a permanent decline in unemployment benefits. Reducing

[7] A negative demand and a positive supply shock, as presented in this paper, both reduce the inflation rate. This tightens the borrowing constraint in real terms, further reducing demand.

[8] Their analysis is based on the EUROMOD model, which belongs to the Flexible System of Global Models developed at the IMF is presented in Andrle et al. (2015).

labour costs permanently in country 2 increases employment in both countries as the terms of trade effect increases the return to a job match in country 1. This result is in contrast with two-country models with a Walrasian labour market, where the wealth effect induced by the terms of trade leads to a reduction in labour supply and to a contraction in both employment and output.

Our approach shares with Kumhof et al. and Kumhof et al. (2012) the central role played by income distribution in shaping the response of macroeconomics variables. Kumhof et al. (2012) argue that the increase in inequality measured by the top 5 percent income share explains a large portion of current account deficit in countries such as the United States and the United Kingdom. The mechanism is that as poor and medium income workers borrow from high income households to sustain their consumption, the consumption of high income earners increases, leading to a current account deficit.

Coenen et al. (2008a) use a two-country model with heterogenous households to assess the employment and output effect of a decline in taxes (either consumption taxes, labour income tax and social contributions). Both households engage in inter-temporal consumption smoothing. However, the two households differ with respect to their access to financial markets. The main result is that reducing taxes leads to both an expansion of output and hours worked at home and abroad.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 discusses the calibration, while section 4 presents the analytic solution of the model. Section 5 presents the numerical simulations and shows a large range of sensitivity tests undertaken. Section 6 concludes. Details of the computation related to the analytic section and additional numerical simulations can be found in the Appendix.

2 Model description

The world economy consists of two identically modelled countries. The relative size of home country over the foreign country, in terms of number of households, is given by o_s. The foreign country variables will be denoted by a star. Unless specifically specified, derived equations hold equivalently in the starred version. Each country consists of two types of households.

2.1 Labour market

The labour market is modelled with search and matching frictions, where at the beginning of a period firms post vacancies v_t to recruit workers out of the beginning of period pool of unemployed u_t. New hires are given by the standard matching function $m_t = \xi_m v_t^{\xi} u_t^{1-\xi}$. Labour market tightness is defined as $\theta_t = \frac{v_t}{u_t}$, the probability to fill a vacancy as $q_t = \frac{m_t}{v_t} = \xi_m \theta_t^{\xi-1}$ and the probability to find a job when unemployed as $s_t = \frac{m_t}{u_t} = \xi_m \theta_t^{\xi}$. Workers from all households have equal characteristics on the labour market. Therefore, they face equal probabilities of finding a job, have equal employment rates n_t and equal wages w_t.

At the end of a period, only a fraction ρ keeps their job, the rest goes into unemployment and searches for a new job in the next period. The beginning of period unemployment is given by new and old unemployed, $u_t = (1-\rho)n_{t-1} + 1 - n_{t-1} = 1 - \rho n_{t-1}$. Employment dynamics is given by $n_t = \rho n_{t-1} + m_t$.

2.2 Households

A share o_c of households is unconstrained, while a share $1 - o_c$ of households is credit-constrained. Both types of households maximize the same intertemporal utility function $U_{i,t} = \sum_{j=0}^{\infty} \beta^{t+j} u(c_{i,t+j})$

for $i = [o, r]$, where β is the time discount factor and the period utility function $u(c_{i,t})$ is defined as $u(c_{i,t}) = \frac{(c_{i,t}-\eta_h c_{i,t-1})^{1-\sigma^i}}{1-\sigma^i}$, with η_h being habit persistence. $c_{i,t}$ is per household consumption. Optimization with respect to $c_{i,t}$ gives the marginal utility of consumption $\lambda_{i,t}$ for each type of household $i = [o, r]$:

$$\lambda_{i,t} = (c_{i,t} - \eta_h c_{i,t-1})^{-\sigma^i} - \beta\eta_h(c_{i,t+1} - \eta_h c_{i,t})^{-\sigma^i} \tag{1}$$

Households of each type pool their labour income across employed and unemployed members, so that total labour income is given by $w_t n_t + w_u(1 - n_t)$, where w_u is the replacement wage.[9] The optimal employment decision by households, subject to their budget constraint and the employment dynamics constraint $n_t = s_t + \rho n_{t-1}(1 - s_t)$, taking as given the aggregate job finding probability s_t, is given by

$$H_{i,t} = w_t - w_u + \beta E_t \left[\Lambda^i_{t,t+1}\rho\left(1 - s_{t+1}\right) H_{i,t+1}\right]. \tag{2}$$

H_i is the real value of a job to a household of type $i = [o, r]$, given by the Lagrange multiplier on the employment dynamics constraint (the utility value of a job) divided by the marginal utility of consumption. $\Lambda^i_{t,t+1} = \frac{\lambda_{i,t+1}}{\lambda_{i,t}}$ can differ for both types of households as their marginal utility of consumption can be different. Consequently, the value of a job H_i can differ for both households.

Credit constrained households are restricted to consume their labour income, thus facing the consumption function

$$c_{r,t} = w_t n_t + w_u(1 - n_t) \tag{3}$$

For simplicity, there is no capital in the economy considered. Unconstrained households receive firm's profits and can borrow or save using domestic bonds $B_{o,h,t}$ at the nominal interest rate R_t and foreign bonds $B_{o,f,t}$ at the nominal return $\phi_{e,t}R^*_t\mathcal{E}_t$ where $\mathcal{E}$ is the nominal exchange rate and ϕ_e a risk adjustment based on foreign bonds held by domestic households.[10] We also define the real exchange rate $Q_t = \mathcal{E}_t\frac{P_{t^*}}{P_t}$.

Optimizing with respect to $B_{o,h,t}$ and $B_{o,f,t}$ the f.o.c. are

$$\Lambda^o_{t,t+1} = \frac{1}{\beta}\frac{\pi_{t+1}}{R_{n,t}} \tag{4}$$

$$\frac{R_t}{\pi_{t+1}} = \phi_{e,t}\frac{R^*_t}{\pi^*_{t+1}}\frac{Q_{t+1}}{Q_t} \tag{5}$$

2.3 Firms

Perfectly competitive firms employ labour to produce primary output using a standard Cobb-Douglas production function $y_{w,t} = z_t n_t^\alpha$. Firms searching for workers face a vacancy posting cost κ. Each firm j maximizes profits w.r.t. labour $n_{j,t}$ and vacancy posting $v_{j,t}$, subject to its production function and the employment dynamics $n_{j,t} = \rho n_{j,t-1} + q_t v_{j,t}$, and taking as given the economy's labour market condition q_t. Since firms are symmetric, we present the aggregate first order conditions suppressing subscripts j:

$$J_t = \frac{\kappa}{q_t} \tag{6}$$

$$J_t = p_{w,t}a_{n,t} - w_t + \beta\rho E_t\left(\Lambda^o_{t,t+1}J_{t+1}\right) \tag{7}$$

[9] The rate os replacement is ω such that $w_u = \omega w$ with w the steady state value of the real wage.

[10] The risk adjustment is required to achieve determinacy of net foreign assets. It is defined as $\phi_{e,t} = \exp(\xi_a(\bar{B}_{o,f,t} - \frac{B_{o,f,t}}{P^*_{c,t}}))$.

where $p_{w,t}$ the real output price (in terms of the domestic price index), w_t is the real wage, J_t is the Lagrange multiplier on the employment dynamics constraint, and hence the marginal value of a worker to the firm, $\Lambda^o_{t,t+1}$ the unconstrained household discount factor as they own the firms and $a_{n,t} = z_t \alpha \frac{y_{w,t}}{n_t}$ is the marginal physical product of labour.

The firm sells output at the real output price $p_{w,t}$ to domestic and foreign wholesale firms. Domestic demand $y_{d,t}$ is made of domestic ($y_{h,t}$) and foreign ($y_{f,t}$) produced primary goods using the CES aggregation function $y_{d,t} = \left[\alpha_w^{\varsigma} y_{h,t}^{\frac{\varsigma-1}{\varsigma}} + (1-\alpha_w)^{\varsigma} y_{f,t}^{\frac{\varsigma-1}{\varsigma}}\right]^{\frac{\varsigma}{\varsigma-1}}$. The domestic real purchase price is $p_{h,t} = p_{w,t}$, while the real purchase price of foreign produced goods is $p_{f,t} = p^*_{w,t} Q_t$,[11]. The optimal quantities of domestic and foreign goods as a function of relative prices are given by

$$y_{h,t} = \alpha_w \left(\frac{p_t}{p_{h,t}}\right)^{\varsigma} y_{d,t} \tag{8}$$

$$y_{f,t} = (1-\alpha_w) \left(\frac{p_t}{p_{f,t}}\right)^{\varsigma} y_{d,t}, \tag{9}$$

where p_t is the real selling price of wholesale good firms. This price index is given by $p_t = \left[\alpha_w p_{h,t}^{1-\varsigma} + (1-\alpha_w) p_{f,t}^{1-\varsigma}\right]^{\frac{1}{1-\varsigma}}$

Repackaging firms purchase wholesale goods and sell them in monopolistic competition to final good firms. These in turn assemble repackaged goods using a Dixit-Stiglitz aggregator with a constant demand elasticity of substitution ϵ and sell them on the goods market. Due to finite demand elasticity, repackaging firms face a downward sloping demand curve and set their price at a mark-up over marginal cost. Hence, the real price p_t equals the real marginal cost of repackaging firms, while final output is given by $y_t = y_{w,t}$ in a zero inflation steady state without price distortion.

Repackaging firms are subject to Calvo price stickiness with a price reset probability of χ. This allows inflation dynamics, where the log-linearized inflation Philips curve is given by

$$\hat{\pi}_t = \beta \hat{\pi}_{t+1} + \zeta \hat{p}_t \tag{10}$$

where variables with a hat describe deviations from their steady state and where $\zeta = \frac{(1-\chi)(1-\beta\chi)}{\chi}$.

2.4 Labour market equilibrium

The labour market equilibrium is reached through Nash bargaining of the real bargained wage w_t^* by workers and firms over their respective surplus from a job using weight η_t for workers: $\max_{w_t^*} \left\{(H_t)^{\eta_t} (J_t)^{1-\eta_t}\right\}$. The bargaining solution implies $\eta_t J_t = (1-\eta_t) H_t$, where the aggregate worker surplus is given as a weighted average of the individual surpluses according to their share in the labour force, $H_t = o_c H_{o,t} + (1-o_c) H_{r,t}$. Inserting the respective functions of H and J into the bargaining solution yields the bargained wage

$$\begin{aligned} w_t^* =& \eta_t p_{w,t} a_{n,t} + (1-\eta_t) w_u + \eta_t \beta \rho \Lambda^o_{t,t+1} \frac{\kappa}{q_{t+1}} \\ & - (1-\eta_t) \beta \rho (1-s_{t+1}) \left[o_c \Lambda^o_{t,t+1} H_{o,t+1} + (1-o_c) \Lambda^r_{t,t+1} H_{r,t+1}\right] \end{aligned} \tag{11}$$

Hall (2005) demonstrates that real wage stickiness greatly improves the ability of a search and matching model to match empirical employment dynamics. For this reason, we follow him by utilizing the following wage rule

$$w_t = \rho_w w_{t-1} + (1-\rho_w) w_t^* \tag{12}$$

The actual wage is a weighted average between the Nash bargained wage and the past period's wage.

[11] In foreign, the price is $p^*_{f,t} = \frac{p_{w,t}}{Q_t}$

2.5 Resource constraint and policy

Aggregate consumption and the aggregate resource constraint (in terms of per household) are given by

$$c_t = o_c c_{o,t} + (1 - o_c) c_{r,t} \tag{13}$$

$$y_{d,t} = c_t + \kappa v_t \tag{14}$$

$$y_{w,t} = y_{h,t} + \frac{y^*_{f,t}}{o_s} \tag{15}$$

The government balances its budget at all times by levying a lump sum tax on unconstrained consumers, $\tau_{o,t} = w_u(1 - n_t)$ The monetary policy target interest rate $R_{p,t}$ is determined according to a Taylor rule

$$\frac{R_{p,t}}{R} = \left\{ \frac{R_{p,t-1}}{R} \right\}^{\phi_m} \left\{ \left(\frac{\pi_t}{\pi} \right)^{\phi_\pi} \left(\frac{y_t}{y} \right)^{\phi_y} \right\}^{1-\phi_m} \tag{16}$$

A lower zero bound (LZB) could be binding for policy. Thus, the actual nominal interest rate is given by $R_t = \max [R_{p,t}, 0]$

The real trade balance per domestic household (normalized by p_t) is then

$$tb_t = p_{h,t} \frac{y^*_{f,t}}{o_s} - p_{f,t} y_{f,t} \tag{17}$$

The domestic and foreign trade balance are related through $tb_t = -Q_t \frac{tb^*_t}{o_s}$.

International asset market equilibrium requires net foreign bond holdings to equal zero, meaning $B_{o,f,t} = -\frac{B^*_{o,h,t}}{o_s}$. Since foreign bonds are denominated in foreign currency, the stock of net foreign assets evolve according to

$$b_{o,f,t} = \frac{R^*_{t-1}}{\pi^*_t} b_{o,f,t-1} + \frac{tb_t}{Q_t} \tag{18}$$

3 Calibration

The model is calibrated at a quarterly frequency using the parameters in Table 1. The discount factor β is set to 0.992, which produces an annual interest rate of 3.2 percent. Risk aversion is identical for both households $\sigma^o = \sigma^r = 1$ generating a logarithmic utility function. The share of optimizing households is fixed at 50 percent in the baseline calibration in line with Galí et al. (2007) and Boscá et al. (2011). This is larger than Cogan et al. (2010), which estimate this share to be 26 percent in a model of fiscal policy using data for the US economy. Lastly, habit persistent is $\eta_h = 0.6$ in line with the estimation of Sala et al. (2008).

The calibration of the parameters related to the labour market is standard and follows Ravenna and Walsh (2008), which estimate their model to US data. The job surviving rate ρ, the employment rate n and the labour market tightness θ are set exogenously at 0.9, 0.95 and 0.5 respectively. The matching elasticities ξ is set at 0.5. This generates a parameter for matching efficiency ξ_m equal to 0.93 and a parameter for vacancy costs κ equal to 0.12. The implied job finding probability is also 0.65, which is both closely related to the value found by Ravenna and Walsh (2008) and within the interval of 0.06 and 0.91 estimated by Hobijn and Sahin (2009) based on 27 high income countries.

Table 1: Calibration: baseline model

Structural parameters		
Share of Optimizing Consumers	o_c	$0.5; 0.5$
Relative risk aversion parameters	$\sigma_o = \sigma_r$	$1; 1$
Discount factor	β	$0.992; 0.992$
Habit persistence	η_h	$0.6; 0.6$
Labour market parameters		
Exogenous job loss probability	$1 - \rho$	$0.1; 0.1$
Employment rate	n	$0.95; 0.95$
Labour market tightness	θ	$0.5; 0.5$
Matching elasticity	ξ	$0.5; 0.5$
Implied matching function parameter	ξ_m	$0.93; 0.93$
Implied employment adjustment cost	κ	$0.12; 0.12$
Implied job finding probability	s	$0.65; 0.65$
wage rigidity	ρ_w	$0.3; 0.3$
Production and Pricing parameters		
Output elasticity of labour	α	$0.7; 0.7$
Price mark-up	μ	$1.11; 1.11$
Price stickiness	χ	$0.8; 0.8$
Open Economy parameters		
Home bias in consumption	α_w	$0.75; 0.75$
Elasticity of substitution between home and foreign goods	ζ	$1.5; 1.5$
Relative size	o_s	$1; 1$
International risk premium slope	ξ_a	0.001
Policy parameters		
Replacement rate	ω	$0.9; 0.9$
Interest rate smoothing	ϕ_m	$0.7; 0.7$
Inflation response	ϕ_π	$1.7; 1.7$
Output response	ϕ_y	$0.2; 0.2$
Bargaining power	η	$0.5; 0.5$
Bargaining power auto-regressive coefficient	ρ_η	$0.9; 0.9$

The ability of the search and matching model to produce realistic employment fluctuations depends on the replacement value of workers ω. Hagedorn and Manovskii (2008) show that a high replacement ratio contributes to a better performance of search and matching model. Similarly, Gertler and Trigari (2009) estimate this value to be comprised between 0.72 and 0.98 depending on the presence of nominal wage stickiness. Christiano et al. (2011) also estimate this value to be 0.92. In this paper, the replacement income is set at an intermediate value of 0.9. Lastly, Gertler and Trigari (2009) argue that wage rigidities contribute to better performances of the search and matching model. For simplicity, we introduce real wage rigidities and set $\rho_w = 0.3$.

The production function has labour as a single factor input. The elasticity of output to labour α is 0.7, which generates a labour share of income of 0.62 in line with empirical evidences. Nominal price rigidities and the Taylor rule are calibrated following Sala et al. (2008) and Christiano et al. (2011). The mark-up is 11 percent at the steady state, which requires to set $\mu = 1.11$. The share of firms unable to reset the price optimally each period is 80 percent slightly inferior to the value found in Sala et al. (2008) (85%)

and Christiano et al. (2011) (88%). Interest rate inertia ϕ_m is 0.7, while the speed of reaction to inflation and the output gap is 1.7 and 0.2 respectively.

The elasticity of substitution between home and foreign goods ζ is crucial for the open economy block adjustment and therefore for the size of the competitiveness effect associated with lower labour costs. Estimating a two country DSGE for the US and EU, de Walque et al. (2005) set the elasticity of substitution to 1.97 in the Euro area and 1.16 in the US in the model without uncovered interest rate parity. The elasticity of substitution is respectively 3.01 in the Euro area and 1.74 in the US in the model with uncovered interest rate parity. The elasticity of substitution is calibrated at an intermediate value of 1.5. This value is in line with a large number of studies Bouakez and Rebei (2008), Smets and Wouters (2006), Dao (2013a), Coenen et al. (2008b) and Backus et al. (1994). Home bias in consumption α_w is set at 0.75 in the home country such that the share of total imports in GDP is 25 percent. Together with the relative size of the two country $o_s = 1$, we get the home bias in consumption in the foreign country $\alpha_w^* = (1 - o_s(1 - \alpha_w)) = 0.75$. The ratio of imports to GDP is also 25 percent in the foreign country. The slope of the risk premium function on net foreign assets is set at $\xi_a = 0.001$ to ensure that net foreign assets remain determinant in the simulation, but otherwise do not affect interest rates and hence the simulations.

Lastly, the bargaining power of workers η is 0.5 meets the Hosios conditions. The experiment studied in this paper is a decline in the bargaining power of workers. The size of the shock is such that the real wage declines on impact by 0.6 percentage point. Additionally, the persistence of the shock is 0.9.

4 Analytical investigation

This section derives an analytical solution of the model using a reduced form, purely forward looking model. There are neither habits ($\eta_h = 0$) nor wage rigidity ($\rho_w = 0$) and the interest rate rule is simply $R_t = \phi_\pi \pi_{t+1}$. Furthermore, all workers are rehired every period ($\rho = 0$), rendering the labour market equilibrium static.[12]

We assume that $y_d = y$ holds at the steady state. We assume further that a balanced trade steady state where import quantities equal under unit relative prices in both economies $(1 - \alpha_w)y = (1 - \alpha_w^*)y^*$ holds. This implies $\frac{p_f}{p_h} = 1$ and $Q = \frac{\mu^*}{\mu}$, but also that the ratio $o_s = (1 - \alpha_w^*)/(1 - \alpha_w)$ determines the relative size of the countries. Hence, when $\alpha_w > \alpha_w^*$, then home is larger than foreign, while $\alpha_w^* \to 1$ implies the small open economy case. The Appendix shows the derivation for the model's IS and AS curves:

$$\begin{aligned}\hat{y}_{w,t} =& \hat{y}_{w,t+1} + m_1 a_4 (1 + a_2^* a_5) \left(\hat{y}_{w,t}^* - \hat{y}_{w,t+1}^*\right) + m_1 a_1 \left[(1 - o_c) - a_4 a_5 \frac{\mu}{\alpha}\right] (\hat{\eta}_t - \hat{\eta}_{t+1}) \\ &+ m_1 a_4 a_5 (\phi_\pi^* - 1)\hat{\pi}_{t+1}^* - m_1 (\phi_\pi - 1)\left(a_4 a_5 + \frac{c}{y}\frac{o_c}{\sigma}\right)\hat{\pi}_{t+1} \qquad (19)\end{aligned}$$

$$\begin{aligned}\hat{y}_{w,t}^* =& \hat{y}_{w,t+1}^* + m_1^* a_4^* (1 + a_2 a_5) \left(\hat{y}_{w,t} - \hat{y}_{w,t+1}\right) + m_1^* a_1^* a_4^* a_5 \frac{\mu^*}{\alpha^*} (\hat{\eta}_t - \hat{\eta}_{t+1}) \\ &+ m_1^* a_4^* a_5 (\phi_\pi - 1)\hat{\pi}_{t+1} - m_1^* (\phi_\pi^* - 1)\left(a_4^* a_5 + \frac{c^*}{y^*}\frac{o_c^*}{\sigma^*}\right)\hat{\pi}_{t+1}^* \qquad (20)\end{aligned}$$

[12] This implies $u_t = 1$ and $m_t = s_t = n_t$. Additionally, we set $\xi = 0.5$, obtaining $q_t = \frac{1}{\xi_m^2 n_t}$ and $v_t = (\xi_m n_t)^2$.

$$\hat{\pi}_t = \beta\hat{\pi}_{t+1} + \zeta\alpha_w a_2 \hat{y}_{w,t} + \zeta(1-\alpha_w)a_2^*\hat{y}^*_{w,t} + \zeta(1-\alpha_w)\hat{Q}_t + \zeta\alpha_w\frac{\mu}{\alpha}a_1\hat{\eta}_t \tag{21}$$

$$\hat{\pi}^*_t = \beta^*\hat{\pi}^*_{t+1} + \zeta^*\alpha^*_w a_2^*\hat{y}^*_{w,t} + \zeta^*(1-\alpha^*_w)a_2\hat{y}_{w,t} - \zeta^*(1-\alpha^*_w)\hat{Q}_t + \zeta^*(1-\alpha^*_w)\frac{\mu}{\alpha}a_1\hat{\eta}_t \tag{22}$$

$$\hat{Q}_t = \hat{Q}_{t+1} + (\phi^*_\pi - 1)\hat{\pi}^*_{t+1} - (\phi_\pi - 1)\hat{\pi}_{t+1} \tag{23}$$

where,

$$\begin{aligned}
a_1 =& \frac{\eta}{1-\eta}\left(\frac{1}{\mu} - \omega\frac{wn}{y}\right)\\
a_2 =& \left(\frac{1-\alpha}{\alpha} + \frac{c_v\mu}{(\alpha)^2 y}\frac{1}{1-\eta}\right)\\
a_3 =& \frac{2c_v}{(\alpha)y} + \frac{1-o_c}{\alpha}\left[\frac{wn}{y}\left(1-\omega\frac{1-n}{n}\right) + \frac{\eta}{1-\eta}\frac{c_v}{y}\right]\\
a_4 =& \frac{1-\alpha_w}{\alpha_w + \alpha^*_w - 1}\\
a_5 =& \varsigma\alpha_w + \varsigma^*\alpha^*_w\\
m_1 =& \frac{1}{1 + a_4 + a_2 a_4 a_5 - a_3}
\end{aligned}$$

The definitions of the additional coefficients hold equivalently for the starred version. a_1 roughly represents the effect of bargaining power on wages. The term a_2 represents the effect of output on marginal cost. The term a_3 is a demand multiplier of output, which feeds first through higher vacancy posting costs and then through the effect of wages on rule of thumb consumer demand. The term a_4 represents the international demand linkage. The term a_5 captures the effect of the elasticity of substitution between domestic and foreign products. The term m_1 is the domestic output multiplier, which is larger than unity in the closed economy case ($a_4 = 0$), but can be below unity due to international demand leakages in the open economy case.

All endogenous variables of the model are forward looking jump variables, meaning that the current value of the variables are a function of the current value of the exogenous shock variable η_t. We apply the method of undetermined coefficients to solve the model, using the guess solution $\hat{y}_{w,t} = \gamma_1\hat{\eta}_t$, $\hat{y}^*_{w,t} = \gamma_2\hat{\eta}_t$, $\hat{\pi}_t = \gamma_3\hat{\eta}_t$ and $\hat{\pi}^*_t = \gamma_4\hat{\eta}_t$. Furthermore, we specify the autoregressive process $\hat{\eta}_t = \rho_\eta\hat{\eta}_{t-1}$, implying $\hat{y}_{w,t+1} = \rho_\eta\gamma_1\hat{\eta}_t$ and equivalents.

The solution for γ_1 and γ_2 is given by

$$\gamma_1 = \frac{a_1}{m_2 b_1}\left[c_0 + c_1 + a_4\frac{b^*_2}{b^*_1}c_2 - a_4 c_3\right] \tag{24}$$

$$\gamma_2 = \frac{a_1}{m_2 b^*_1}\left[a^*_4\frac{b_2}{b_1}(c_0 + c_1) + c_2 + a^*_4 c_3\right] \tag{25}$$

where

$$\begin{aligned}
b_1 =& \frac{1-\rho}{m_1} + a_2\frac{c}{y}\frac{o_c}{\sigma}\left(a_6\alpha_w(1-a_7) + a^*_6(1-\alpha^*_w)a_7\right) + a_2 a_4 a_5(1-a_7-a^*_7)\left(a_6\alpha_w - a^*_6(1-\alpha^*_w)\right)\\
b_2 =& (1-\rho)(1+a^*_2 a_5) + a^*_2 a_5(1-a_7-a^*_7)\left(a^*_6\alpha^*_w - a_6(1-\alpha_w)\right) - a^*_2\frac{a_7}{a_4}(1-\rho+a^*_6)\frac{c}{y}\frac{o_c}{\sigma}\\
a_6 =& (\phi_\pi - 1)\rho_\eta\frac{\zeta}{1-\beta\rho_\eta}\\
a_7 =& \frac{(1-\alpha_w)a_6}{1-\rho+(1-\alpha_w)a_6 + (1-\alpha^*_w)a^*_6}
\end{aligned}$$

$$
\begin{aligned}
m_2 =& 1 - a_4 \frac{b_2}{b_1} a_4^* \frac{b_2^*}{b_1^*} \\
c_0 =& (1 - o_c)(1 - \rho_\eta) \\
c_1 =& -\frac{\mu}{\alpha} \frac{c}{y} \frac{o_c}{\sigma} \left(a_6(1 - a_7)\alpha_w + a_6^* a_7 (1 - \alpha_w^*)\right) \\
c_2 =& -\frac{\mu}{\alpha} \frac{c^*}{y^*} \frac{o_c^*}{\sigma^*} \left(a_6 \alpha_w a_7^* + a_6^* (1 - \alpha_w^*)(1 - a_7^*)\right) \\
c_3 =& a_5 (1 - a_7 - a_7^*)(1 - \rho + a_6 \alpha_w - a_6^* (1 - \alpha_w^*)) \frac{\mu}{\alpha} \left(1 - a_4^* \frac{b_2^*}{b_1^*}\right)
\end{aligned}
$$

The term a_6 represents the reaction of the real interest rate to a marginal cost shock and plays a crucial role in determining the overall reaction of output. It can be seen that this parameter becomes very large as ρ_η approaches unity, while it is zero for $\rho_\eta = 0$. The term a_7 represents the effect of higher foreign inflation on domestic inflation through import prices. The term $(1 - a_7)$ is the real exchange rate muting effect on marginal cost. When inflation increases, the real interest rate goes up, which appreciates the currency, reduces cost of imports and hence diminishes the rise in inflation. This term is zero for the closed economy.

The term $1/b_1$ represents the output multiplier when the impact of higher production on marginal cost, inflation, the real interest rate, the real exchange rate and in turn export demand is taken into account. The part containing $\frac{c}{y} \frac{o_c}{\sigma}$ shows the net effect of higher domestic output on the net real exchange rate effect working through domestic and foreign inflation and the corresponding real interest rates. The part containing $a_2 a_4 a_5$ shows the direct relative price effect of higher domestic production cost on domestic and foreign demand for domestic products.

The term $a_4 \frac{b_2^*}{b_1^*} < 1$ represents the impact of a foreign demand effect on the domestic economy. The term b_2^* represents the demand multiplier of foreign output on domestic demand. This includes the direct effect (1), the effect of higher foreign output on foreign production cost and thus domestic competitiveness $(a_2^* a_5)$, the indirect effect through which higher foreign production cost depreciates the domestic real exchange rate and thereby increases competitiveness (the third term) and finally has the negative impact whereby higher import prices raises domestic inflation and the real interest rate, lowering demand. The combination of terms of b_1 and b_2 serves as a multiplier.

4.1 Discussion of model mechanics

The response of aggregate output to a decline in worker's bargaining power depends on the sign of the brackets in equations (24) and (25), while the terms in front of the brackets are multipliers. When the sign of the bracket is positive, then a fall in bargaining power will have a negative impact on output in the respective country.

Three main effects, given by the terms c_0, c_1, c_2 and c_3, determine the reaction of output in a country to a change in bargaining power in the home economy. First, there is the impact of a change in demand by home consumers, given by $c_0 + c_1$. Second, there is the impact of the change in demand by foreign consumers, given by c_2. Finally, there is the demand-switching effect from foreign to home, which is given by c_3. Its impact on a country's demand depends on the international demand linkage, a_4 (a_4^*). The foreign demand effect impacts home through the multiplier $a_4 b_2^* / b_1^*$, while the home demand effect impacts foreign through the equivalent multiplier. Each of these effects is discussed below.

Rule of thumb consumers induce a direct link from lower real wages to aggregate demand, captured by c_0. This effect increases with the share of rule of thumb consumers, but becomes smaller as the persistence of

the bargaining power shock increases. In fact, the positive demand effect from rule of thumb consumers earning more only occurs when unconstrained consumers do not cut their consumption by an equal amount. This happens when unconstrained consumers try to smooth their consumption in face of a temporary shock. In contrast, all demand adjustment to a permanent shock happens immediately, so that the presence of rule of thumb consumers makes no difference.

A fall in bargaining power lowers domestic real wages, marginal cost and hence inflation, which through exports also passes through to foreign inflation. Hence, the real interest rate in both countries falls, thereby raising demand by unconstrained consumers. Additionally, there is a more complex reaction due to the feedback from the real interest rate to the real exchange rate, to inflation and in turn to the real interest rate. However, this channel does not overturn the basic direction of the demand effect by optimizing consumers, which will increase following a fall in bargaining power. This is the standard effect in New-Keynesian models. The term c_1 represents this effect for home households, while the term c_2 represents it for foreign households.

The size of the interest rate pass-through effect is determined partly by the term $\frac{c}{y}\frac{o_c}{\sigma}$, hence by the share of unconstrained consumers and by their intertemporal elasticity of substitution. The main effect though is given by the term a_6 in equations (24) and (25). The smaller is a_6, the smaller is the positive reaction of demand to falling bargaining power. Besides the straightforward impact of the monetary policy reaction parameter ϕ_π, price stickiness and the persistence of the shock play a very important role. As price stickiness approaches very high values, the parameter ζ approaches zero. On the other hand, a_6 becomes very large as the persistence of the bargaining power shock approaches unity. Due to the forward looking nature of the New-Keynesian Philips curve a permanent deviation in marginal cost would imply a very large inflation reaction at time t.

The final channel is the demand-switching term c_3, whose sign is positive for any realistic calibration. It stems from the fact that a fall in bargaining power lowers the relative price of home goods, causing a substitution from foreign to home goods in both foreign and home. The actual impact on the countries depends on their openness a_4. This demand switching channel is a zero sum game, since $a_4 c_3 - \frac{1-\alpha_w}{1-\alpha_w^*} a_4^* c_3 = 0$.[13]

A special case occurs when countries are symmetric. The world output reaction in that case is given by

$$\gamma_1 + \gamma_2 = \frac{a_1}{m_2 b_1}\left(1 + a_4 \frac{b_2}{b_1}\right)\left((1-o_c)(1-\rho_\eta) - \frac{\mu}{\alpha}\frac{c}{y}\frac{o_c}{\sigma}a_6\right). \tag{26}$$

The last bracket in equation 26 represents also the closed economy effect, while the other terms are open economy multipliers. Hence world output increases whenever the supply side channel working through marginal cost and inflation is stronger than the direct demand channel of rule of thumb consumers. This analysis has been conducted in Charpe and Kühn (2012).

The following sections provide some numerical examples for the analytical solution. To this aim, the parameters are calibrated largely to the baseline values shown in Table 1. Since the reduced model has less rigidities, the price stickiness parameter is increased to $\chi = 0.85$. In all cases, bargaining power falls in the home economy, while there is no exogenous change in the foreign economy. The focus of the analysis lies in the size of γ_1 and γ_2 in equations (24) and (25) as well as their components, which

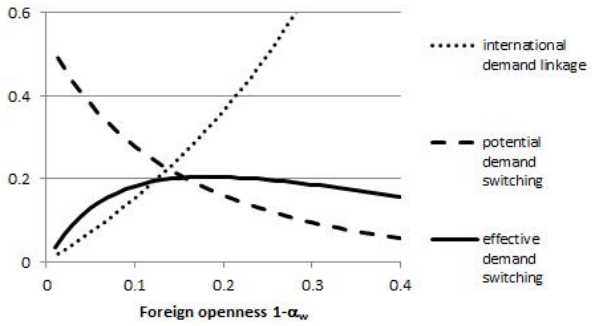
[13] The impact on foreign output is rescaled by relative output $\frac{y}{y^*} = \frac{1-\alpha_w^*}{1-\alpha_w}$ to show this result.

represent the multiplier impact on home and foreign GDP, respectively, to a percentage point drop in bargaining power.[14]

4.2 The demand switching effect

The main focus of this paper is whether a beggar-thy-neighbour effect follows falling wages in a country. An important component is the size of the demand switching effect, which is investigated in this section. It depends both on the extent of demand switching and on the impact this has on the economy. For example, when the foreign country is very large compared to home, then foreign output will remain unaffected despite potentially large demand switching by home consumers. Figure 1 graphically shows the potential demand switching effect (corresponding to c_3 in eq 24), the international demand linkage (corresponding to a_4 in eq 24) and the resulting impact of demand switching on the foreign economy in dependence of its openness, where the home economy has an openness of $1 - \alpha_w = 0.25$. In fact, due to how the model is calibrated, higher openness in the figure is equivalent to a smaller foreign economy relative to the home economy.

Figure 1: International demand switching and country size



The figure decomposes the effective demand switching effect, dependent on foreign openness, using the baseline calibration. It is the product of the pass-through and the basic size of demand switching.

Figure 1 shows that potential demand switching is falling with foreign openness. The reason is that when home is smaller, foreign's supply and demand conditions are less impacted by demand switching, thereby keeping the inflation and the interest rate unchanged. In contrast, when foreign is small relative to home (large openness), then demand switching causes a strong reaction in foreign's prices and interest rate, and hence also the real exchange rate, limiting demand switching.

On the other hand, the pass-through effect strictly rises with the openness of the home economy, because exports and imports from home contribute a larger share to foreign total output. The final demand switching effect is the product of the two curves and represented by the solid line. It increases with relative size up to a turning point and then falls. The turning point depends on all of the model parameters, but is actually below the point of equal country size, at $\alpha_w^* = 0.82$ while $\alpha_w = 0.75$. It implies that a larger country will be more negatively affected by demand switching than a smaller country, unless it is beyond the turning point where it engages in only little trade with the country experiencing falling bargaining power.

[14] Since the analysis is only illustrative, the scale of the impact is not important in itself.

4.3 Sensitivity discussion

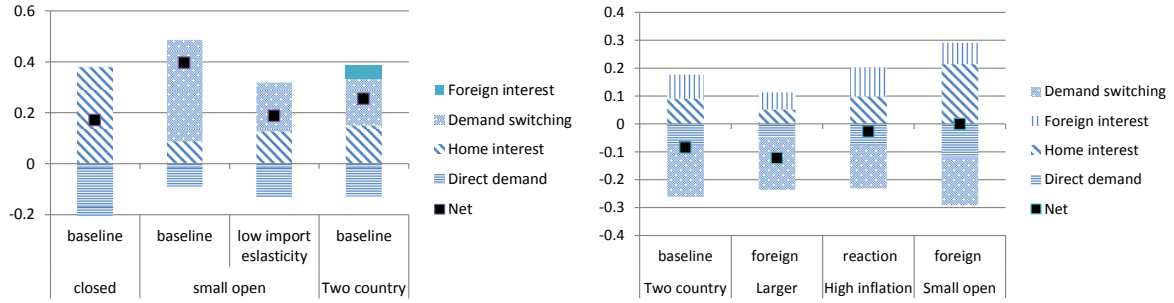
This section discusses the parameter sensitivity surrounding the impact of a bargaining power shock on the aggregate economy, focusing on open economy parameters. The figures show a decomposition of the overall impact into four components. The direct demand effect stemming from lower wages; the interest rate effect impacting demand of optimizing consumers in both the domestic and the foreign country; and the demand switching effect. The direct demand effect and the home interest effect represent a change in demand by home consumers, which affects foreign economy through the international demand linkage, while the foreign interest effect functions vice versa. The demand switching effect was described in the previous section.

Charpe and Kühn (2012) extensively discuss the parameter sensitivity around a bargaining shock in a closed economy. Aggregate output falls more in response to a fall in bargaining when the share of credit-constrained consumers is larger, when the persistence of the shock is lower, when price stickiness is larger and when the monetary policy reaction to inflation is lower. These parameter sensitivities also hold in the open economy case for both countries. Consequently, changes in these parameters will not be investigated.

Figure 2(a) decomposes the impact of lower bargaining power into its various components for a number of cases. In the closed economy case, there is only the direct demand effect of lower wages pushing down demand, which is countered by the interest rate effect due to lower inflation, pushing up demand. In the calibration presented here, the interest rate effect is stronger. However, Charpe and Kühn (2012) show that the opposite can hold when there is a liquidity trap or expectations about shock persistence adjust slowly.

Figure 2: Sensitivity analysis

(a) Sensitivity on home output change decomposition (b) Sensitivity on foreign output change decomposition



Subfigure (a) decomposes the channels through which a fall in bargaining power affects home output. Subfigure (b) decomposes the channels through which a fall in bargaining power affects foreign output.

The small open economy case assumes $\alpha_w^* = 0.9999$, implying that the foreign economy is essentially unaffected by home. Consequently, home can export and import any quantity desired. Both the direct demand effect and the interest rate effect are greatly diminished. First, the open economy demand multiplier is reduced due to export leakages. Second, the inflationary impact, and hence the interest rate effect, is reduced since foreign prices remain unchanged. In contrast, the lowered interest rate depreciates the real exchange rate, raising export and lowering import demand. This effect is shown as demand switching, since it represents a pure shift of demand. When the import elasticity of substitution is lower ($\varsigma = 0.5$) import and export demand change less and the demand switching effect diminishes. However, the domestic demand effects are stronger since the open economy leakages diminish.

The two country case in Figure 2(a) presents the baseline calibration of symmetric countries. Consequently, the fall in bargaining power in home also has an impact on the foreign economy. Specifically, it will lower its inflation and interest rate, which in turn creates a positive demand effect. This, in turn, raises demand for home output, labelled foreign interest effect in the Figure 2(a). However, since home impacts foreign, the demand switching effect is reduced. Furthermore, the domestic direct and interest rate demand effect are reinforced compared to the small open economy case, again due to a larger output multiplier.

Figure 2(b) decomposes the impact of a fall in bargaining power in home on the foreign economy. The baseline represents the symmetric two large country case. The foreign economy is also directly negatively affected by the direct demand effect in home due to lower wages since home's import demand falls. This is countered by heightened foreign export demand due to home's interest rate effect. Additionally, foreign inflation falls, creating an interest rate effect, also raising demand. Finally, there is the negative demand switching effect. Overall, the baseline calibration predicts a sizable beggar-thy-neighbour effect from lower home bargaining power.

The second scenario shows the impact when foreign is around twice as large as home, having $\alpha_w^* = 0.87$. First, the international demand linkage impact of the change in consumption demand by home consumers is diminished. Second, the inflationary impact is reduced, as shown by the lower foreign interest effect. In contrast, in line with the previous section, the negative demand switching effect increases slightly. Consequently, when home is somewhat smaller than foreign the prosper-thy-neighbour channel is reduced while the beggar-thy-neighbour channel remains important. It is only when foreign becomes very large that the latter channel also disappears.

A third scenario investigates the case where foreign monetary policy is more responsive to inflation, setting $\phi_\pi^* = 2.3$. This causes a stronger fall in the foreign real interest rate, directly enhancing the foreign interest channel. Furthermore, the real exchange rate appreciation is reduced as well, lowering demand switching. Overall, the foreign country experiences less output fall when its interest rate reacts more strongly.

A final scenario investigates a small open economy that benefits from another country's bargaining power change. In this scenario home experiences the demand reaction shown in the closed economy case in Figure 2(a). The effects described above are passed through to foreign to the extent of its openness. Additionally, foreign experiences an interest rate and a demand switching effect similar to the baseline scenario, despite the fact that it is much smaller. Since the aggregate demand effect in the large home economy is positive, the overall impact on foreign is higher than in the symmetric two-country case, removing almost entirely a beggar-thy-neighbour effect.

5 Simulation

The experiment implemented in this section is a drop in the bargaining power of workers η in the home country, which generates a decline of real wages by 0.6 percentage point. This decline corresponds to the weighted average drop in real monthly wages of employees in developed economies in 2011 during the Great Recession. The figures for output, consumption and investment are in percentage point deviation with respect to GDP.[15] The figures for employment and inflation are in annualized percentage change.

[15] GDP is normalized to one at the steady state.

5.1 Recap of the main transmission channels

This section describes some mechanisms that are common to all the numerical simulations described below. In all scenarios, a fall in home bargaining power reduces home nominal and real wages. Home competitiveness is determined by two factors. First, the price of home output falls with lower labour cost. This fall is similar in all scenarios as the fall in bargaining power is always the same. Second, foreign prices rise (fall) when the real exchange rate depreciates (appreciates). However, the former effect always dominates, even in scenarios where a real exchange rate appreciation occurs, so that home output gains competitiveness.

Exports of each country are determined by competitiveness and demand. In all presented scenarios, home exports increase while foreign's fall. The scenarios differ to the extent that foreign exports fall. For instance, a strong rise of home's and a small fall of foreign exports occur when world demand increases significantly. The trade balance shows the difference between home and foreign exports, where price changes are taken into account. For instance, a real depreciation raises the cost of imports, and hence deteriorates the trade balance.

Lower real wages lower the real price of home produced goods, which tends to reduce home CPI inflation, and to the degree of imported inflation also the one of foreign. As a consequence, the central bank reduces the interest rate, so that the real rate falls, although rate smoothing might imply an initial short-lived increase of the real interest rate. In general, the home interest rate falls more than the foreign one since home inflation is much more affected. In addition to inflation, the central bank adjusts the interest rate to output. In scenarios where home output increases clearly, the home real interest rate is hence not falling as much as when there is no output increase, given an inflation rate.

The change in the real exchange rate is given by the real interest rate parity. The rate is monotonically decreasing when the domestic real interest rate is always lower than the foreign real interest rate. Since in the long run the real exchange rate has to return to zero in a DSGE model, it has to depreciate on impact.

Section 4 showed that the impact on output will be given by the sum of four components. Domestic consumption demand falls due to the direct demand effect stemming from lower wages, but rises due to a lower domestic real interest rate. Both of these channels affect home's demand for domestic and imported products. Next, foreign consumption demand can change due to the foreign interest rate falling. Finally, there is demand switching from foreign to home products due to the gain in competitiveness. The balance of these four effects determines the simulated response of output. Employment follows output closely, as it is the variable factor of production in the model.

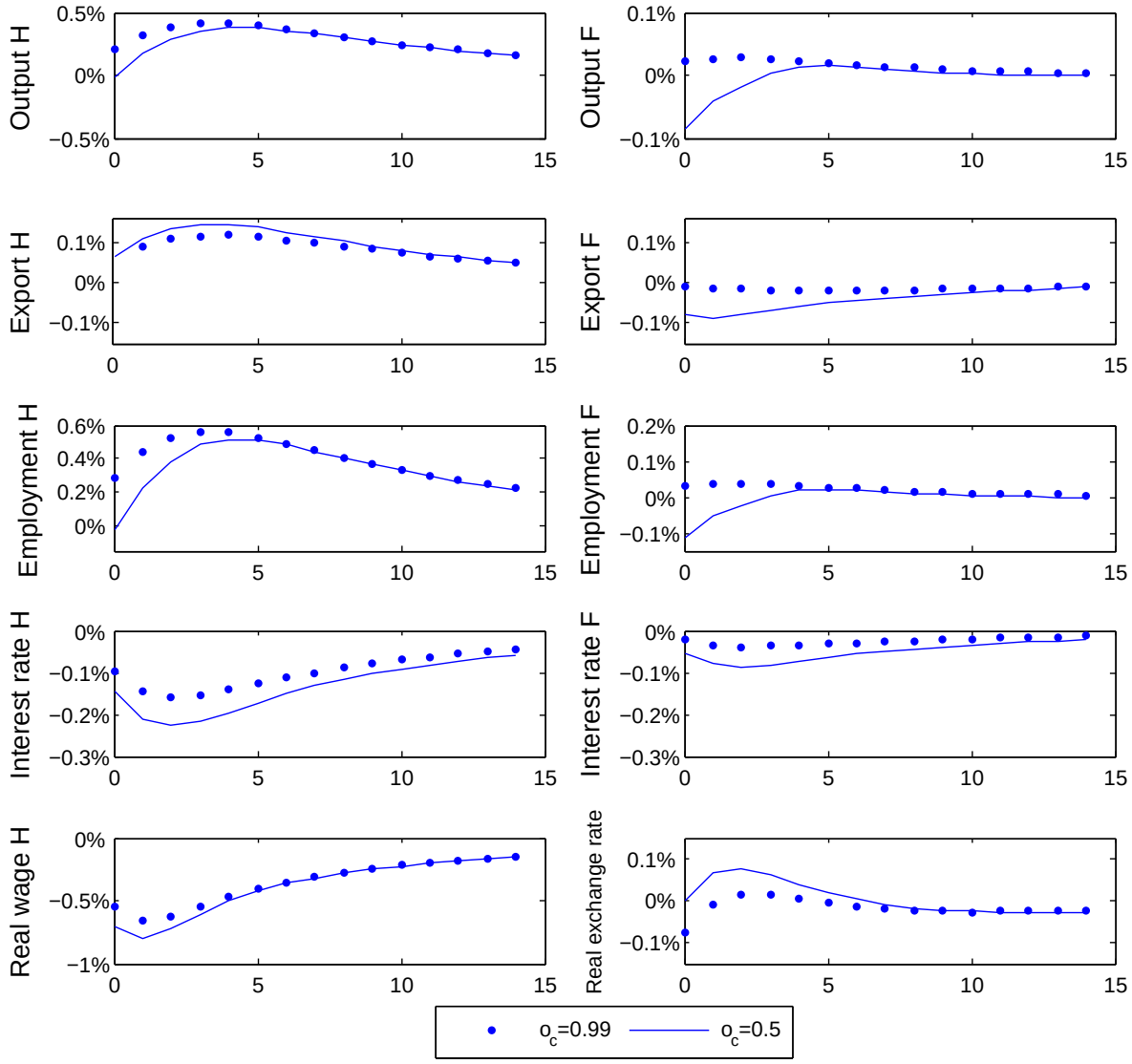
5.2 Rule of thumb households

The first set of simulation in Figure 3 illustrates the impact on output and employment of a negative shock on the bargaining power of workers under two assumptions regarding the relative size of rule-of-thumb households. In the first case, there are only optimizing households $o_c = 0.99$ (dotted-line). In the second case, the share of rule-of-thumb household is $o_c = 0.5$ (solid line). All remaining parameters are calibrated following Table 1.

In the absence of rule-of-thumb households a decline in the bargaining power of worker in the home country leads to an increase in output in both the home country and the foreign country. Output in the home country increases by 0.21 percentage point on impact and reaches a maximum of 0.41 percentage

point after 4 quarters. Both demand by domestic consumers as well as export demand increases. The interest rate, being the only channel to affect domestic demand, falls by 0.1 per cent on impact, while inflation drops by 0.23 percent on impact. The real exchange rate appreciates on impact but then depreciates, contributing to the competitiveness of the home country. The appreciation of the real exchange rate on impact is associated with interest rate inertia, which slows down the reaction of the interest rate to inflation.

Figure 3: New-Keynesian model and RoT model



The decline in the bargaining power of workers in the home country also increases output in the foreign country by 0.02 percentage point on impact. The increase in the foreign output is relatively smaller (approximately 1 tenth) than that of the home country. The size of the transmission channel is explained by both large home bias and moderate elasticity of substitution between domestic and foreign goods. However, this transmission channel is in line with the literature on two country DSGE model such as Dao (2013b). The output in the foreign country reacts positively despite the ambivalent transmission channels associated with lower labour costs in the home country. The foreign country is relatively less competitive than the home country and witnesses a deterioration in the trade balance, although export demand

is supported by higher overall home demand. Contrastingly, lower import prices leads to a decline in inflation in the foreign country. This leads to lower interest rate and to an expansion of demand in the foreign country.

In the absence of rule-of-thumb households, the two international spill-overs go into opposite directions. Although the positive (demand spillover) channel out-weighs the negative (competitiveness) channel in the present calibration, question arises whether the overall effect in the foreign country could turn negative under a calibration that would reduce the size of the imported inflation. This case is discussed in section 5.3 further below.

In the presence of rule-of-thumb households $o_c = 0.5$, output also reacts positively in the home country but with a delay compared to the previous case. The output reaction is zero on impact and reaches 0.38 percentage point after 5 quarters. This absence of an adjustment on impact is due to the ambivalent effects generated by the interaction between lower labour incomes and rule-of-thumb households. In the presence of rule-of-thumb households, a change in income distribution is translated into lower aggregate consumption decisions if the relative size of the population is large enough. This effect tends to limit the positive effects described above namely the vacancy positing effect, the monetary policy effect and the competitiveness effect.

In the presence of rule-of-thumb households, the drop in real wages in the home country has a lasting negative effect on the foreign economy. Output declines on impact by -0.08 percentage point and stays negative for 3 quarters. Similarly employment drops by -0.11 percentage point on impact and recovers after 4 quarters. The main reason is that rule-of-thumb households reduce the size of the demand spillover effect, while the competitiveness effect is strengthened. Consequently, foreign exports fall significantly, thereby overcoming the positive demand effect from a lowered real interest rate and reducing overall output. The negative shock on the bargaining power of workers in the home country has a beggar-thy-neighbour effect on the foreign country. Eventually, the economy recovers as the Central Bank lowers the interest rate as both the output gap and the inflation gap are negative.

5.3 New-Keynesian model: Beggar-thy-neighbour without rule-of-thumb households?

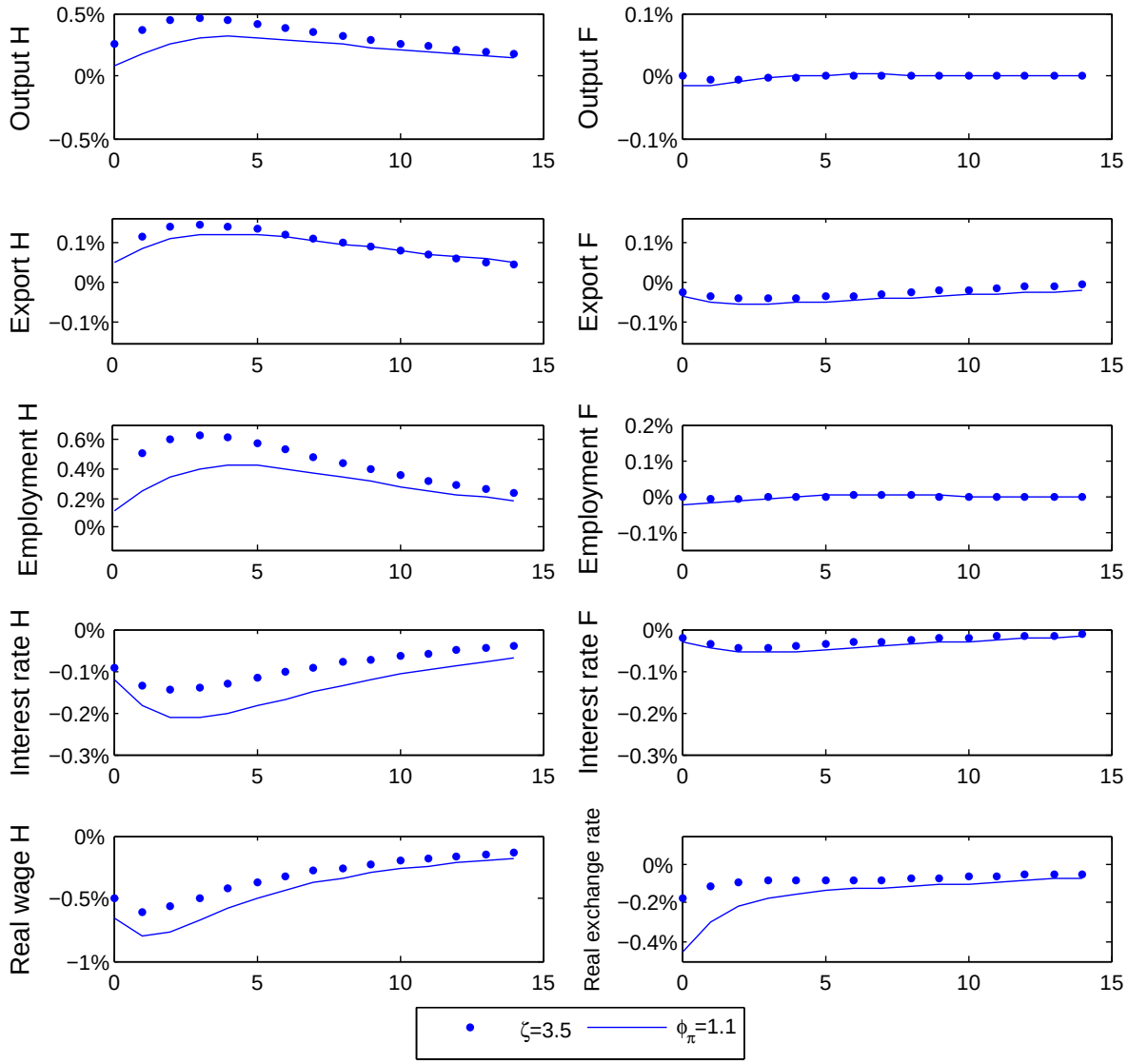
Section 5.2 highlighted that there is no beggar-thy-neighbour effect in a model without rule-of-thumb households and for the calibration presented in Table 1. This conclusion was drawn as the negative competitiveness effect is overbalanced by a positive demand spillover effect. This section enquires whether a beggar-thy-neighbour effect can be generated if the substitution between domestic and foreign goods is increased from $\zeta = 1.5$ to $\zeta = 3.5$ or if monetary policy is less reactive to inflation dynamic $\phi_\pi = \phi^*_{\pi^*} = 1.1$.

The dotted line in Figure 4 displays the reaction of output in the foreign country in the absence of rule-of-thumb households $o_c = 0.99$ and in the presence of high substitution between domestic and foreign goods $\zeta = 3.5$. While output in the foreign country reacts positively in the New-Keynesian case (+0.02 percentage point increase at peak), output does not react at best or is slightly negative (-0.0067 percentage point decline at trough). The main reason is a widening trade deficit. Exports from the home country to the foreign country now increase from 0.12 percentage point to 0.14 percentage point at peak. The strengthened demand switching effect conceals the positive demand spillover effect.

The solid line in Figure 4 illustrates the reaction of the foreign economy when monetary policy in both countries reacts slowly to inflation dynamic $\phi_\pi = \phi^*_{\pi^*} = 1.1$ (keeping $o_c = 0.99$ and $\zeta = 1.5$). The slow

reaction of monetary policy reduces the size of the imported inflation / monetary policy channel. Output in the foreign country now declines by -0.017 percentage point on impact and remains negative for 5 periods. Contrastingly, the real exchange rate appreciates in the home country because the monetary authority, balancing lower inflation and higher output in its interest rate setting, lowers the real interest rate much less than in the baseline scenario. As a result, the real interest rate in the home country will be higher than that of foreign, which leads to a real exchange rate appreciation.

Figure 4: Beggar-thy-neighbour without rule-of-thumb households?

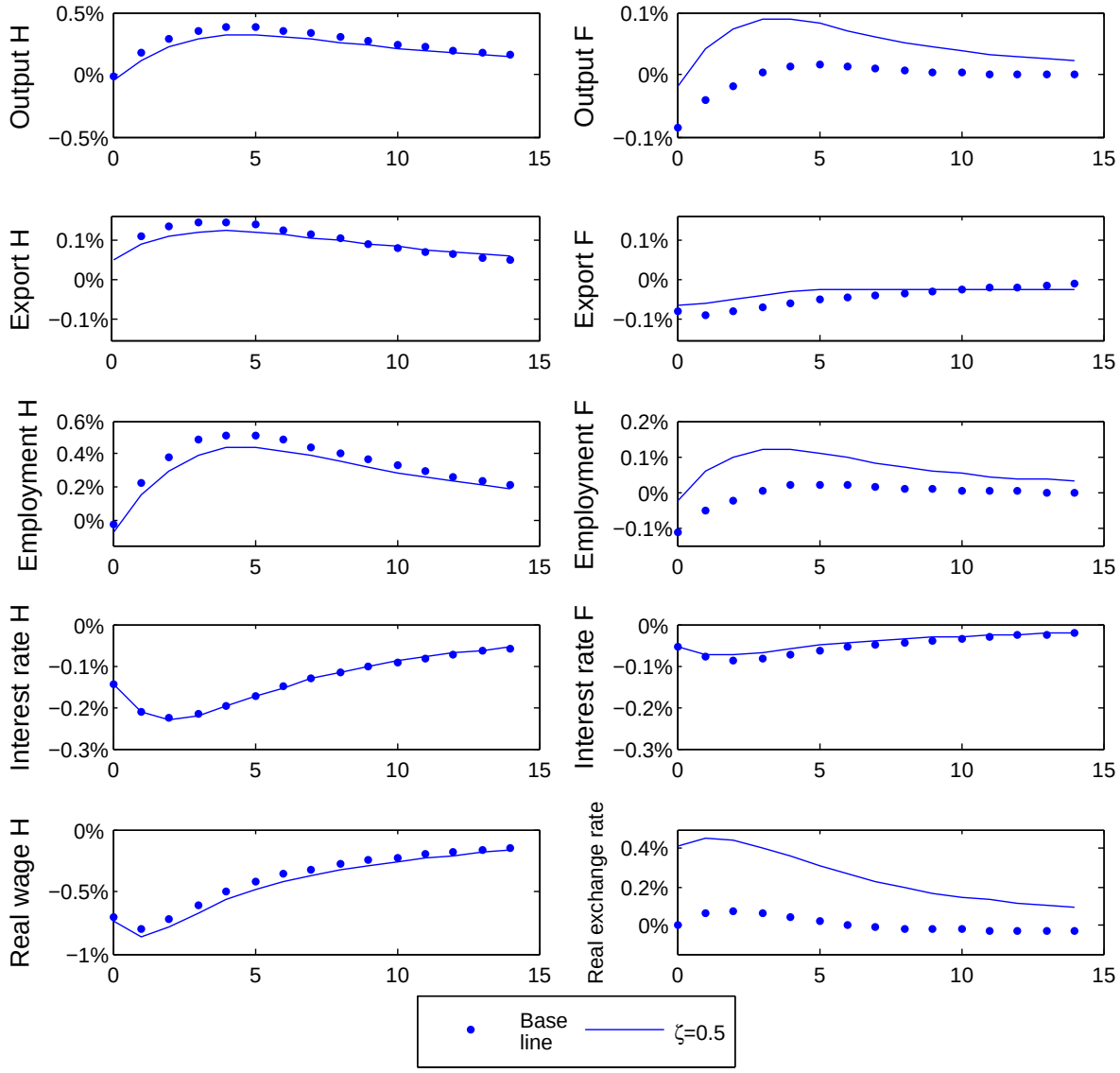


These two experiments show that in the absence of rule-of-thumb households there are alternative calibrations of the model that balance out the positive and negative international spill-overs to the foreign country. It seems however that the calibration would need to be stretched-out to produce a significant beggar-thy-neighbour effect.

5.4 Sensitivity analysis of the model with rule-of-thumb: External sector

This subsection discusses the size of the beggar-thy-neighbour effect depending on the calibration of the two main parameters driving the reaction of the external sector and the trade balance in particular: the elasticity of substitution between home goods and foreign goods ζ as well as home bias α_w.

Figure 5: Sensitivity to elasticity of substitution $\zeta = 0.5$

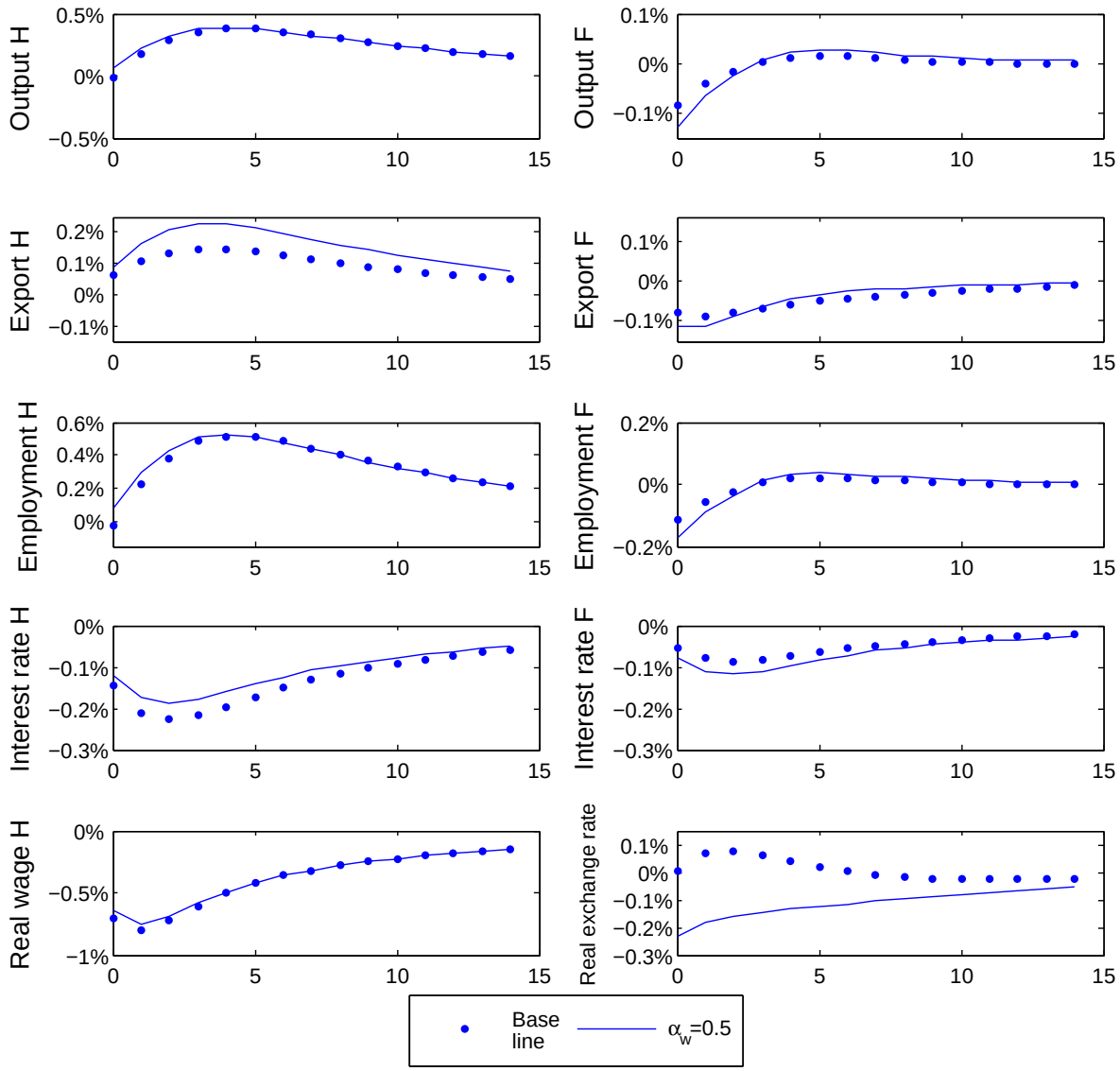


The solid line in Figure 5 illustrates the behaviour of the model corresponding to a lower elasticity of substitution between home and foreign goods $\zeta = \zeta^* = 0.5$. Contrastingly to the baseline calibration, the positive effects on the home country and the negative effects on the foreign country are both smaller in magnitude. In the foreign country especially, output reacts positively reaching 0.09 percentage point after five quarters. A lower elasticity of substitution between home and foreign goods reduces the size of the competitiveness effect as the choice of the consumption basket is less dependant on relative prices. It follows that the trade deficit of the foreign country is reduced. The real exchange rate depreciates

significantly by 0.4 percentage point, increasing the relative price spread compared to the baseline scenario so that the world relative demand and supply match.

Figures 6 illustrate the international spill-overs associated with a reduction in the real wage when home bias is reduced to 0.5 down from 0.75. This implies that both economies have a larger degree of openness. This increases the strength of the competitiveness effect as the relative demand for consumption goods is weighted by home bias. Exports from the home country are larger while exports from the foreign countries are lower. Output in the foreign country drops by 0.13 percentage point on impact.

Figure 6: Sensitivity to home bias $\alpha_w = 0.5$

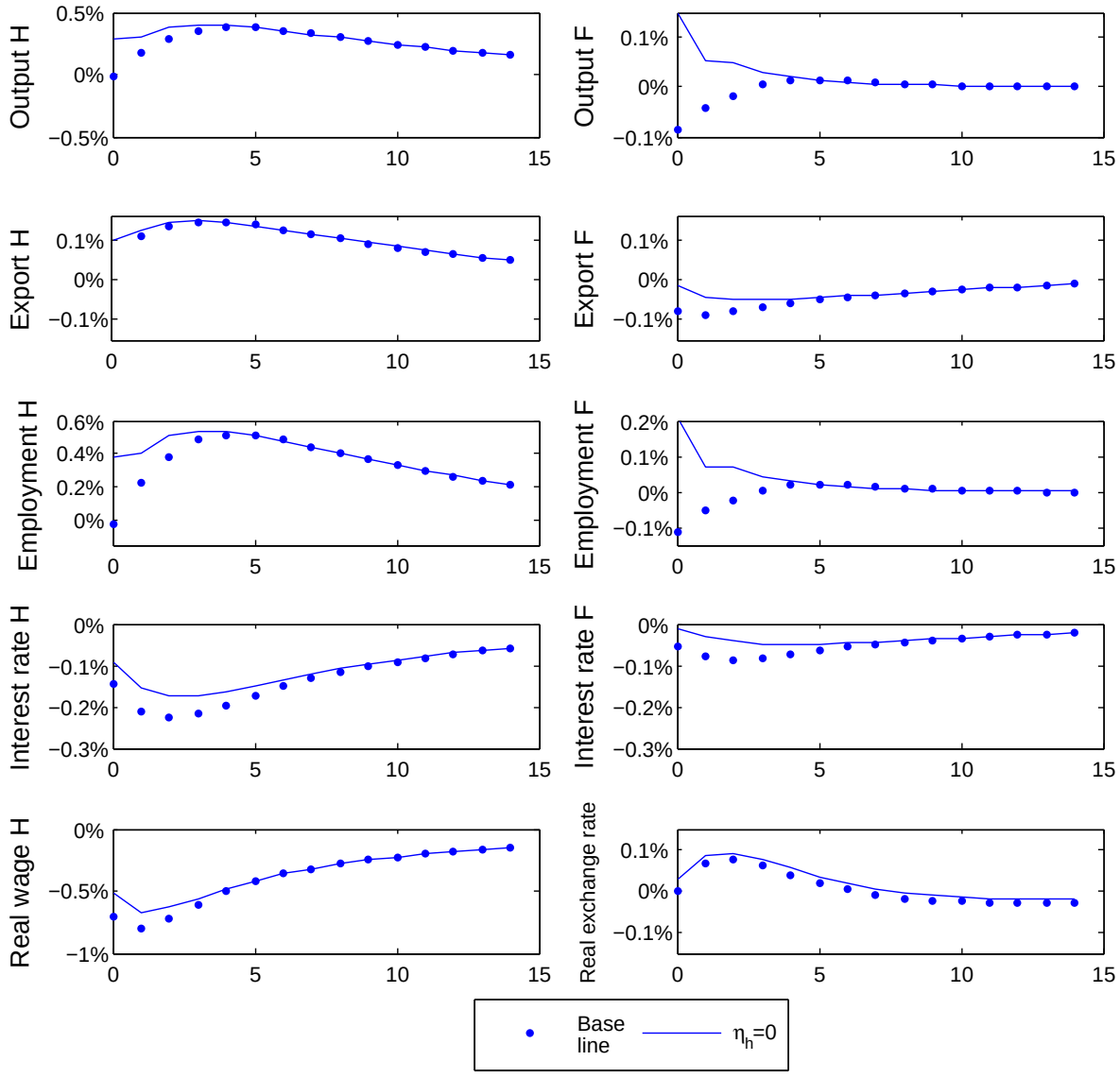


In line with the previous scenario, but in the opposite direction, the real exchange rate appreciates in the wake of the stronger competitiveness channel so as to reduce the relative price spread between home and foreign products. Openness also implies a larger imported inflation effect in the foreign country. The interest rate drops relatively more for $\alpha_w = 0.5$.

5.5 Sensitivity analysis of the model with rule-of-thumb: Habits and Calvo prices

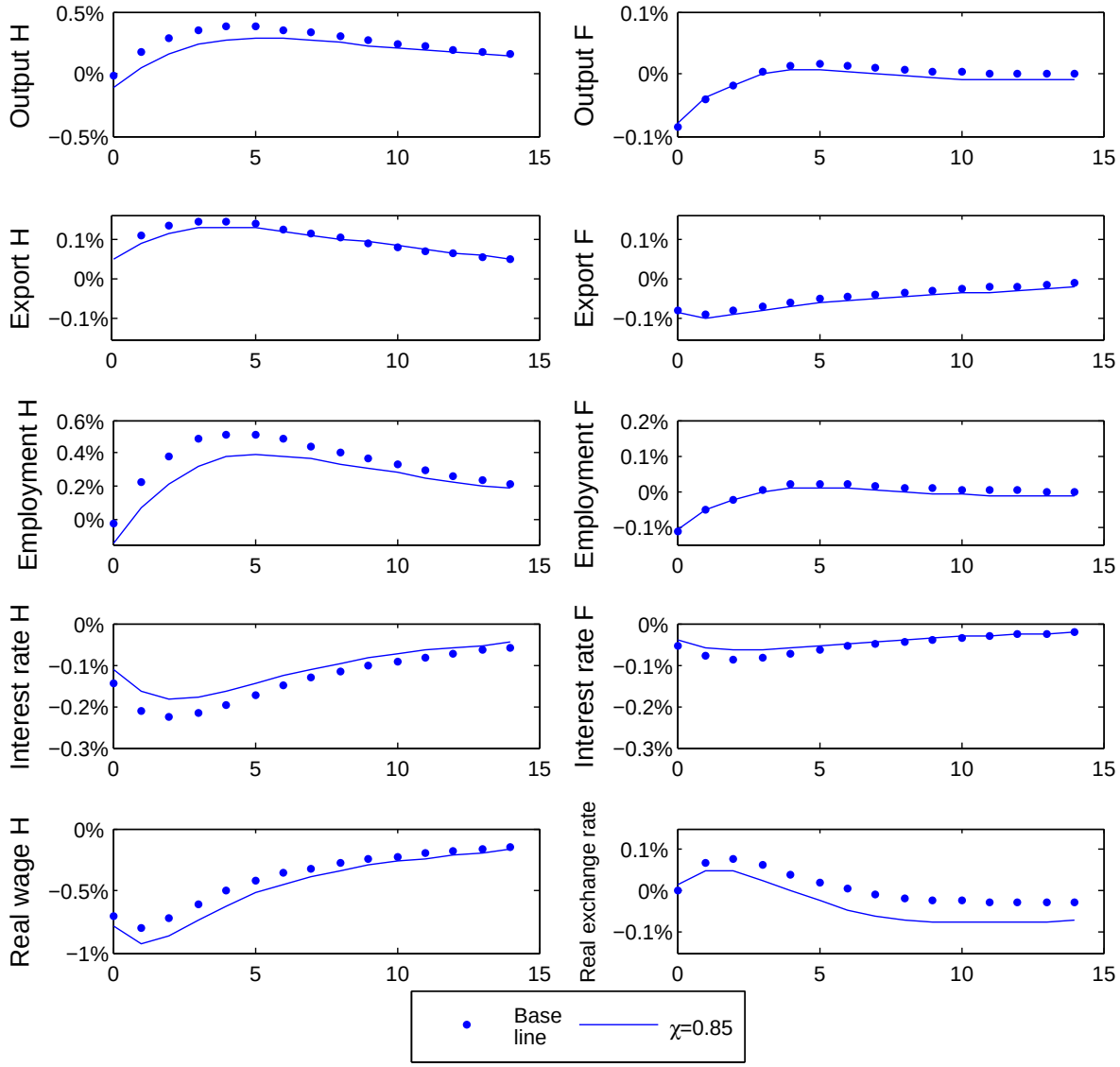
Figures 7 illustrates the importance of habit formation in consumption for the reaction of consumption decisions following a decline in the bargaining power of workers. Reducing η_h from 0.6 to 0 leads to a positive outcome in both the home and the foreign countries. Output increases by 0.28 percentage point in the home country and 0.16 percentage point in the foreign country. In the absence of habit in consumption, optimizing households revise their consumption upwards at a faster speed. Consumption decisions are more sensitive to the decline in the interest rate. This mechanism takes place in both countries. Higher consumption of optimizing households is reflected into higher domestic demand which increases by 0.19 percentage point in the home country and 0.17 percentage point in the foreign country.

Figure 7: Sensitivity to consumption habit formation $\eta_h = 0$



In Figure 8, the share of firms, which cannot set their price optimally in response to the negative cost shock is increased from 80 percent to 85 percent. Consequently, price inflation at home is -0.2 percent compared to -0.3 percent previously. This tends to weaken the home interest rate channel that increases demand, so that output declines by -0.11 percent on impact. The effects on the foreign country are however small, since a lower demand spillover is balanced by smaller real exchange rate depreciation.

Figure 8: Sensitivity to price stickiness $\chi = 0.85$

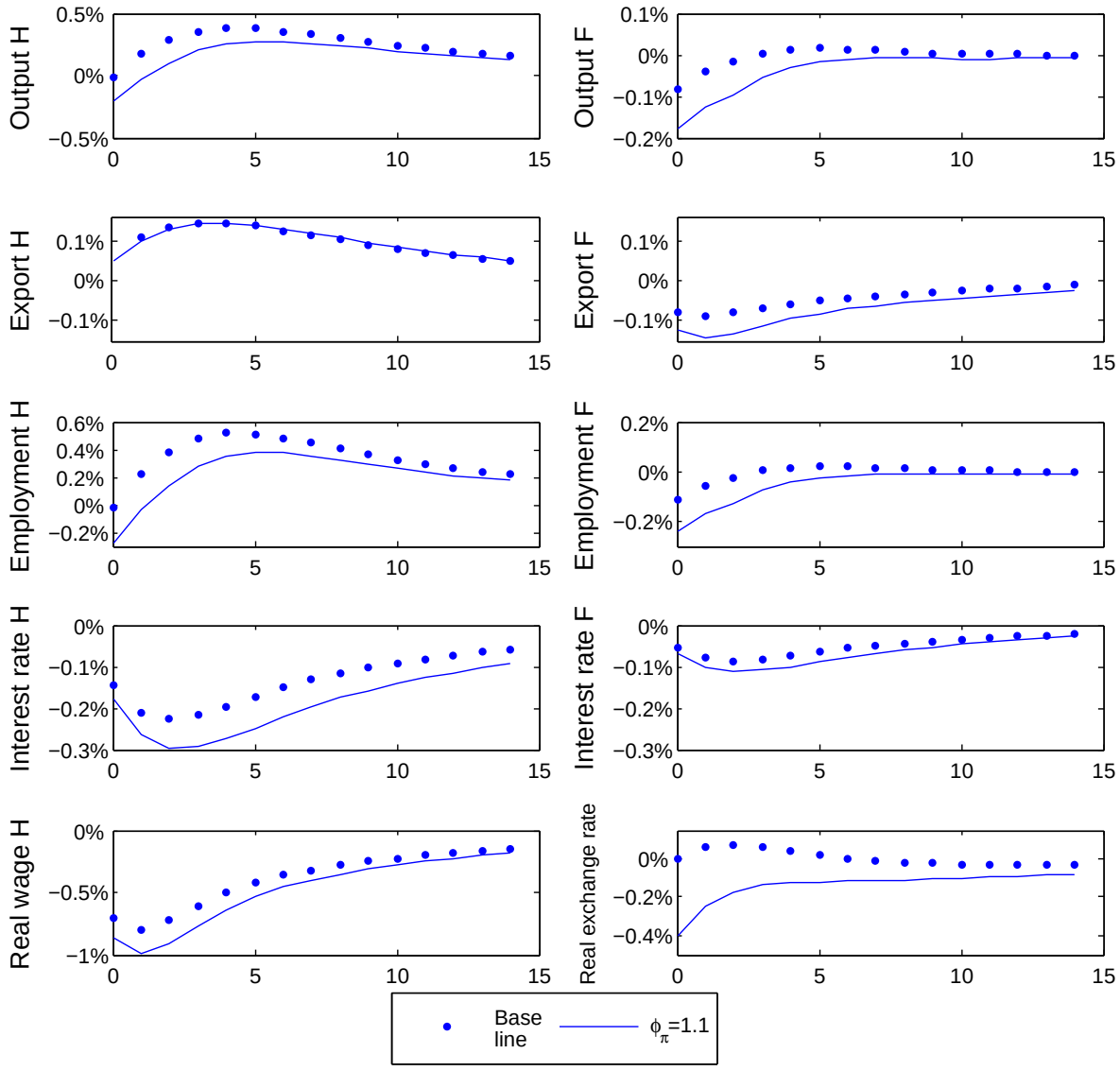


5.6 Sensitivity analysis of the model with rule-of-thumb: Monetary policy

This section discusses the existence of a beggar-thy-neighbour effect for different calibration of monetary policy. The role of the Central Bank is crucial in this respect as the adjustment in the interest rate affects the adjustment in the real exchange rate through the uncovered interest rate parity as well as the consumption decisions of optimizing households.

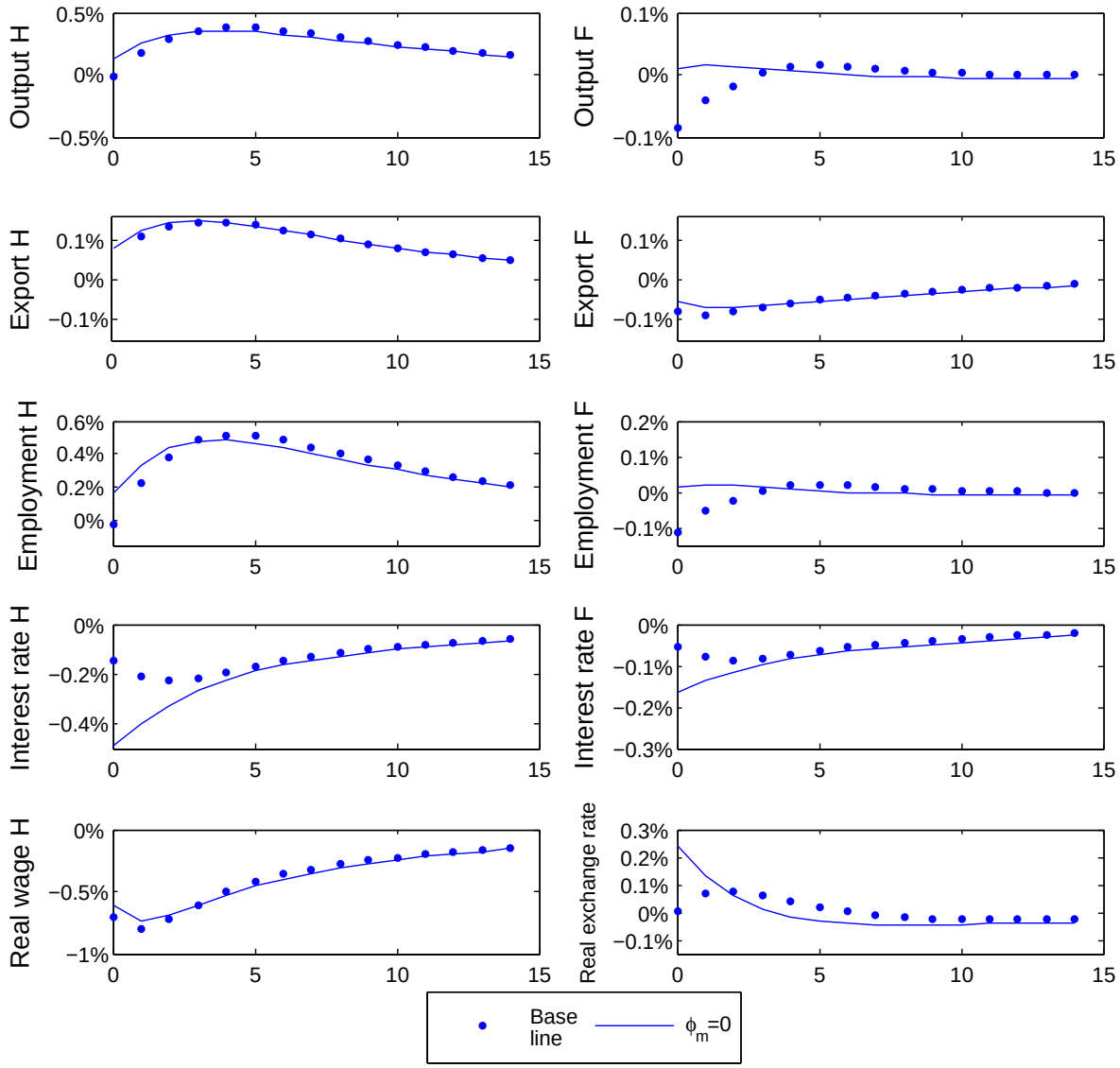
In Figure 9, the calibration of the Taylor rule is modified to lower the speed of reaction of the Central Bank to changes in inflation with $\phi_\pi = \phi^*_{\pi^*} = 1.1$ down from 1.7. Output in the home country declines on impact by -0.21 percentage point and stays negative for 2 quarters. In the foreign country, output declines by -0.18 percentage points on impact and stays negative for 15 quarters. The real exchange rate appreciates similar to section 5.3. This underlines that the beggar-thy-neighbour effect is strengthened when the Central Bank reacts relatively slowly to price inflation. The main reason is that the lower interest rate channel is the main mechanism, which balances the decline in aggregate demand following the bargaining shock. While rule-of-thumb households revise their consumption decisions downward, lower interest rate leads optimizing households to revise their consumption decisions upwards as well as firms to increase vacancy posting.

Figure 9: Sensitivity to monetary policy $\phi_\pi = 1.1$



Contrastingly, the inertia of interest rate ϕ_m is set to 0 in Figures 10. This implies that monetary policy is less dependent on past interest rate adjustment increasing mechanically the importance of inflation. The interest rate drops on impact by -0.5 percent far below the -0.15 percent decline under the baseline calibration. This has a positive impact on vacancy posting and on the consumption decisions of optimizing households. Output in the home country increases by 0.13 percentage point on impact. In the foreign country, the reduction in the interest rate as a result of imported inflation is also more pronounced dropping to -0.16 percent from -0.05 percent. This cancels out the beggar-thy-neighbour effect.

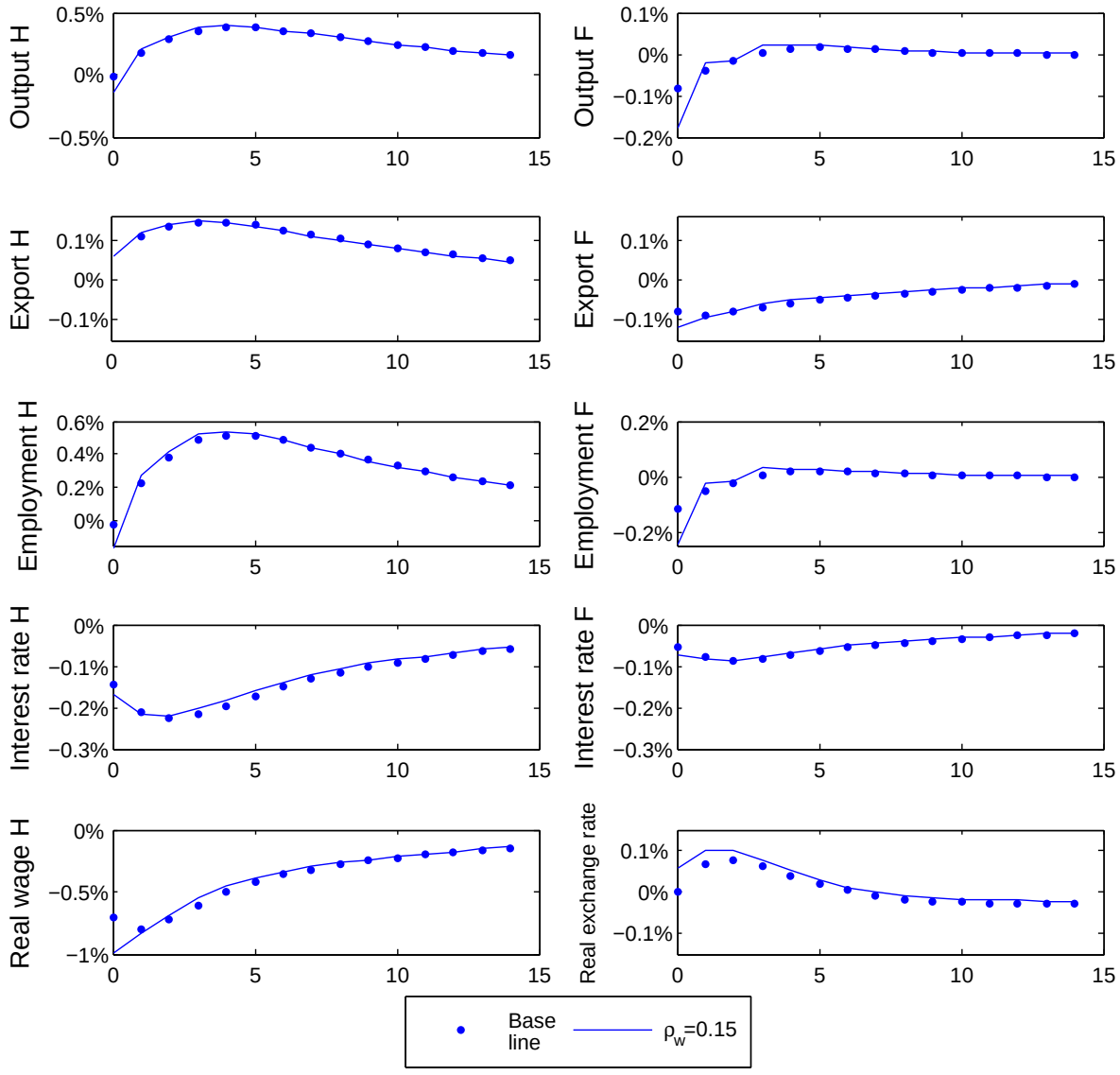
Figure 10: Sensitivity to monetary policy $\phi_m = 0$



5.7 Sensitivity analysis of the model with rule-of-thumb: Labour market variables

This section illustrates the importance of two key labour market parameters for the international spill-overs between the home country and the foreign country. The first parameter is real wage rigidity ρ_w. The second parameter is the replacement income ω. Labour market variables are of interest to the extent that they affect the adjustment in the real wage as well as the size of the labour demand effect.

Figure 11: Sensitivity to real wage rigidities $\rho_w = 0.15$

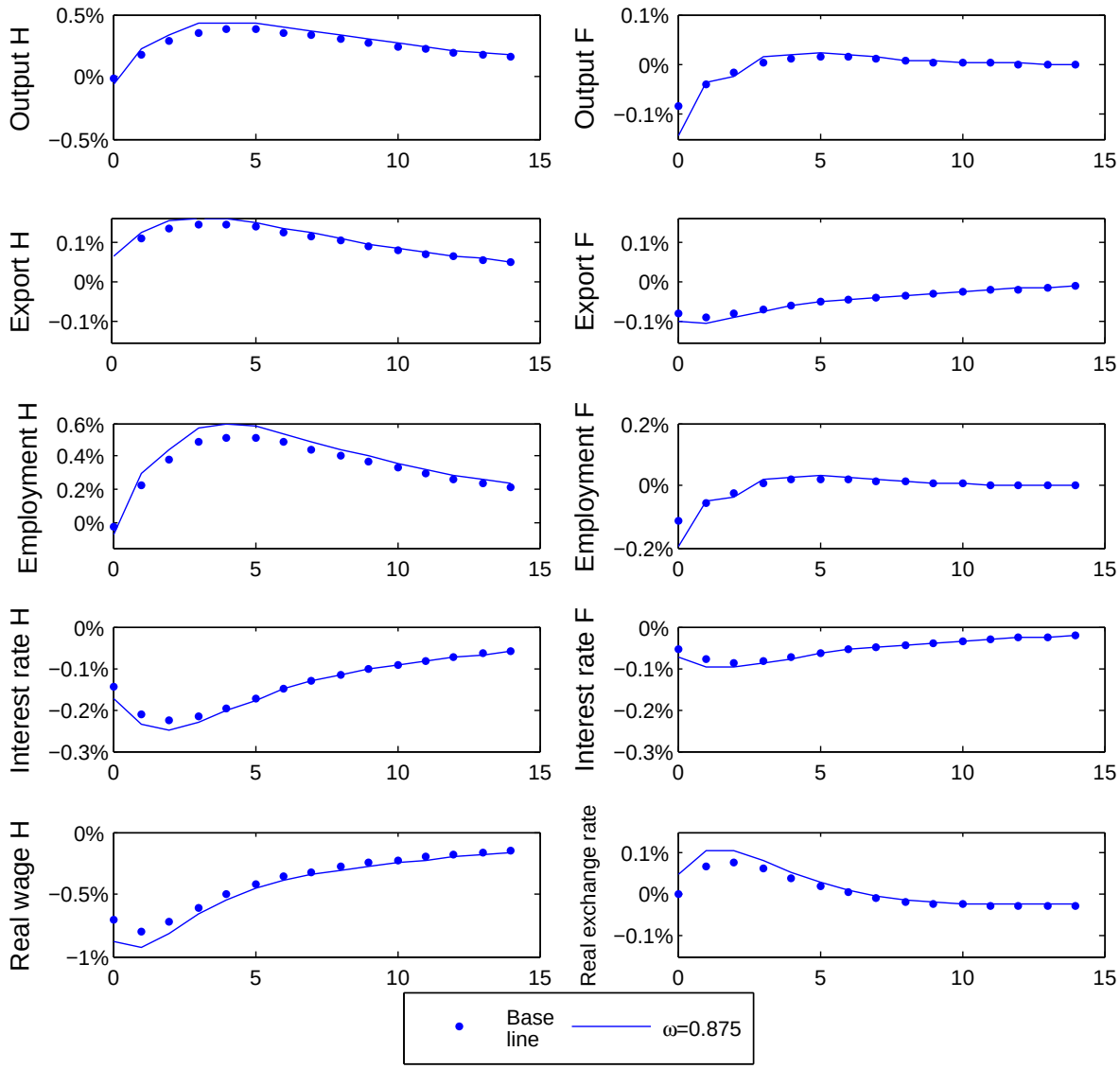


In Figure 11, real wage rigidity ρ_w is reduced from 0.3 to 0.15. In the presence of lower real wage rigidity, the negative bargaining shock leads to a larger drop in the real wage. It follows that on impact the downward adjustment in aggregate consumption is more pronounced enhancing the negative domestic aggregate demand effect. Domestic aggregate demand drops by -0.2 percentage point against -0.07 percentage point previously. Consequently, output in the home country declines by -0.14 percentage point. The large adjustment in real wage on impact also translates into inflation and the real exchange

rate. Lower domestic consumption impacts negatively exports fo the foreign country. It follows that output in the foreign country drops by -0.18 percentage point on impact.

The replacement rate ω is reduced from 0.9 to 0.875 in Figure 12. The replacement rate affects the size of the surplus of workers from an employment relationship. Reducing the replacement rate shifts the response of the labour market to a labour productivity change from an employment to a wage adjustment. Hence, changing the replacement wage has second round effects given the conducted experiment of lower bargaining power. However, these are very small, resulting in a slightly larger drop of inflation and the interest rate, as well as their associated response of output and employment.

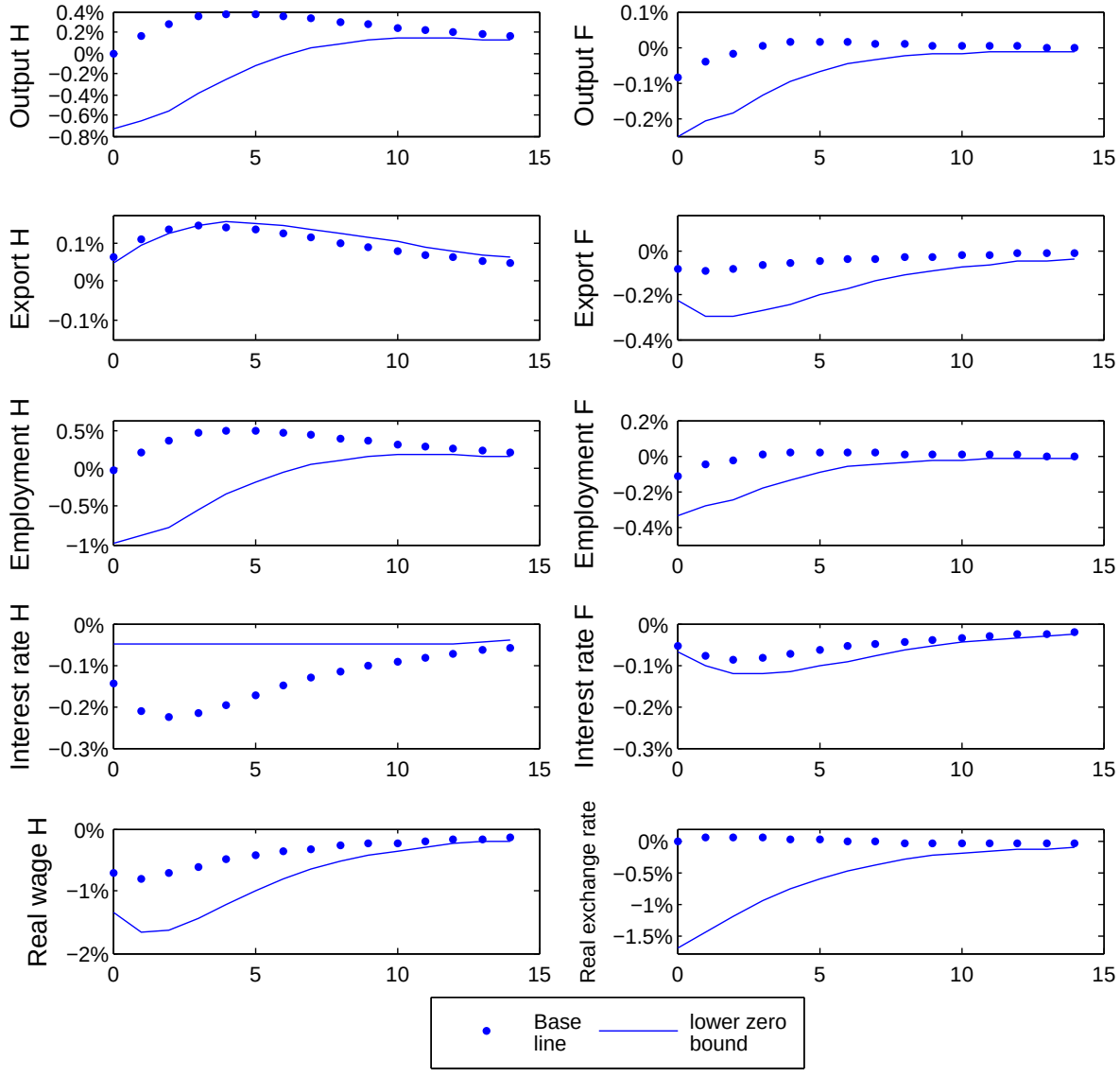
Figure 12: Sensitivity to replacement rate $\omega = 0.875$



5.8 Zero lower bound in monetary policy

Figure 13 displays the effect of a decline in real wage in the home and foreign country in the presence of a zero lower bound on monetary policy in the home country. Calibration is similar to the two country case with rule of thumb households as discussed in the previous figure. The only difference is the existence of a downward rigidity in the nominal interest rate. The lower bound is not set at zero as this would require an unrealistically large shock to bring the interest rate from a 3.2 percent annual steady state to zero. Instead the interest rate cannot decline further from 0.5 percentage point from the steady state. A further justification is that even when the interest rate set by the central bank is zero, borrowers either firms or households face positive interest rates as banks set a mark-up on the Central Bank rate. Additionally, the share of firms, which cannot reset their price optimally each period is increased from 0.8 to 0.875. Changing χ does not affect the direction of the effect but reduces the negative effects on impacts that would be too large otherwise.[16]

Figure 13: Model with lzb

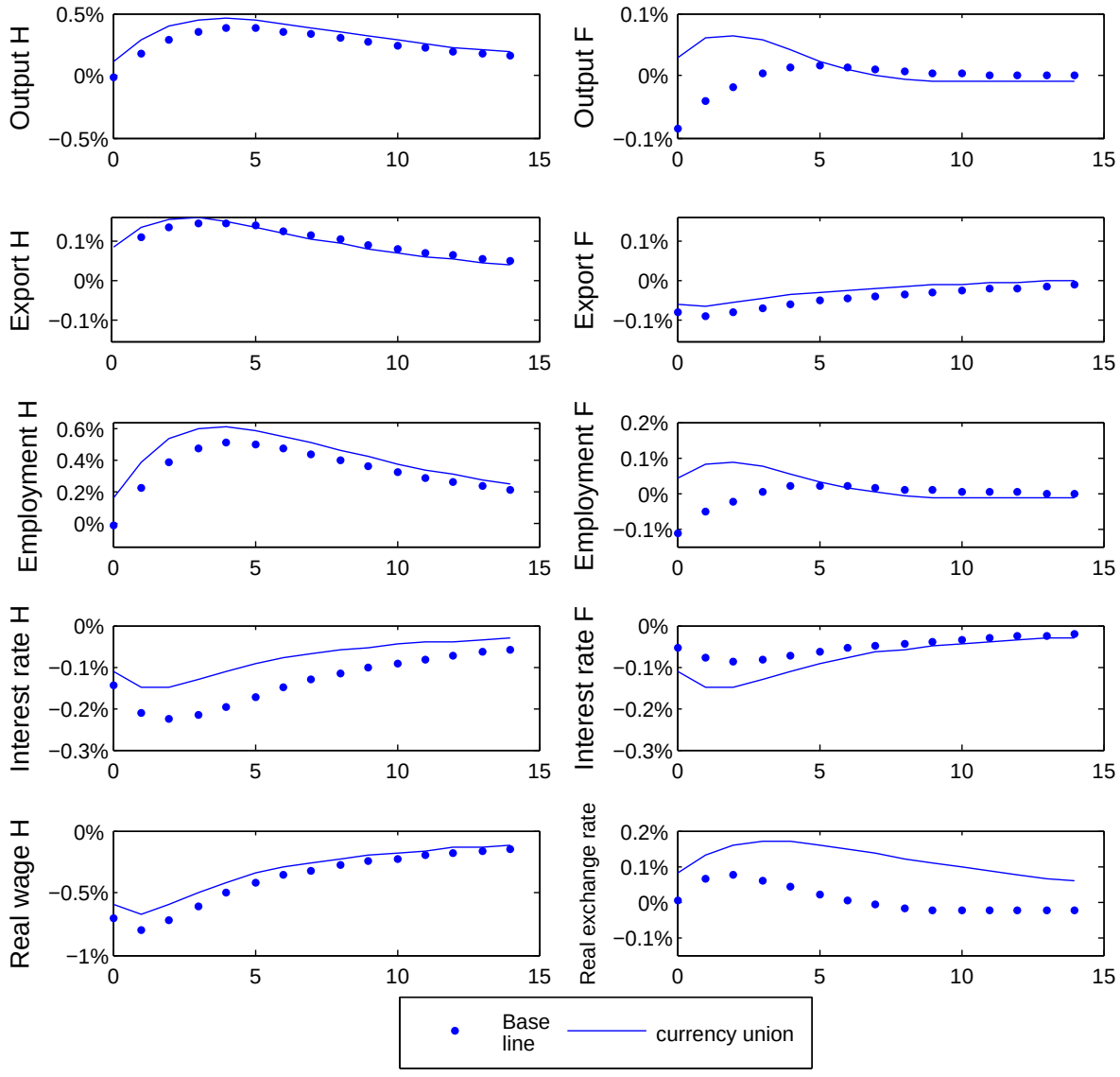


[16] The procedure for the introduction of a lower bound on a variable into a stochastically simulated model in Dynare is described in Holden (2011).

The liquidity trap amplifies the negative effect on aggregate demand of a decline in the consumption of rule-of-thumb households. Output in the home country declines by 0.7 percentage point, while the employment rate declines by 1 percentage point. The effect is long lasting. It takes 7 quarters for output to recover to its steady state level. Output and employment in the foreign country also decline on impact by 0.25 percentage points and 0.35 percentage points respectively. The effect is long lasting in the foreign country as well, as output converges monotonously back towards the steady state. The main effect of the zero lower bound is that when the nominal interest rate reaches zero while price inflation is negative, the real interest rate increases. This discourages vacancy posting and reduces consumption demand.

The effect on the foreign country is larger than in the baseline case described in Figure 3 for two reasons. First, the competitiveness effect is larger with real wages dropping by 1.3 percent on impact in the home country against 0.6 percent in the baseline case. Second, the decline in imports related to the drop in consumption is also substantially larger than in the baseline case.

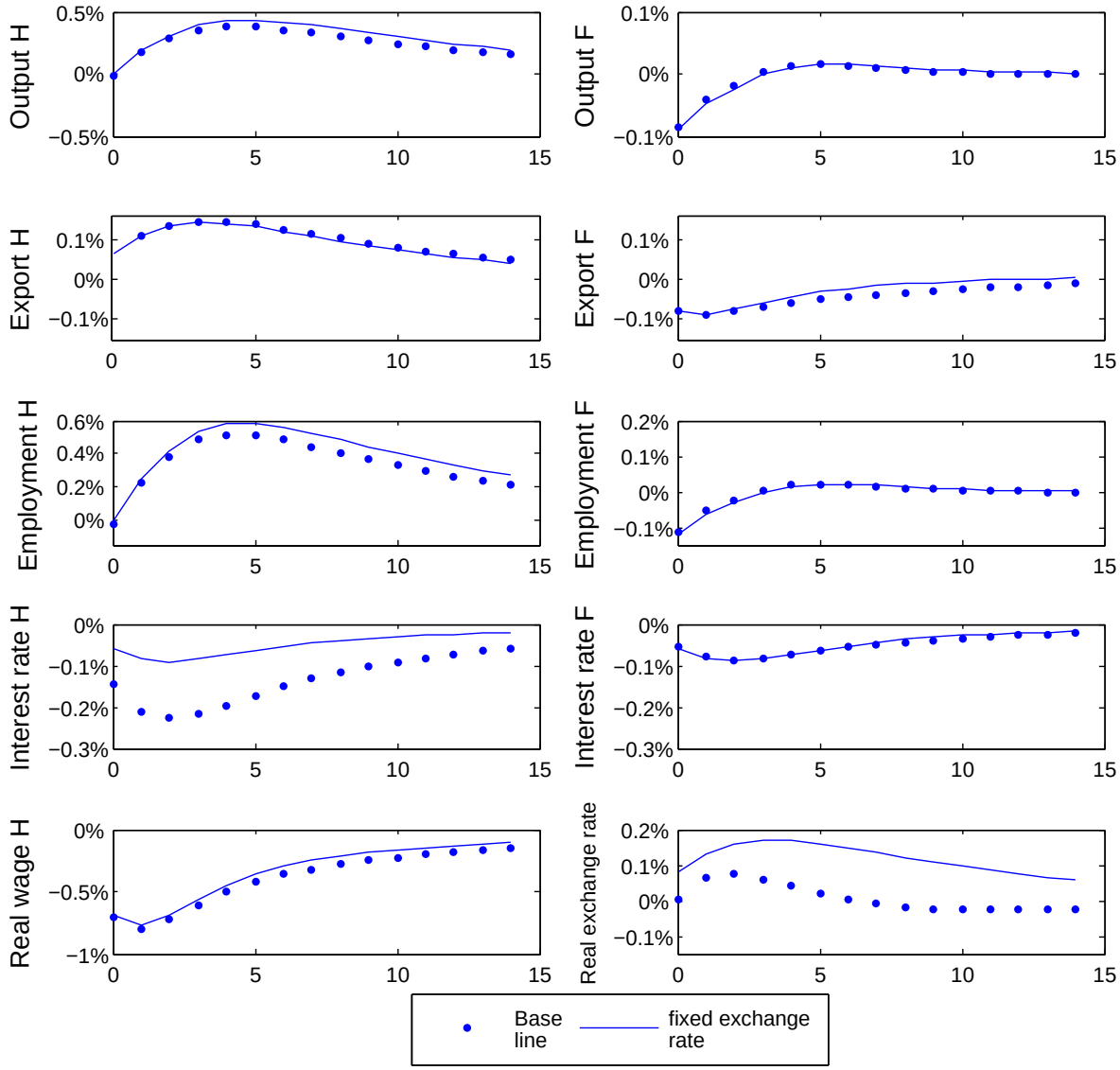
Figure 14: Currency union



5.9 Sensitivity analysis of the model with rule-of-thumb: Exchange rate regime

In a monetary union central banks cannot adjust the interest rate in response to idiosyncratic shocks. Other policy instruments therefore become more important. Figure 14 displays this case. A single central bank sets the interest rate in reaction to a weighted average of the countries' inflation and output. Consequently, the common rate is between the rate of home and foreign in the baseline scenario. The much lower real interest rate in foreign produces a significant demand boom, which also spills over to the home economy. Consequently, employment is higher in both countries. The real exchange rate depreciates further since it is only determined by the inflation differential between the two countries.

Figure 15: Fixed exchange rate



The simulation of the monetary union shows the importance of the interest rate setting when evaluating the consequences of a bargaining power change. This is logical, since the interest rate is the price equilibrating demand and supply in a New Keynesian model. The foreign economy benefits from a too loose monetary policy when the interest rate responds to the supply-led lower inflation in the home

economy. Figure 15 displays the interesting example of a fixed exchange rate situation where the interest rate responds only to foreign variables. This could also be interpreted as a monetary union where the central bank does not adjust the interest rate in response to the supply-shock induced inflation.

All variables evolve similar to the baseline scenario, with the exception of the home interest rate and the real exchange rate. The latter once again is purely a function of the inflation differential. Consequently, the beggar-thy-neighbour effect persists.

6 Conclusion

Countercyclical policy mainly relies on monetary and fiscal policy. Nevertheless, significant political and public pressure can mount on the social partners in wage negotiations in times of economic downturns in order to exercise wage restraint. Such pressure can temporarily lower the bargaining power of workers without any actual change of regulation. This paper investigates the consequences of such a temporary drop in bargaining power for both the domestic economy and its trading partners, with the help of a New-Keynesian model featuring a direct link from labour income to aggregate demand.

The main conclusion of the paper is that a fall in bargaining power in the home economy has a detrimental impact on the foreign economy's output and employment. The four main channels impacting on the foreign economy are broken down using an analytical approach. While the direct link between labour incomes and aggregate demand reduces consumption demand in the home country, the rise in home and foreign demand due to lower interest rates counters this effect. The final channel, being increased competitiveness is an important argument for temporary wage restraint and proves decisive to creating a beggar-thy-neighbour effect on the foreign economy.

The paper conducts sensitivity analysis, showing that a beggar-thy-neighbour effect occurs under a wider range of parameters. The monetary policy regime is the most important determinant of the impact of the bargaining power shock. For instance, when a single central bank in a currency union lowers the common interest rate significantly in response to falling inflation in the home economy, then the foreign economy experiences a demand boom due to its too low real interest rate. Contrastingly, when monetary policy is constrained by a zero lower bound on the interest rate, the negative demand effect stemming from falling wages cannot be countered by lowered real interest rates. Instead, real rates rise, and home demand falls significantly. This has strong repercussions on the foreign economy, which also suffers a serious and persistent fall in output.

To summarize, temporarily lowering bargaining power can boost the domestic economy, but imposes a beggar-thy-neighbour effect on the foreign economy. Furthermore, the beneficial effect relies on monetary policy to be accommodative. However, a straightforward monetary impulse would represent a better strategy, being much more responsive and less distortive to the social dialogue process. When monetary policy has no space to manoeuvre, then lowering bargaining power aggravates the situation even further.

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Appendix: Derivation of mathematical solution

A.1 Production and wages

By setting $\rho = 0$, it holds that beginning of period unemployment is unity, $u_t = 1$, so that $q_t = m_t = \nu_t = n_t$. Removing real wage rigidity, the labour market simplifies to

$$w_t = \eta_t p_{w,t} a_{n,t} + (1 - \eta_t) w_u \tag{27}$$

$$\kappa n_t \xi_m^2 = p_{w,t} a_{n,t} - w_t \tag{28}$$

The steady state labour share is given by

$$\frac{wn}{y} = \frac{\alpha}{\mu} - \frac{c_v}{y} \tag{29}$$

The labour share is the share of labour in the production function, net of monopoly profits, minus steady state cost of vacancy posting, $c_v = \kappa v$. The log-linear labour market equations are then

$$\frac{wn}{y}\hat{w}_t = \eta \frac{\alpha}{\mu}(\hat{p}_{w,t} + \hat{a}_{n,t} + \hat{\eta}_t) - \eta\omega \frac{wn}{y}\hat{\eta}_t \tag{30}$$

$$\frac{wn}{y}\hat{w}_t = \frac{\alpha}{\mu}(\hat{p}_{w,t} + \hat{a}_{n,t}) - \frac{\kappa v}{y}\hat{n}_t \tag{31}$$

Using the production function, $\hat{y}_{w,t} = \alpha \hat{n}_t$, and $\hat{a}_{n,t} = \hat{y}_{w,t} - \hat{n}_t$, we obtain

$$\frac{wn}{y}\hat{w}_t = \eta \frac{\alpha}{\mu}(\hat{p}_{w,t} - \frac{1-\alpha}{\alpha}\hat{y}_{w,t}) + \eta\left(\frac{1}{\mu} - \omega\frac{wn}{y}\right)\hat{\eta}_t \tag{32}$$

$$\frac{wn}{y}\hat{w}_t = \frac{\alpha}{\mu}(\hat{p}_{w,t} - \frac{1-\alpha}{\alpha}\hat{y}_{w,t}) - \frac{c_v}{(\alpha)y}\hat{y}_{w,t} \tag{33}$$

where we make use of $y = y_w$ in steady state, meaning that produced output equals total demand, implying a zero trade balance. The real wage is given by

$$\frac{wn}{y}\hat{w}_t = \frac{\eta}{1-\eta}\frac{c_v}{\alpha y}\hat{y}_{w,t} + a_1\hat{\eta}_t \tag{34}$$

where $a_1 = \frac{\eta}{1-\eta}\left(\frac{1}{\mu} - \omega\frac{wn}{y}\right)$ is the elasticity of wages to bargaining power. The real wage increases with produced output only through an indirect effect, the increased cost of vacancy posting. Marginal cost as a function of output are

$$\hat{p}_{w,t} = a_2\hat{y}_{w,t} + \frac{\mu}{\alpha}a_1\hat{\eta}_t \tag{35}$$

where $a_2 = \left(\frac{1-\alpha}{\alpha} + \frac{c_v\mu}{(\alpha)^2 y}\frac{1}{1-\eta}\right)$ is the elasticity of marginal cost to output changes. The first part of a_2 represents the increasing marginal cost of production due to diminishing returns to labour. This part disappears for constant returns, $\alpha = 1$. The second part shows the increasing cost due to higher vacancy posting requirements. Also, higher bargaining power raises marginal cost.

A.2 Resource constraint and consumption

The resource constraint and consumption functions are given by

$$\hat{y}_t = \frac{c}{y}\hat{c}_t + 2\frac{c_v}{y}\hat{n}_t \tag{36}$$

$$\hat{c}_t = o_c\hat{c}_{o,t} + (1-o_c)\hat{c}_{r,t} \tag{37}$$

$$\hat{c}_{o,t} = \hat{c}_{o,t+1} - \frac{\phi_\pi - 1}{\sigma}\hat{\pi}_{t+1} \tag{38}$$

$$\hat{c}_{r,t} = \left(\frac{wn}{c} - \frac{\omega w(1-n)}{c}\right)\hat{n}_t + \frac{wn}{c}\hat{w}_t \tag{39}$$

$$\Leftrightarrow \hat{c}_{r,t} = \frac{y}{c}\frac{1}{\alpha}\left[\frac{wn}{y}\left(1-\omega\frac{1-n}{n}\right) + \frac{\eta}{1-\eta}\frac{c_v}{y}\right]\hat{y}_{w,t} + \frac{y}{c}a_1\hat{\eta}_t \tag{40}$$

Consumption of credit-constrained consumers depends on the employment effect of output, on the indirect real wage effect, and on the bargaining power effect. This solves to

$$\begin{aligned}\hat{c}_t =& \hat{c}_{t+1} + (1-o_c)(\hat{c}_{r,t} - \hat{c}_{r,t+1}) - o_c\frac{\phi_\pi - 1}{\sigma}\hat{\pi}_{t+1}\\ \hat{y}_t - a_3\hat{y}_{w,t} =& \hat{y}_{t+1} - a_3\hat{y}_{w,t+1} + (1-o_c)a_1(\hat{\eta}_t - \hat{\eta}_{t+1}) - o_c\frac{c}{y}\frac{\phi_\pi - 1}{\sigma}\hat{\pi}_{t+1}\end{aligned} \tag{41}$$

with

$$a_3 = \frac{2c_v}{\alpha y} + \frac{1-o_c}{\alpha}\left[\frac{wn}{y}\left(1-\omega\frac{1-n}{n}\right) + \frac{\eta}{1-\eta}\frac{c_v}{y}\right]$$

When $\hat{y}_t = \hat{y}_{w,t}$, as holds in a closed economy, then the term $1/(1-a_3)$ is a demand multiplier, which becomes larger the larger is a_3. The first term of a_3 multiplies output because higher output requires higher vacancy posting cost, which in itself increases demand. This effect is small. The second part of a_3 is the actual output multiplier working through rule of thumb consumers. As output increases, labour income increases, which rises demand again. Under any realistic calibration $a_3 < 1$.

Not the level, but only the difference in consumption of credit-constrained households matters. Higher consumption by credit constrained households today as compared to tomorrow would leave less resources today compared to tomorrow for unconstrained households. However, consumptions smoothing implies that they want to keep their consumption, raising the output demand.

A.3 Imports and exports

Now follows the derivation of the relation between produced and consumed output, which utilizes import and export demand. The steady state assumptions are $p_h = p_f = p$, $p_h^* = p_f^* = p^*$ and $(1-\alpha_w)y = (1-\alpha_w^*)y^*$, so that $Q = 1$, $y_h = \alpha_w y$ and $y_f = (1-\alpha_w)y$. The price index as well as optimal demand for domestic and imported goods is given by

$$\hat{p}_t = \alpha_w\hat{p}_{h,t} + (1-\alpha_w)\hat{p}_{f,t} \tag{42}$$

$$\hat{y}_{h,t} = \varsigma(\hat{p}_t - \hat{p}_{h,t}) + \hat{y}_t \tag{43}$$

$$\hat{y}_{f,t} = \varsigma(\hat{p}_t - \hat{p}_{f,t}) + \hat{y}_t \tag{44}$$

and equivalent equations for foreign. It also holds that $\hat{p}_{h,t} = \hat{p}_{w,t}$, $\hat{p}_{f,t} = \hat{p}_{w,t}^* + \hat{Q}_t$ and $\hat{p}_{f,t}^* = \hat{p}_{w,t} - \hat{Q}_t$. Also, demand for produced output is given by $y_{w,t} = y_{h,t} + y_{f,t}^*$ so that

$$\hat{y}_{w,t} = \alpha_w\hat{y}_{h,t} + (1-\alpha_w)\hat{y}_{f,t}^* \tag{45}$$

and equivalent for foreign follows. Combining these equations, we obtain

$$\hat{y}_{w,t} = \alpha_w \hat{y}_t + (1-\alpha_w)\hat{y}_t^* + \alpha_w \varsigma(\hat{p}_t^* - \hat{p}_{h,t}) + (1-\alpha_w)\varsigma^*(\hat{p}_t^* - \hat{p}_{f,t}^*) \tag{46}$$

$$\hat{y}_t = \frac{1}{\alpha_w}\hat{y}_{w,t} - \frac{(1-\alpha_w)}{\alpha_w}\hat{y}_t^* + \frac{(1-\alpha_w)}{\alpha_w}(\varsigma\alpha_w + \varsigma^*\alpha_w^*)(\hat{p}_{w,t} - \hat{p}_{w,t}^* - \hat{Q}_t) \tag{47}$$

relating consumed output to produced output, foreign output and relative prices. Combining this with the equivalent equation for foreign yields

$$\hat{y} = (1+a_4)\hat{y}_p - a_4\left(\hat{y}_{w,t}^* - a_6(\hat{p}_{w,t} - \hat{p}_{w,t}^* - \hat{Q}_t)\right) \tag{48}$$

$$\hat{y}^* = (1+a_4^*)\hat{y}_p^* - a_4^*\left(\hat{y}_{w,t} + a_6(\hat{p}_{w,t} - \hat{p}_{w,t}^* - \hat{Q}_t)\right) \tag{49}$$

where

$$a_4 = \frac{1-\alpha_w}{\alpha_w + \alpha_w^* - 1}$$

$$a_5 = \varsigma\alpha_w + \varsigma^*\alpha_w^*$$

The denominator $\alpha_w + \alpha_w^* - 1$ is positive when there is home bias ($\alpha_w > 0.5$) in demand. These equations are easier understood when relating $\hat{y}_{w,t}$ to the other variables. The term a_4 represents the impact of foreign output on domestic production. The term a_5 captures the substitution effects related to relative price changes. The smaller is α_w, the less an increase in domestic demand raises domestic production directly. However, it raises demand for foreign output, which in turn has a feedback effect on domestic output, unless the small open economy assumption holds ($\alpha_w^* \to 1$). As $\alpha_w \to 1$, it is clear that $a_4 \to 0$, so that $\hat{y}_t = \hat{y}_{w,t}$.

Furthermore, the marginal cost equation (35) can be inserted to relate consumed output only to domestic and foreign produced output and the bargaining power. For clarity of exposition, we set $\hat{\eta_t}^* = 0$ as we do not consider this experiment.

$$\hat{y}_t = (1 + a_4 + a_2a_4a5)\hat{y}_{w,t} - a_4(1 + a_2^*a_5)\hat{y}_{w,t}^* + a_4a_5\left(\frac{\mu}{(\alpha)}a_1\hat{\eta}_t - \hat{Q}_t\right) \tag{50}$$

$$\hat{y}_t^* = (1 + a_4^* + a_2^*a_4^*a_5^*)\hat{y}_{w,t}^* - a_4^*(1 + a_2a_5)\hat{y}_{w,t} - a_4^*a_5\left(\frac{\mu}{(\alpha)}a_1\hat{\eta}_t - \hat{Q}_t\right) \tag{51}$$

A.4 The final equations

The IS equations are given by

$$\begin{aligned}\hat{y}_{w,t} =& \hat{y}_{w,t+1} + m_1a_4(1 + a_2^*a_5)\left(\hat{y}_{w,t}^* - \hat{y}_{w,t+1}^*\right) + m_1a_1\left[(1-o_c) - a_4a_5\frac{\mu}{\alpha}\right](\hat{\eta}_t - \hat{\eta}_{t+1}) \\ &+ m_1a_4a_5\left(\hat{Q}_t - \hat{Q}_{t+1}\right) - o_cm_1\frac{c}{y}\frac{\phi_\pi - 1}{\sigma}\hat{\pi}_{t+1}\end{aligned} \tag{52}$$

$$\begin{aligned}\hat{y}_{w,t}^* =& \hat{y}_{w,t+1}^* + m_1^*a_4^*(1 + a_2a_5)\left(\hat{y}_{w,t} - \hat{y}_{w,t+1}\right) + m_1^*a_1a_4^*a_5\frac{\mu}{\alpha}(\hat{\eta}_t - \hat{\eta}_{t+1}) \\ &- m_1^*a_4^*a_5\left(\hat{Q}_t - \hat{Q}_{t+1}\right) - o_c^*m_1^*\frac{c^*}{y^*}\frac{\phi_\pi^* - 1}{\sigma^*}\hat{\pi}_{t+1}^*\end{aligned} \tag{53}$$

where

$$m_1 = \frac{1}{1 + a_4 + a_2a_4a_5 - a_3}$$

m_1 is an output multiplier which is larger unity in the closed economy case. The more open are the economies, the smaller becomes m_1. However, the larger is $1 - o_c$, the larger becomes a_3 and hence the

multipler. Finally, the real exchange rate development is given by the real interest rate parity, so that $\hat{Q}_t - \hat{Q}_{t+1} = (\phi^*_\pi - 1)\hat{\pi}^*_{t+1} - (\phi_\pi - 1)\hat{\pi}_{t+1}$ holds.

A rise in domestic bargaining power raises domestic demand through the rule of thumb consumer channel, but lowers it through the export channel. At the same time it raises foreign demand through the import channel. Additionally, second round effects through changes in domestic and foreign output follow.

Marginal cost in the Philips curve contains domestic and foreign marginal cost according to their shares, $\hat{p}_t = \alpha_w \hat{p}_{h,t} + (1-\alpha_w)\hat{p}_{f,t}$. Hence, the AS curve is given by

$$\hat{\pi}_t = \beta\hat{\pi}_{t+1} + \zeta\alpha_w a_2 \hat{y}_{w,t} + \zeta(1-\alpha_w)a^*_2\hat{y}^*_{w,t} + \zeta(1-\alpha_w)\hat{Q}_t + \zeta\frac{\mu}{\alpha}a_1\hat{\eta}_t \tag{54}$$

a_2 represents the elasticity of marginal cost with respect to output changes. An increase in foreign output as well as a depreciation of the exchange rate raises domestic inflation.

A.5 Solving the dynamic model

Using the method of undetermined coefficients, the system of equations to be solved is given by

$$\begin{aligned}
\gamma_1 =& m_1 a_4(1 + a^*_2 a_5)\gamma_2 + m_1 a_4 a_5(\phi^*_\pi - 1)\frac{\rho_\eta}{1-\rho_\eta}\gamma_4 - m_1(\phi_\pi - 1)\left(a_4 a_5 + \frac{c}{y}\frac{o_c}{\sigma}\right)\frac{\rho_\eta}{1-\rho_\eta}\gamma_3 \\
&+ m_1 a_1\left[(1-o_c) - a_4 a_5\frac{\mu}{\alpha}\right] && (55)\\
\gamma_2 =& m^*_1 a^*_4(1 + a_2 a_5)\gamma_1 + m^*_1 a^*_4 a_5(\phi_\pi - 1)\frac{\rho_\eta}{1-\rho_\eta}\gamma_3 - m^*_1(\phi^*_\pi - 1)\left(a^*_4 a_5 + \frac{c^*}{y^*}\frac{o^*_c}{\sigma^*}\right)\frac{\rho_\eta}{1-\rho_\eta}\gamma_4 \\
&+ m^*_1 a_1 a^*_4 a_5\frac{\mu}{\alpha} && (56)\\
\gamma_3 =& \frac{\zeta}{1-\beta\rho_\eta}\left(\alpha_w a_2\gamma_1 + (1-\alpha_w)a^*_2\gamma_2\right) + \frac{\zeta}{1-\beta\rho_\eta}(1-\alpha_w)\gamma_5 + \alpha_w\frac{\zeta}{1-\beta\rho_\eta}\frac{\mu}{\alpha}a_1 && (57)\\
\gamma_4 =& \frac{\zeta^*}{1-\beta^*\rho_\eta}\left(\alpha^*_w a^*_2\gamma_2 + (1-\alpha^*_w)a_2\gamma_1\right) - \frac{\zeta^*}{1-\beta^*\rho_\eta}(1-\alpha^*_w)\gamma_5 + (1-\alpha^*_w)\frac{\zeta^*}{1-\beta^*\rho_\eta}\frac{\mu}{\alpha}a_1 && (58)\\
\gamma_5 =& \frac{\rho_\eta}{1-\rho_\eta}\left((\phi^*_\pi - 1)\gamma_4 - (\phi_\pi - 1)\gamma_3\right) && (59)
\end{aligned}$$

Inserting γ_5 into (57) and (58) yields

$$\begin{aligned}
(1-\rho_\eta + (1-\alpha_w)a_6)\gamma_3 =& \frac{\zeta(1-\rho)}{1-\beta\rho_\eta}\left(\alpha_w a_2\gamma_1 + (1-\alpha_w)a^*_2\gamma_2\right) + \\
& (1-\alpha_w)a_6\frac{\phi^*_\pi - 1}{\phi_\pi - 1}\gamma_4 + \alpha_w\frac{\zeta(1-\rho_\eta)}{1-\beta\rho_\eta}\frac{\mu}{\alpha}a_1 && (60)\\
(1-\rho_\eta + (1-\alpha^*_w)a^*_6)\gamma_4 =& \frac{\zeta^*(1-\rho_\eta)}{1-\beta^*\rho_\eta}\left(\alpha^*_w a^*_2\gamma_2 + (1-\alpha^*_w)a_2\gamma_1\right) + \\
& (1-\alpha^*_w)a^*_6\frac{\phi_\pi - 1}{\phi^*_\pi - 1}\gamma_3 + (1-\alpha^*_w)\frac{\zeta^*(1-\rho_\eta)}{1-\beta^*\rho_\eta}\frac{\mu}{\alpha}a_1 && (61)
\end{aligned}$$

with

$$a_6 = (\phi_\pi - 1)\rho_\eta\frac{\zeta}{1-\beta\rho_\eta}$$

The term a_6 represents the reaction of the real interest rate to a marginal cost shock and plays a crucial role in determining the overall impact. It can be seen that this parameter becomes very large as ρ_η approaches unity, while it is zero for $\rho_\eta = 0$. γ_3 and γ_4 solve to

$$\begin{aligned}
\gamma_3 =& (1-a_7)\frac{\zeta}{1-\beta\rho_\eta}\left[\alpha_w a_2\gamma_1 + (1-\alpha_w)a^*_2\gamma_2 + \alpha_w\frac{\mu}{\alpha}a_1\right] \\
&+ a_7\frac{\zeta^*}{1-\beta^*\rho_\eta}\frac{\phi^*_\pi - 1}{\phi_\pi - 1}\left[(1-\alpha^*_w)a_2\gamma_1 + \alpha^*_w a^*_2\gamma_2 + (1-\alpha^*_w)\frac{\mu}{\alpha}a_1\right] && (62)
\end{aligned}$$

$$\begin{aligned}\gamma_4 =&(1-a_7^*)\frac{\zeta^*}{1-\beta^*\rho_\eta}\left[(1-\alpha_w^*)a_2\gamma_1+\alpha_w^*a_2^*\gamma_2+(1-\alpha_w^*)\frac{\mu}{\alpha}a_1\right]\\&+a_7^*\frac{\zeta}{1-\beta\rho_\eta}\frac{\phi_\pi-1}{\phi_\pi^*-1}\left[\alpha_w a_2\gamma_1+(1-\alpha_w)a_2^*\gamma_2+\alpha_w\frac{\mu}{\alpha}a_1\right]\end{aligned} \tag{63}$$

with

$$a_7 =\frac{(1-\alpha_w)a_6}{1-\rho_\eta+(1-\alpha_w)a_6+(1-\alpha_w^*)a_6^*}$$

The constant $(1-a_7)$ is the real exchange rate muting effect on marginal cost. When inflation increases, the real interest rate goes up, which appreciates the currency, reduces cost of imports and hence diminishes the rise in inflation. This term is zero for the closed economy.

Inserting γ_3 and γ_4 into (55) and (56) reduces to the system to

$$\begin{aligned}b_1\gamma_1 =&a_4b_2^*\gamma_2+a_1(1-\rho_\eta)(1-o_c)-a_1\frac{\mu}{\alpha}\frac{c}{y}\frac{o_c}{\sigma}\left(a_6\alpha_w(1-a_7)+a_6^*(1-\alpha_w^*)a_7\right)\\&-a_1a_4a_5\frac{\mu}{\alpha}(1-a_7-a_7^*)\left(1-\rho_\eta+a_6\alpha_w-a_6^*(1-\alpha_w^*)\right)\end{aligned} \tag{64}$$

$$\begin{aligned}b_1^*\gamma_2 =&a_4^*b_2\gamma_1-a_1\frac{\mu}{\alpha}\frac{c^*}{y^*}\frac{o_c^*}{\sigma^*}\left(a_6\alpha_w a_7^*+a_6^*(1-\alpha_w^*)(1-a_7^*)\right)\\&+a_1a_4^*a_5\frac{\mu}{\alpha}(1-a_7-a_7^*)\left(1-\rho_\eta+a_6\alpha_w-a_6^*(1-\alpha_w^*)\right)\end{aligned} \tag{65}$$

with

$$\begin{aligned}b_1 =&\frac{1-\rho_\eta}{m_1}+a_2\frac{c}{y}\frac{o_c}{\sigma}\left(a_6\alpha_w(1-a_7)+a_6^*(1-\alpha_w^*)a_7\right)+a_2a_4a_5(1-a_7-a_7^*)\left(a_6\alpha_w-a_6^*(1-\alpha_w^*)\right)\\b_2 =&(1-\rho_\eta)(1+a_2^*a_5)+a_2^*a_5(1-a_7-a_7^*)\left(a_6^*\alpha_w^*-a_6(1-\alpha_w)\right)-a_2^*\frac{a_7}{a_4}(1-\rho_\eta+a_6^*)\frac{c}{y}\frac{o_c}{\sigma}\end{aligned}$$

where we make use of $a_6\alpha_w a_7^*+a_6^*(1-\alpha_w^*)(1-a_7^*)=a_7^*(1-\rho_\eta+a_6^*)$. It holds that $0<1-a_7-a_7^*\leq 1$. Also, the terms $a_6\alpha_w-a_6^*(1-\alpha_w^*)>0$ for any calibration with some home bias, similar price stickiness and similar monetary policy in both countries.

The term $1/b_1$ represents the output multiplier when the impact of higher production on marginal cost, inflation, the real interest rate, the real exchange rate and in turn export demand is taken into account. The part containing $\frac{c}{y}\frac{o_c}{\sigma}$ shows the net effect of higher domestic output on the net real exchange rate effect working through domestic and foreign inflation and the corresponding real interest rates. The part containing $a_2a_4a_5$ shows the direct relative price effect of higher domestic production cost on domestic and foreign demand for domestic products.

The term a_4 represents the impact of foreign demand on domestic production, while the term b_2^* represents the demand multiplier of foreign output on domestic demand. This includes the direct effect (1), the effect of higher foreign output on foreign production cost and thus domestic competitiveness $(a_2^*a_5)$, the indirect effect through which higher foreign production cost depreciate the domestic real exchange rate and thereby increase competitiveness (the third term) and finally the negative impact whereby higher import prices raise domestic inflation and the real interest rate, lowering demand. The combination of terms of b_1 and b_2 will serve as a multiplier.

The solution for γ_1 and γ_2 is given by

$$\gamma_1 =\frac{a_1}{m_2b_1}\left[c_0+c_1+a_4\frac{b_2^*}{b_1^*}c_2-a_4c_3\right] \tag{66}$$

$$\gamma_2 =\frac{a_1}{m_2b_1^*}\left[a_4^*\frac{b_2}{b_1}(c_0+c_1)+c_2+a_4^*c_3\right] \tag{67}$$

with

$$
\begin{aligned}
m_2 =& 1 - a_4 \frac{b_2}{b_1} a_4^* \frac{b_2^*}{b_1^*} \\
c_0 =& (1 - o_c)(1 - \rho_\eta) \\
c_1 =& -\frac{\mu}{\alpha} \frac{c}{y} \frac{o_c}{\sigma} \left(a_6(1 - a_7)\alpha_w + a_6^* a_7 (1 - \alpha_w^*)\right) \\
c_2 =& -\frac{\mu}{\alpha} \frac{c^*}{y^*} \frac{o_c^*}{\sigma^*} \left(a_6 \alpha_w a_7^* + a_6^* (1 - \alpha_w^*)(1 - a_7^*)\right) \\
c_3 =& a_5 (1 - a_7 - a_7^*)(1 - \rho + a_6 \alpha_w - a_6^* (1 - \alpha_w^*)) \frac{\mu}{\alpha} \left(1 - a_4^* \frac{b_2^*}{b_1^*}\right)
\end{aligned}
$$