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Economic Openness and Fiscal Multipliers

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Economic Openness and Fiscal Multipliers*

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Abstract

Recent empirical findings attribute a central role to the degree of economic openness to determine the size of the fiscal multiplier. See for instance Ilzetzki, Mendoza & Végh (2013). However, traditional macroeconomic models have difficulties to account for this evidence. By introducing 'deep-habit' formation into a New Keynesian small open economy model, this paper provides a theoretical framework which is able to attest for the new empirical evidence. Deep habits give rise to counter-cyclical firm markups, which are crucial to generate effects of openness on the fiscal multiplier as found in the data. We study three dimensions of economic openness: Exchange rate flexibility, trade openness and capital mobility. In line with the empirical findings, we report a negative relationship between measures of economic openness and the fiscal multiplier.

JEL class: E12, E62, F4

Keywords: Deep habits, fiscal multiplier, exchange rate flexibility, openness to trade, capital mobility

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1 Introduction

With the process of worldwide economic integration – characterized by the adoption of flexible exchange rate arrangements, further trade integration through the reduction of trade barriers, and higher capital mobility – economic openness has become a determining factor of the effectiveness of fiscal stimuli. In a series of recent empirical studies, the evidence attributes a central role to the degree of economic openness for the size of the fiscal multiplier.[1] For instance, the impact of the exchange rate regime on the fiscal multiplier has been studied by Corsetti, Meier & Müller (2012b), Ilzetzki et al. (2013), and Born, Juessen & Müller (2013). Although different in terms of econometric methods and data samples, they find that fiscal policy is more effective when the exchange rate is pegged. Regarding the degree of trade openness, Karras (2012) and Ilzetzki et al. (2013) have shown that higher openness leads to lower effectiveness of fiscal expansions. Capital mobility has attracted less attention in its role as a determinant for the fiscal multiplier. A notable exception is given by Dellas, Neusser & Wälti (2005), yet the empirical evidence provided therein remains inconclusive.

While there is ample empirical evidence, the substantial role of economic openness has been largely neglected in the theoretical analysis of fiscal policy. It is the objective of this paper to provide a framework which emphasizes the role of *three* different measures of economic openness, namely exchange rate flexibility, openness to trade, and capital mobility, to determine the size of the fiscal multiplier.

The effectiveness of fiscal policy in open economies depends on the response of the real exchange rate to an increase in government spending. Both Monacelli & Perotti (2010) and Ravn, Schmitt-Grohé & Uribe (2012) report as a result of their empirical analysis a real depreciation of domestic currency in response to a fiscal expansion.[2] These studies do not discriminate for the exchange rate regime. In a related study, Corsetti et al. (2012b) show that the impact of a fiscal expansion on the real exchange rate is crucially affected by the underlying economic structures and by the exchange rate policy. From a theoretical perspective, these empirical findings have questioned the predictions of classic macroeconomic models such as the textbook Mundell-Fleming framework.[3] While the latter suggests that fiscal policy is more effective under fixed exchange rates, it cannot account for an empirically consistent role of the real exchange rate, namely a real depreciation of the domestic currency. This is one aspect to which our model is aimed to contribute, to provide a response of the real exchange rate which within a small open economy model (qualitatively) depends on the exchange rate regime and therefore is consistent with Corsetti et al. (2012b).

An important ingredient of our model is borrowed from Ravn et al. (2012). According to the traditional real business cycle literature, private consumption decreases significantly in response to

[1]There exists a vast and growing literature on the effectiveness of fiscal policy in general. As we focus only on the relationship of fiscal policy and economic openness, we restrict ourselves to name just a selection of influential papers. For theoretical contributions see for example Baxter & Stockman (1989), Perotti (2008), Hall (2009), Woodford (2011) or Canzoneri, Collard, Dellas & Diba (2012). For a survey of empirical contributions, see Ramey (2011).

[2]See also for example Kollmann (2010) and Bénétrix & Lane (2013).

[3]We refer here to an open economy baseline *IS-LM* model as it is outlined for example in the textbook by Blanchard (2013).

a fiscal expansion as a consequence of a negative wealth effect, a conclusion for which the empirical counterpart is rarely found.[4] In order to solve this theoretical challenge, Ravn et al. (2012) enrich the modeling of private and public households via the implementation of deep-habit formation. We exploit their mechanism to generate effects of openness on the multiplier which are in line with the empirical literature.

In the light of the above, we develop a stochastic general equilibrium model accounting for the three mentioned dimensions of economic openness and we analyze their implications for the fiscal multiplier. Following Ravn, Schmitt-Grohé & Uribe (2006) and Ravn et al. (2012), we introduce 'deep-habit' formation into this model. Deep-habit formation means that households form a consumption routine over narrow categories of goods such as clothing, vacation destinations, music, or cars. Habit formation is considered to be external, hence people adopt the preferences of a particular group based on learning, social concerns (e.g. identification), or brand credibility.[5] This household behavior provides firms with an incentive to set their markup counter-cyclically: An increase in aggregate demand makes the individual demand of the monopolistically competitive producer more elastic such that firms can increase future demand by lowering the current markup. In other words, if government expenditures increase, markups decline. Lower markups, in turn, shift the labor demand curve outward, and thus increase the real wage. This provides the household with an incentive to increase consumption while decreasing leisure. Hence, the negative wealth effect induced by a fiscal expansion can be compensated if this substitution effect is strong enough. It is precisely the combination of deep habits with economic openness that distinguishes our theoretical exercise and the novelty of our results.

We depart from Ravn et al. (2012) in *three* main aspects. First, we introduce monopolistic competition in the market of domestic goods and nominal rigidities in the form of price adjustment costs for domestic firms.[6] Price rigidity is an important feature of this model, because it causes the firms to change their markup through a 'wage channel' to a larger extent than a 'price channel' and as it allows us to explain the effect of monetary accommodation on the fiscal multiplier. Next, rather than having a two-country setup, we deploy a small open economy framework with imperfect international financial markets. We follow Schmitt-Grohé & Uribe (2003) by assuming that adjusting the bond portfolio is costly. This assumption allows us to study the role of capital mobility. Finally, we give a specific role to monetary policy. Importantly, this variation permits us to investigate the accommodation by the central bank in response to a fiscal expansion.

Qualitatively, our model reproduces the patterns found in the recent empirical literature. *First*, the fiscal multiplier is higher when the exchange rate is pegged rather than floating. *Second*, trade openness diminishes the effectiveness of fiscal policy. *Third*, higher capital mobility leads to a lower

[4]The effect of government spending on private consumption has received considerable attention. See for example: Linnemann (2006), Gali, López-Salido & Vallés (2007) or Hall (2009).

[5]Chintagunta, Kyriazidou & Perktold (2001) provide a recent survey of the empirical evidence on habitual consumption behavior.

[6]The introduction of deep habits to a framework with nominal rigidities is not new. Both Cantore, Levine, Melina & Yang (2012) and Zubairy (2014a) develop New Keynesian models with deep-habit formation. The former test its implication for optimal monetary policy and the latter study equilibrium determinacy under different interest rate rules.

fiscal multiplier. Summing up, economic openness decreases the fiscal multiplier. The intuition lies in the way the three different dimensions of economic openness affect how firms set their markups and how the monetary authority reacts to it, which in turn changes the response of labor, consumption, the trade balance and the real exchange rate to an increase in government spending.

In our model, lower economic openness leads to less of the domestic fiscal expansion passing off to the foreign economy: Under flexible exchange rates, the central bank reacts to falling CPI inflation after an increase in government spending by lowering the nominal interest rate.[7] The domestic currency *appreciates*, causing a deterioration in the trade balance, partly offsetting the stimulating effect of the fiscal expansion. With a strict exchange rate target, the central bank loses the interest rate as a policy instrument such that a fiscal expansion causes a real *depreciation* of the domestic currency. In turn, the trade balance improves, enhancing the effect on output. If the consumption pattern of domestic households exhibits a home bias (and hence a smaller degree of openness to trade), the crowding-out effect of the trade balance is reduced because of an expenditure-switching effect. That is, when households are less likely to substitute their consumption of domestic goods for imports, the trade balance deteriorates less, resulting in a larger fiscal multiplier. Finally, the degree of capital mobility directly affects the portfolio allocation of households. The more costly the re-allocation of the portfolio towards foreign bonds, the less the households' demand for these bonds changes. Consequently, decreasing the degree of capital mobility leads to less real exchange rate appreciation, implying less crowding-out of the trade balance and thus a higher fiscal multiplier.

The rest of this paper is organized as follows. Section 2 presents the derivation of the model. Section 3 shows its calibration, and Section 4 presents the main results. In Section 5, we discuss the transmission mechanism of the fiscal policy shock. We turn to the role of economic openness for the determination of the fiscal multiplier in Section 6. Section 7 concludes.

2 Model

This section presents the main dynamic model. The model is a standard New-Keynesian small open economy model with Rotemberg price stickiness, and its only departure in this respect is the introduction of good-specific habit formation in consumption and government spending along the lines of Ravn et al. (2006, 2012). Such a model is useful as we lay our focus on trade openness, capital mobility and the exchange rate regime and hereby mimic particular characterizations of small open economies such as Canada, Norway or New Zealand.[8]

The modeled economy consists of four building blocks. First, there is a representative household who maximizes its utility over both a bundle of domestic and foreign goods, which are internationally traded, and over leisure. The household's degree of home bias in consumption represents

[7]See Davig & Leeper (2011), Coenen, Erceg, Freedman, Furceri, Kumhof, Lalonde, Laxton, Lindé, Mourougane & Muir (2012) or Christiano, Eichenbaum & Rebelo (2011) for a discussion of the accommodation channel and its role for the transmission mechanism of fiscal policy shocks.

[8]Examples of similar models include McCallum & Nelson (2000), Devereux, Lane & Xu (2006) and Lim & McNelis (2008).

our measure of trade openness.[9] The household has access to domestic and foreign bonds. To model capital mobility, we introduce convex portfolio adjustment costs of foreign bonds as a part of the household's budget constraint. Second, there is a government which finances its consumption expenditures via a lump-sum tax.[10] Third, there is a continuum of monopolistically competitive producers who incur price adjustment costs. Fourth, we model a monetary authority following a standard interest rate rule targeting inflation, the output gap, and the exchange rate. In order to keep the model tractable, we assume that the (large) foreign economy is exogenous.

2.1 Households

Following Ravn et al. (2012), the representative domestic household consumes a composite good of domestically produced individual goods, $x^d_{c,t}$, and a composite good of foreign individual goods, $x^f_{c,t}$.[11] These two composite goods are combined to x^c_t, the final index which is an argument of the utility function of the household:

$$x^c_t = \left[\omega(x^d_{c,t})^{1-1/\xi} + (1-\omega)(x^f_{c,t})^{1-1/\xi}\right]^{1/(1-1/\xi)}. \quad (2.1)$$

It is an aggregator function with constant elasticity of substitution, as discussed by Dixit & Stiglitz (1977). Here, $\xi \in (1, \infty)$ denotes the elasticity of substitution between domestic and foreign goods. Parameter $\omega \in [0, 1]$ measures the relative importance of domestic goods in the consumption basket and has two interesting interpretations: First, it measures the degree of home bias in consumption. $\omega > 0$ indicates a home bias because otherwise, with a continuum of monopolistically competitive firms, the percentage of domestic goods in the consumption basket should be infinitely small. Second, $1-\omega$ can be seen as a natural measure of *trade openness* of the economy (i.e., the higher is ω, the more closed is the economy).[12] By construction, ω is unrelated to the actual substitutability of domestic and foreign goods with respect to observable features other than the country of origin. Think of people wanting to buy a domestically produced good rather than a foreign one just because it comes from their own country, even if the goods themselves are identical. In the case where domestic and foreign goods are perfect substitutes ($\xi \to \infty$ and hence $x^c_t \to \omega x^d_{c,t} + (1-\omega)x^f_{c,t}$), it is only the home bias, ω, and the prices which decide how the households allocate their budget across domestic and foreign goods.[13] On the other hand if $\xi \to 1$, meaning that domestic and foreign goods are complements, decreasing marginal utility attained both from consuming domestic goods

[9] By the term "home bias" we refer to household's preference for domestic over foreign goods.

[10] Government spending does neither yield utility to the households, nor does it serve as a productive input to the firms.

[11] Throughout the text, the following conventions in terms of notation will be met: The subscript t denotes the time period, the superscripts d and f denote that a variable belongs to the domestic or the foreign economy, respectively. That is, d (f) refers to goods produced by the domestic (foreign) economy. All variables are scalars, they are denoted in italics, and have a time period subscript. Constants/parameters are likewise denoted in italics but do not have a time subscript.

[12] In general, the parameter ω is comprised of two parts: (*i*) the extent of trade openness, ϑ; and (*ii*) the country size n. ω is then defined by $\omega \equiv \vartheta(1-n)$. We take a shortcut by assuming that we are in the limiting case in which $n \to 0$. A similar distinction between country size and trade openness is used, for example, in Gali & Monacelli (2005), Faia & Monacelli (2008) and Benigno & De Paoli (2010).

[13] In this extreme case where $\xi \to \infty$: If $\omega/(1-\omega) > P^d_t/(e_t P^f_t)$, the household buys domestic goods only.

and from consuming foreign goods implies that consumers want to consume a mix of domestic and foreign goods, even if their home bias is strong.

2.1.1 Habit formation

The distinctive feature of this economy from the traditional New Keynesian small open economy framework is that the household and the government form consumption habits over individual goods. The two composite goods $x^d_{c,t}$ and $x^f_{c,t}$, which together form the index x^c_t, are habit-adjusted. Habit-adjustment, besides the very utility function to be defined below, is a further component which directly affects the way the household derives utility from consumption. Following the example of Ravn et al. (2006, 2012), deep habits are formed at the level of each individual variety i of domestic and foreign goods. Habit formation is external to the individual household, meaning that households are trying to 'catch up with the Joneses'. Technically, we implement this mechanism by assuming that the habit stock of the domestic good of variety i, denoted by $s^d_{c,t}(i)$, creates a gap between $x^d_{c,t}(i)$ and $c^d_t(i)$. The latter denotes the actual (not habit-adjusted) amount of output of variety i consumed by the household. Sticking to the case of domestic goods for the explanation of the mechanism, each variety i belongs to the set $\{d\}$ of domestically produced goods. Let

$$x^d_{c,t} = \left\{ \int_0^1 \left[c^d_t(i) - \theta^c s^d_{c,t-1}(i) \right]^{1-1/\eta} \mathrm{d}i \right\}^{1/(1-1/\eta)}, \tag{2.2}$$

in which $\theta^c \in [0,1)$ measures the intensity of habit formation, and $\eta > 1$ denotes the elasticity of substitution across varieties. The mirror images are given with respect to exports, $c^{d\star}_t(i)$, and imports, $c^f_t(i)$. From a technical point of view, the *marginal utility* derived by the households from one unit of variety i increases with the habit stock built on variety i in the past. From an economic point of view, this gives the household an incentive to consume more of variety i today if it has consumed i yesterday. This mechanism has important implications on how firms set their markups, as we will discuss below. The habit stock evolves according to

$$s^d_{c,t}(i) = \rho s^d_{c,t-1}(i) + (1-\rho)\bar{c}^d_{c,t}(i). \tag{2.3}$$

$\bar{c}^d_{c,t}(i)$ is the average amount of output of variety i consumed per household and ρ measures the degree of habit persistence. Hence, for a given level of $x^d_{c,t}$, the household chooses $c^d_t(i)$ to minimize its total expenditure on domestic goods, $\int_0^1 P^d_t(i)c^d_t(i)\mathrm{d}i$, subject to equation (2.2). This yields the demand functions of the domestic household:

$$c^d_t(i) = \left(\frac{P^d_t(i)}{P_t} \right)^{-\eta} x^d_{c,t} + \theta^c s^d_{c,t-1}(i), \tag{2.4}$$

$$c^f_t(i) = \left(\frac{e_t P^f_t(i)}{P_t} \right)^{-\eta} x^f_{c,t} + \theta^c s^f_{c,t-1}(i). \tag{2.5}$$

The former equation is the household's demand for the domestic good, and the latter shows the demand for the foreign good of variety i (i.e., the demand for imports). This latter equation is derived analogously to its domestic counterpart, as households form habits for foreign goods in the same manner as for domestic goods. Note that the price elasticity of demand $\epsilon_t^{c,j}(i) = -[\partial c_t^j(i)/\partial p_t(i)][p_t(i)/c_t^j(i)]$ for $j \in \{d, f\}$ is time-dependent. In the symmetric equilibrium, we have $\epsilon_t^{c,j} = \eta(1 - \theta^c c_{t-1}^j / c_t^j)$. This is in contrast to models without deep habit formation, where $\theta^c = 0$, so that the price elasticity of demand is constant and equal to η. As will be shown in Section 2.3, the time-varying nature of the price elasticity has important implications for the price setting behavior of the firms.

The expenditure of the household in period t to cover its habits carried over from $(t-1)$ amount to $\varpi_{c,t}^d = \theta^c \int_0^1 P_t^d(i) s_{c,t-1}^d \mathrm{d}i$ and $\varpi_{c,t}^f = \theta^c \int_0^1 e_t P_t^f(i) s_{c,t-1}^f \mathrm{d}i$, and it holds that $P_t^d x_{c,t}^d + \varpi_{c,t}^d = P_t^d c_t^d$ and $e_t P_t^f x_{c,t}^f + \varpi_{c,t}^f = e_t P_t^f c_t^f$. The household takes this amount as given for its decision at time t.

2.1.2 Utility maximization

The household chooses a set of variables $\mathcal{H} = \left\{ x_{c,t}^d,\ x_{c,t}^f,\ h_t,\ B_t^d,\ B_t^f \right\}$ in order to maximize the present value of its present and future utility $U_t(x_t^c, h_t)\ \forall\ t \in [0, \infty)$ subject to a budget constraint

$$
\begin{aligned}
\max_{\mathcal{H}} \quad & \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[\frac{(x_{t+j}^c)^{1-\sigma} - 1}{1-\sigma} - \psi \frac{h_{t+j}^{1+\phi}}{1+\phi} \right] \right\}, \qquad 0 < \phi; \quad 0 \le \sigma, \psi; \quad 0 < \beta < 1, \\
\text{s.t.} \quad & P_t^d x_{c,t}^d + \varpi_{c,t}^d + e_t P_t^f x_{c,t}^f + \varpi_{c,t}^f + P_t (B_t^d + e_t B_t^f) = \\
& W_t h_t - T_t + P_{t-1}(R_{t-1} B_{t-1}^d + e_t R_{t-1}^\star B_{t-1}^f) - \frac{\chi}{2} P_t (e_t B_t^f)^2 + \mathcal{F}_t\,,
\end{aligned}
$$

in which β is the discount factor, σ is the intertemporal elasticity of substitution, and ϕ is the inverse labor supply elasticity. ψ gives the weight of disutility the household derives from working. Households divide their total time endowment, $l_t + h_t = 1$, into leisure, l_t, and hours worked, $h_t \in (0, 1)$. B_t^d is a one-period domestic bond, which is not traded internationally and is in zero net supply at the domestic household level. B_t^f is a traded one-period foreign bond denominated in the foreign currency. P_t^d denotes the price of the domestic composite good, P_t^f is the price of the foreign composite good, P_t the domestic consumer price index, e_t the nominal exchange rate (in price notation), W_t the nominal wage rate, T_t a lump-sum tax, R_t the domestic interest rate, $R_t^\star$ the foreign interest rate, and $\mathcal{F}_t$ the profits of domestic firms.[14] All prices are denoted in domestic currency.

Following Schmitt-Grohé & Uribe (2003), it is costly for the household to hold foreign bonds, a circumstance which is modeled by a term that is convex-increasing in foreign bonds and weighted by $\chi > 0$. The parameter χ serves as a measure of *capital mobility* (where the lower χ, the more capital is mobile). This convex portfolio adjustment cost function also serves to induce stationarity into the foreign debt process and to close the small open economy model.[15] Note that these portfolio

[14]The superscript $\star$ denotes throughout the paper that a variable or parameter belongs to the foreign economy. In particular, foreign demand for domestic goods is denoted with the $\star$ superscript. $\mathbb{E}_t$ stands for the expected present value at time period t of a function of future values.

[15]This approach comes to use in related papers with small open economy models, such as Pierdzioch (2004), Devereux et al. (2006) and Punzi (2013). Schmitt-Grohé & Uribe (2003) show that portfolio adjustment costs are one way among others (e.g., endogenous discount rate, debt elastic interest rate, complete asset markets) to get rid of the unit root problem of net foreign assets in small open economy models. Most importantly, all approaches to eliminate this unit root problem

costs are a dead-weight loss to the economy; they are not redistributed, a feature which will show up in the general equilibrium condition of the model.

Together with the necessary transversality conditions to prevent the household from engaging in Ponzi schemes,[16] the *deflated* first-order conditions of the representative household can be expressed as

$$(x_t^c)^{1/\xi-\sigma}\omega(x_{c,t}^d)^{-1/\xi} = \lambda_t p_t^d \quad (2.6)$$
$$(x_t^c)^{1/\xi-\sigma}(1-\omega)(x_{c,t}^f)^{-1/\xi} = \lambda_t rer_t p_t^f \quad (2.7)$$
$$\psi h_t^\phi = \lambda_t w_t \quad (2.8)$$
$$\lambda_t = \beta R_t \mathbb{E}_t\left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right) \quad (2.9)$$
$$\lambda_t = \beta\frac{R_t^\star}{1+\chi b_t^f}\mathbb{E}_t\left(\frac{e_{t+1}\lambda_{t+1}}{e_t\pi_{t+1}}\right), \quad (2.10)$$

in which rer_t represents the real exchange rate, and $b_t^f = e_t B_t^f$ are the real foreign bond holdings by domestic households.[17]

2.2 Government

The domestic government forms deep habits of consumption at the level of each variety i, analogously to the household. Following Ravn et al. (2012), this assumption is motivated by situations in which the provision of a public good in one community, like for example garbage collection, street lightning or traffic signals, creates the desire for these public services in another community.[18] Hence we have:

$$x_{g,t}^d = \left\{\int_0^1 \left[g_t(i) - \theta^g s_{g,t-1}^d(i)\right]^{1-1/\eta} \mathrm{d}i\right\}^{1/(1-1/\eta)}. \quad (2.11)$$

In contrast to the household however, the government consumes domestically produced goods only.[19] $x_{g,t}^d$ denotes the habit-adjusted composite good, while $g_t(i)$ represents the actual amount of variety i that is consumed. The habit stock evolves according to

$$s_{g,t}^d(i) = \rho s_{g,t-1}^d(i) + (1-\rho)g_t(i). \quad (2.12)$$

The government does not buy or issue any bonds and finances its expenditures by lump-sum taxes, hence $T_t = P_t^d g_t$. Then, by integrating over all the varieties i, one obtains the amount of total

deliver virtually identical dynamics at business cycle frequencies, as measured by unconditional second moments and impulse response functions.

[16]The transversality conditions is given by $\lim_{t\Rightarrow\infty}\beta^t\Omega_{t+1}\Lambda_t = 0$, with $\Omega_t = B_{H,t} + S_t B_{F,t}$.

[17]In order to deflate the model, we make the following definitions: $\lambda_t = \Lambda_t P_t$, where Λ_t is the Lagrange multiplier, $W_t = w_t P_t$, $p_t^f = P_t^f/P_t$, $rer_t = e_t P_t^\star/P_t$, $b_t^f = e_t B_t^f$, and $\pi_{t+1} = P_{t+1}/P_t$.

[18]This is equivalent to a setup in which households value government expenditures in a way separable to the consumption of private goods and leisure and form deep habits on the publicly provided goods. The same assumption is also used for example in Cantore et al. (2012), Zubairy (2014a), Zubairy (2014b) or Jacob (2015).

[19]Trionfetti (2000) and Brülhart & Trionfetti (2004) report that governments appear to import significantly less than the private sector does, i.e., there is substantial evidence of stronger home bias in government than in private consumption for OECD economies. The assumption that $x_{g,t}^d$ is completely home-biased is frequently used, for instance in Pierdzioch (2004) and Gali & Monacelli (2008).

government spending

$$P_t^d g_t = \int_0^1 P_t^d(i) g_t(i) \mathrm{d}i. \tag{2.13}$$

Cost minimization yields a demand function which is analogous to the one of the representative household:

$$g_t(i) = \left(\frac{P_t^d(i)}{P_t}\right)^{-\eta} x_{g,t}^d + \theta^g s_{g,t-1}^d(i). \tag{2.14}$$

The habit-adjusted government consumption, $x_{g,t}^d$, follows an exogenous AR(1)-process with $|\gamma^g| < 1$ and $\epsilon_{g,t} \sim \mathcal{N}(0, \sigma_g^2)$:

$$x_{g,t}^d = \gamma^g x_{g,t-1}^d + (1-\gamma^g)\bar{x}_g^d + \varepsilon_t^g. \tag{2.15}$$

Hence, when deciding to increase its expenditures, the government takes habit formation into account.[20]

2.3 Firms

There is imperfect competition among the goods-producing firms as in Chari, Kehoe & McGrattan (2002), and firms face nominal rigidities in the form of price adjustment costs following Rotemberg (1982).[21] Each firm i is a monopolistic producer of a good of variety i, using linear technology with labor (hours worked) as the only input, so its individual output $y_t(i)$ at time t equals $h_t(i)$. Firms do not price discriminate between the domestic and export market, which means that the law of one price holds for all goods at all times.[22] Total domestic demand for variety i amounts to the consumption demand arising from the domestic households, $c_t^d(i)$, from the foreign economy (i.e., exports), $c_t^{d\star}(i)$, and from the domestic government, $g_t(i)$, which is expressed by $y_t(i) = h_t(i) = c_t^d(i) + c_t^{d\star}(i) + g_t(i)$. Note at this point that due to portfolio holding costs of the household, and price adjustment costs of the firm, total demand of goods in the domestic economy amounts to

$$h_t = c_t^d + g_t + c_t^{d\star} + \frac{\chi}{2}\left(b_t^f\right)^2 + \frac{\varphi_p}{2}\left(\pi_t^d - 1\right)^2 h_t. \tag{2.16}$$

Firm i sets its price $P_t^d(i)$, which is denoted in domestic currency.[23] When the firm decides to change its price, it faces a quadratic price-adjustment costs as proposed by Rotemberg (1982). The

[20] Note that this is in contrast to Ravn et al. (2012), who impose a stochastic shock to *non-adjusted* government consumption. The latter implies that the government chooses to increase its expenditures on each variety i of goods by a given percentage. We have tested this variant within our model. The results are consistent to our assumption, both concerning the dynamics of the benchmark of as well as the comparison of the fiscal multiplier for the different scenarios of economic openness (as presented in section 6).

[21] Up to a first order, Rotemberg and Calvo pricing deliver similar Phillips curves and aggregate dynamics of inflation are equivalent.

[22] This assumption is common in the literature, see for example Gali & Monacelli (2005), Benigno & De Paoli (2010) or Corsetti, Meier & Müller (2012a).

[23] We assume "producer currency pricing", which implies complete exchange rate pass-through. Betts & Devereux (2001) find that the degree of pass-through is relatively unimportant for the international transmission mechanism of fiscal shocks, making this assumption frequently used in the open economy literature.

cost function (in nominal terms) is given by

$$\frac{\varphi_p}{2}\left(\frac{P_t^d(i)}{P_{t-1}^d(i)}-1\right)^2 P_t^d h_t, \tag{2.17}$$

in which $\varphi_p > 0$ determines the degree of nominal price rigidity and h_t denotes total aggregate supply in the symmetric equilibrium.[24] As the firm makes its price-setting decision, it takes into account the demand functions and the laws of habit stock evolution of the domestic and foreign households and the government. This is crucial for the model's predictions concerning the effects of a fiscal expansion, as it induces firms to react to changes in aggregate demand by moving markups in a counter-cyclical fashion. We will now explain the mechanism of counter-cyclical markups in more detail.[25]

Each firm i faces an individual demand function (as in equations (2.4), (2.5)) of the form

$$c_t^d(i) = \left(\frac{P_t^d(i)}{P_t}\right)^{-\eta} x_{c,t}^d + \theta^c s_{t-1}^d(i). \tag{2.18}$$

This individual demand is the sum of a price-elastic component, $\left(\frac{P_t^d(i)}{P_t}\right)^{-\eta} x_{c,t}^d$, and a price inelastic component, $\theta^c s_{t-1}^d(i)$. The elastic component is proportional to the aggregate demand of the current period, y_t, while the inelastic component stems from the habit formation of past periods. Therefore, the price elasticity of the individual demand function that firm i faces is a weighted average of η and 0. As a result of an increase in current aggregate demand at time t (caused by a fiscal expansion), the weight of the elastic component increases, making the individual demand function more price-elastic. In other words, the price elasticity of individual demand is pro-cyclical. This provides a clear intra-temporal incentive for the firm to charge a counter-cyclical markup.

In addition, there is an inter-temporal incentive: As firms anticipate that the habit stock is a weighted average of past sales, they face a dynamic profit maximization problem. By decreasing the markup today, a firm can acquire 'new customers' which will return tomorrow as they will be 'bound to their own habits.' As the results will show, this inter-temporal incentive is strengthened by the phase of transition after a fiscal shock, and firms are even able to slightly increase their markup above the steady state level for a few periods, and hereby partly compensate for the initial drop in the markup.

Firm i maximizes its expected future discounted profit function, taking into account the individual demand functions for each of the goods, $c_t^d(i), g_t(i)$ and $c_t^{d\star}(i)$, by choosing the optimal levels of a set of variables $\mathcal{S} = \left\{P_t^d(i), c_t^d(i), g_t(i), c_t^{d\star}(i), s_{c,t}^d(i), s_{g,t}^d(i), s_{c,t}^{d\star}(i)\right\}$, taking as given $\Phi_{0,t}$, W_t, P_t^d, $P_t^{d\star}$, c_t^d, g_t, $c_t^{d\star}$, and the initial conditions $s_{c,-1}^d(i), s_{g,-1}^d(i)$, and $s_{c,-1}^{d\star}(i)$:

$$\max_{\mathcal{S}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Phi_{0,t}\left\{[P_t^d(i) - W_t]\cdot \underbrace{[c_t^d(i) + g_t(i) + c_t^{d\star}(i)]}_{=y_t(i)} - \frac{\varphi_p}{2}\left(\frac{P_t^d(i)}{P_{t-1}^d(i)}-1\right)^2 P_t h_t\right\}.$$

[24] Price adjustment costs of this type are used in similar settings for example by Dedola & Leduc (2001) and Devereux et al. (2006). Note that these price adjustment costs are not a tax, but a dead-weight loss to the economy (think of menu-costs, contracts that are costly to be changed, etc.)

[25] See Ravn et al. (2012) for a more detailed exposition.

The first-order conditions of the symmetric equilibrium are then given by

$$\begin{aligned} 0 &= p_t^d y_t - \varphi_p \left(\pi_t^d - 1\right) \pi_t^d h_t \;-\; \eta \left[\nu_{c,t}(c_t^d - \theta^c s_{c,t-1}^d) \right. \\ &\quad \left. + \nu_{g,t}(g_t - \theta^g s_{g,t-1}^d) + \nu_{c,t}^\star (c_t^{d\star} - \theta^\star s_{c,t-1}^{d\star}) \right] \\ &\quad + \beta \varphi_p \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}^d \left(\pi_{t+1}^d - 1\right) h_{t+1} \right] \end{aligned} \tag{2.19}$$

$$w_t = p_t^d - \nu_{c,t} - (1-\rho)\varrho_{c,t} \tag{2.20}$$

$$w_t = p_t^d - \nu_{g,t} - (1-\rho)\varrho_{g,t} \tag{2.21}$$

$$w_t = p_t^d - \nu_{c,t}^\star - (1-\rho)\varrho_{c,t}^\star \tag{2.22}$$

$$\varrho_{c,t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{c,t+1} - \theta^c \nu_{c,t+1}\right) \right] \tag{2.23}$$

$$\varrho_{g,t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{g,t+1} - \theta^g \nu_{g,t+1}\right) \right] \tag{2.24}$$

$$\varrho_{c,t}^\star = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{c,t+1}^\star - \theta^\star \nu_{c,t+1}^\star\right) \right], \tag{2.25}$$

for which we define $\pi_t^d = P_t^d / P_{t-1}^d$, $\lambda_{t+1} = \Lambda_{t+1} P_{t+1}$, and $W_t = w_t P_t$. Again, Λ_t is the Lagrange multiplier of the representative household's optimization problem. It is related to the firm's discount factor by assuming that $\Phi_{0,t} = \beta^j \Lambda_t / \Lambda_0$. Further, $\nu_{c,t}$, $\nu_{g,t}$, $\nu_{c,t}^\star$, $\varrho_{c,t}$, $\varrho_{g,t}$, and $\varrho_{c,t}^\star$ are the Lagrange multipliers of firm i's optimization problem. Note that, since initial habit stocks are assumed to be identical across different varieties, all domestic firms will charge the same price in a symmetric equilibrium. It follows that in equilibrium, all prices and consumption quantities will be the same across varieties i. In the following, we define the real markup per unit of output that the producer gets in the symmetric equilibrium as $\mu_t \equiv p_t^d - w_t$.

2.4 Monetary policy

The domestic monetary authority sets the nominal interest rate following a Henderson-McKibbin-Taylor type of a policy rule.[26] Following Monacelli (2004), the rule is specified in a way that is consistent with the present open economy framework. The following equation describes the target for the nominal interest rate, $\bar{R}_t$:

$$\bar{R}_t = \bar{R} \left(\frac{P_t}{P_{t-1}}\right)^{\gamma_\pi} \left(\frac{y_t}{\bar{y}}\right)^{\gamma_y} \left(\frac{e_t}{e_{t-1}}\right)^{\frac{\gamma_e}{1-\gamma_e}}. \tag{2.26}$$

In a setting with active monetary policy, the central bank adjusts the nominal interest rate by putting a weight to *current* inflation ($\gamma_\pi \geq 1$), deviations from steady state output ($\gamma_y \geq 0$), and to changes in the nominal exchange rate ($\gamma_e \in [0,1)$).[27] A purely floating exchange rate regime is characterized by $\gamma_e = 0$. For any value of $\gamma_e \in (0,1)$ the exchange rate arrangement resembles a managed floating

[26] The rule is based on Henderson & McKibbin (1993) and Taylor (1993) and has found application in the open economy context as for example Kollmann (2002), Monacelli (2004) or Devereux et al. (2006).

[27] We assume that the central bank targets the price change between the previous period and today. Schmitt-Grohé & Uribe (2007) show that there are no welfare gains from targeting expected future values of inflation as opposed to current or lagged values of these macroeconomic indicators.

regime. The central bank achieves a strict peg by setting $\gamma_e \to 1$. In the steady state, the target interest rate equals $\bar{R}$. Following Monacelli (2004), the monetary authority has the desire to smooth changes in the nominal interest rate at a rate ρ_r such that the determination of the actual short-term nominal interest rate, R_t, can be described as follows,

$$R_t = (\bar{R}_t)^{1-\rho_R} (R_{t-1})^{\rho_R}. \tag{2.27}$$

With this rule, the central bank sets a long-run target for CPI inflation, output and the nominal exchange rate, and it adjusts the nominal interest rate as a feedback on short-run deviations from this target:

$$R_t = \left[\left(\frac{P_t}{P_{t-1}} \right)^{\gamma_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\gamma_y} \left(\frac{e_t}{e_{t-1}} \right)^{\frac{\gamma_e}{1-\gamma_e}} \bar{R} \right]^{1-\rho_R} (R_{t-1})^{\rho_R}. \tag{2.28}$$

2.5 Rest of the world

As in Clarida, Gali & Gertler (2001) and Gali & Monacelli (2005) among others, we treat the foreign country as large relative to the domestic economy. Consequently, the domestic economy has no effect on the steady state equilibrium conditions of the foreign economy. The foreign country has the dynamics of a closed economy.[28] The assumption that the law of one price holds at all times implies that the foreign goods price paid by domestic households equals the foreign currency price of foreign-produced goods, namely, $e_t P_t^f = e_t P_t^\star$. For simplicity, only the consumption of domestic goods by foreign households is part of the model (but not their consumption of foreign goods). The foreign households have the same preferences as the households in the domestic small open economy such that their consumption Euler equation must satisfy:

$$\left(x_{c,t}^{d\star} \right)^{-\sigma} = \beta R_t^\star \mathbb{E}_t \left[\frac{\left(x_{c,t+1}^{d\star} \right)^{-\sigma}}{\pi_{t+1}^\star} \right], \tag{2.29}$$

in which $\pi_{t+1}^\star = P_{t+1}^\star / P_t^\star$. Following the above mentioned literature, we represent the foreign prices $P_t^\star$ and consumption of domestic goods by foreign households $c_t^{d\star}$ by exogenous and independent AR(1)-processes,

$$z_t^\star = \gamma^{z\star} z_{t-1}^\star + (1 - \gamma^{z\star})\bar{z} + \epsilon_{z,t}^\star, \qquad \text{for} \quad z = x, \pi, \tag{2.30}$$

with $|\gamma^{z\star}| < 1$ and $\epsilon_{z\star,t} \sim \mathcal{N}(0, \sigma_{z\star}^2)$, and in which $x_{c,t}^{d\star}$ is the habit-adjusted composite good

$$x_{c,t}^{d\star} = \left\{ \int_0^1 \left[c_t^{d\star}(i) - \theta^\star s_{c,t-1}^{d\star}(i) \right]^{1-1/\eta} \mathrm{d}i \right\}^{1/(1-1/\eta)}. \tag{2.31}$$

[28] See for example Gali & Monacelli (2005), Divino (2009), Faia & Iliopulos (2011) and chapter 6.5 in Walsh (2010) for this approach.

Foreign households form habits over consumption of domestic goods at the level of each variety i, in the same manner as the domestic households do. The habit stock evolves according to

$$s_{c,t}^{d\star}(i) \quad = \quad \rho s_{c,t-1}^{d\star}(i) + (1-\rho) c_t^{d\star}(i). \tag{2.32}$$

The foreign household minimizes its expenditure $\int_0^1 c_t^{d\star}(i) P_t^{d\star}(i)/e_t \mathrm{d}i$, which gives rise to a demand function for variety i of the following form:[29]

$$c_t^{d\star}(i) \quad = \quad \left(\frac{P_t^{d\star}(i)}{e_t P_t^\star}\right)^{-\eta} x_{c,t}^{d\star} + \theta^\star s_{c,t-1}^{d\star}(i). \tag{2.33}$$

2.6 Price Level and Inflation

We follow Cantore et al. (2012) and do not distinguish between habit formation of the government and the households, that is we set $\theta^c = \theta^g = \theta^\star = \theta$. This implies that in equilibrium $\nu_c = \nu_g = \nu$ and $\varrho_c = \varrho_g = \varrho$.[30]

Similarly to Ravn et al. (2012), we define the consumer price index (CPI), P_t, as an expenditure weighted average of the prices of the composite goods:

$$P_t = \gamma P_t^d + (1-\gamma) e_t P_t^f, \qquad \text{for which} \qquad \gamma = \frac{\bar{P}^d(\bar{c}_c^d + \bar{g})}{\bar{P}^d(\bar{c}_c^d + \bar{g}) + \bar{e}\bar{P}^f \bar{c}_c^f}. \tag{2.34}$$

Hence, by defining $p_t^d = P_t^d / P_t$ and with the law of one price, the definition of the domestic real exchange rate ($rer_t = e_t P_t^\star / P_t$) can be used to find:

$$1 \quad = \quad \gamma\, p_t^d + (1-\gamma)\, rer_t. \tag{2.35}$$

The inflation rate of the domestic CPI, $\pi_t = P_t / P_{t-1}$, is related to the price of the domestic good as follows:

$$\pi_t^d \quad = \quad \frac{P^d}{P_{t-1}^d} \quad = \quad \frac{p_t^d P_t}{p_{t-1}^d P_{t-1}} \quad = \quad \frac{p_t^d}{p_{t-1}^d}\pi_t \quad \Rightarrow \quad p_t^d \quad = \quad \frac{\pi_t^d}{\pi_t} p_{t-1}^d. \tag{2.36}$$

The inflation rate of the foreign CPI reads $\pi_t^\star = P_t^\star / P_{t-1}^\star$. The foreign CPI influences the domestic CPI. The two are linked by

$$rer_t \quad = \quad \frac{e_t \pi_t^\star}{e_{t-1}\pi_t} rer_{t-1}. \tag{2.37}$$

2.7 Market clearing

In the equilibrium, all domestic households are identical and there is zero net-supply of domestic bonds, $B_t^d = 0$. The net return which the domestic economy attains from foreign bond holdings must equal the trade balance (TB_t). Expressed in real terms it must hold that

$$b_t^f \quad = \quad \frac{e_t}{e_{t-1}\pi_t} R_{t-1}^\star b_{t-1}^f \underbrace{+ p_t^d c_t^{d\star} - rer_t c_t^f}_{\equiv TB_t}. \tag{2.38}$$

[29] Note that as the foreign economy is large relative to the domestic small open economy, we have that foreign domestic prices $P_t^{d\star}$ are equal to the foreign CPI $P_t^\star$.

[30] As shown by Gali (1996), if this assumption is relaxed there exists the risk of multiple equilibria.

Aggregate private consumption is the sum of domestically produced goods and imports, $P_t c_t = P_t^d c_t^d + e_t P_t^f c_t^f$. The trade balance in nominal terms is given by the difference between exports and imports

$$TB_t \quad = \quad P_t^d c_t^{d\star} - e_t P_t^f c_t^f. \tag{2.39}$$

Adding up the budget constraint from the household, the firm and the government, the aggregate market clearing equation can be written as follows:

$$P_t^d y_t = P_t^d c_t^d + e_t P_t^f c_t^f + P_t^d g_t + TB_t + P_t \frac{\chi}{2} \left(b_t^f\right)^2 + P_t^d \frac{\varphi_p}{2} \left(\frac{P_t^d}{P_{t-1}^d} - 1\right)^2 y_t. \tag{2.40}$$

2.8 Definition of equilibrium

Let us define the competitive general equilibrium of the present model as follows:[31]

Definition. *Given the sequence of the stochastic shocks $\mathcal{Z}_{t=0}^{\infty} = \{\epsilon_{g,t}, \epsilon_{x,t}^{\star}\}_{t=0}^{\infty}$ an equilibrium allocation of this economy is a sequence of prices $\mathcal{P}_{t=0}^{\infty} = \{P_t, P_t^d, P_t^f, P_t^{\star}, e_t, R_t, R_t^{\star}, W_t\}_{t=0}^{\infty}$, and quantities $\mathcal{Q}_{t=0}^{\infty} = \{\Lambda_t, \nu_t, \nu_t^{\star}, \varrho_t, \varrho_t^{\star}, c_t^d, c_t^f, g_t, c_t^{d\star}, s_{c,t}^d, s_{c,t}^f, s_{g,t}^d, s_{c,t}^{\star}, B_t^d, B_t^f, \mu_t, x_t^c, x_{c,t}^d, x_{c,t}^f, x_{c,t}^{d\star}, x_{g,t}^d, y_t, h_t\}_{t=0}^{\infty}$ satisfying the following conditions: (i) the household's allocation solves its optimization problem; (ii) the prices of the monopolistically competitive firms solves their profit maximization problem; (iii) the market-clearing conditions hold; (iv) the government chooses its spending rule and (v) the monetary authority chooses an exchange rate policy.*

3 Calibration and Multipliers

In order to solve the nonlinear stochastic general equilibrium model, we take a first-order linear approximation around the (zero-inflation) non-stochastic steady state.[32] We have used values for the structural parameters which are common in the open economy literature.[33] The benchmark calibration is reported in Table 1. Time is measured in quarters.

3.1 Calibration

Structural parameters. The discount factor β is such that the annual steady state interest rate amounts to 4 per cent. We follow Gali & Monacelli (2005) by setting the parameter of relative risk aversion, $\sigma = 1$, and the inverse of the Frish labor supply elasticity, ϕ, to 3. The parameters ψ and γ are implicit. ψ corresponds to the weight of hours worked in the utility function and is set such that agents devote $1/3$ of their total time endowment to work. γ is the weight of the domestic price level in the consumer price index. Following Faia & Iliopulos (2011), we set the elasticity of substitution

[31] Appendix A provides a detailed solution of the model and lists the complete set of model equations.
[32] For the simulation of the model, we use the DYNARE implementation for Matlab (http://www.dynare.org).
[33] See for example Clarida et al. (2001), Monacelli (2004), Gali & Monacelli (2005), or Faia & Iliopulos (2011).

Table 1: Parameter values or ranges

Description	Parameter	Value
Structural parameters		
Discount factor	β	0.990
Relative risk aversion	σ	1.000
Inverse Frish labor supply elasticity	ϕ	3.000
Price adjustment cost parameter	φ_p	55.000
Elasticity of substitution between differentiated goods	η	8.000
Elasticity of substitution (d vs. f)	ξ	1.500
Weight of domestic prices in CPI	γ	0.600
Weight of labor-disutility	ψ	600.000
Habit mechanism		
Habit persistence	ρ	0.850
Habit formation	θ	0.860
Openness parameters		
Openness preference	ω	$[0, 0.500, 1]$
Capital adjustment	χ	$[0, 0.0019, 0.01]$
Monetary policy		
Persistence (policy rule)	ρ_R	0.790
Inflation coefficient (policy rule)	γ_π	1.500
Output gap coefficient (policy rule)	γ_y	0.5/4
Exchange rate coefficient (policy rule)	γ_e	$\in [0, 1)$
Fiscal policy		
Share of government spending	s_g	0.200
Persistence in government process	γ^g	0.900
Steady state values		
Steady state hours worked	$\bar{h}$	1/3
Steady state inflation	$\bar{\pi}$	1.000

among the different varieties of goods in the domestic economy to $\eta = 8$, implying a steady state markup of 15%. We calibrate the parameter governing the price adjustment costs, ϕ_p, to generate the same degree of nominal rigidity as the standard Calvo price adjustment process. As Keen & Wang (2007) show, if η is equal to 8 and assuming a price adjustment on average after 4 quarters, then ϕ_p is roughly 55. The elasticity of substitution between domestic and foreign goods, ξ, is equal to 1.5. This value is also used in Ravn et al. (2012) and common in the analysis of business cycles.[34]

Habit mechanism. In order to calibrate the parameter values of the deep-habit mechanism we rely on the available literature by Ravn et al. (2006, 2012) and Cantore et al. (2012). We set the degree of habit persistence, ρ, to 0.85, and the value of habit formation, θ, to 0.86.

Economic openness. Our main interest is to examine the impact of economic openness on the fiscal multiplier in a New Keynesian model with deep habits. The first dimension of interest is the degree of *trade openness* (i.e., the inverse of home bias in consumption). For the benchmark calibration we follow Ravn et al. (2012) and set the degree of trade openness, $\omega = 0.5$. This value implies that households allocate the same fraction of their consumption basket to domestic and

[34] We have run simulations of the model for different calibrations, namely σ and ϕ ranging between $(1, 5)$ and η, ϕ_p and ξ set to 5, 25 and 3 respectively. Changing these structural parameters does not affect the qualitative implications of the results presented in Table 2.

foreign goods. This parametrization implies an import share in GDP of 40%, a value frequently used in the literature.[35] To study the effect of trade openness we consider two extreme cases: (*i*) the economy has 100% home bias when ω converges to 1. In that case we call it a *zero trade* economy; (*ii*) when there is no home bias, i.e., $\omega \to 0$, households only consume foreign goods. This extreme case is called a *100% trade* economy. A further dimension of economic openness is the *mobility of capital*, which is characterized by the parameter χ. Here we take the value used in Kollmann (2002) for the benchmark simulation and set $\chi = 0.0019$. This corresponds to a dead weight loss of 0.1% of foreign bond holdings.[36] International bond markets are perfectly integrated, i.e., we have *high capital mobility* when $\chi \to 0$. As a benchmark for *low capital mobility*, we assume a dead weight loss of 0.5%, that is, $\chi = 0.01$.[37]

Monetary policy. The third dimension of economic openness is characterized by the *degree of exchange rate targeting* by the central bank. We define a *floating exchange rate regime* by calibrating $\gamma_e = 0$. This is a classical characterization of a monetary policy rule with which the central bank only targets deviations in inflation and output. We call it an *exchange rate peg*, when $\gamma_e \to 1$. Here, the central bank's target is to maintain changes in the nominal exchange rate constant. As to the further parameters in the monetary policy rule, we follow the existing literature such as Taylor & Woodford (1999) and set the response to inflation, γ_π, to 1.5 and the response to output, γ_y to $0.5/4$. The degree of interest rate smoothing is $\rho_R = 0.79$ and taken from Chari et al. (2002).

Fiscal policy. The share of public consumption in output is equal to 20%. This value approximately corresponds to the mean of the government spending share in OECD economies. We are interested in the consequences of a fiscal policy shock, hence the process of g_t is the only stochastic source in the model which we consider. As in Cantore et al. (2012), we set the calibration of the exogenous process for government expenditures such that the parameter for auto-correlation, γ^g, is 0.9. The size of the fiscal policy shock equals 1 percent of steady state output.

In the steady state we have perfect price stability, i.e., $\bar{\pi} = 1$, which implies $\bar{P} = \bar{P}^d = \bar{P}^f = \bar{P}^* = \bar{e} = r\bar{e}r = 1$ and $\bar{R} = \bar{R}^* = 1/\beta$.

3.2 Fiscal multipliers

The fiscal multiplier measures how real GDP changes when government spending increases by one unit of domestic goods. For example, if a one-unit increase in government spending causes domestic real GDP to increase by half a unit, then the multiplier is 0.5. We follow Ilzetzki et al. (2013) for the calculation of two types of fiscal multipliers. On the one hand, we measure the change of real GDP to a an increase in government spending when the expenditure shock occurs at $t = 0$. We define

35 See for example Gali & Monacelli (2005) or Faia & Monacelli (2008).

36 Since capital adjustment costs equal $\frac{\chi}{2}\left(b_t^f\right)^2$, the share of foreign bond holdings which is lost equals $\frac{\chi}{2}(b_t^f)$.

37 Sutherland (1996) and Pierdzioch (2004) calibrate $\chi = 5$ for low capital mobility. This would correspond to a dead weight loss of 250%. We have tested our model also for values of χ equal to 1 and 5. The results for the fiscal multiplier remain both qualitatively and quantitatively unchanged. See also Figure 1.

the *impact multiplier* as:

$$\text{impact multiplier} = \frac{\Delta y_0}{\Delta g_0}. \tag{3.1}$$

On the other hand, we wish to be able to study the multiplier effect over a long forecast horizon. To this end we also report the *cumulative multiplier* obtained at horizon T:

$$\text{cumulative multiplier}(T) = \frac{\sum_{t=0}^{T} \Delta y_t}{\sum_{t=0}^{T} \Delta g_t}. \tag{3.2}$$

4 Results

Table 2 summarizes the main results of this paper. The impact and cumulative fiscal multipliers on aggregate output are displayed for different degrees of economic openness. If not stated otherwise, the calibration assumed corresponds to Table 1 and the exchange rate is floating.

Table 2: Economic openness and fiscal multipliers

		Fiscal Multiplier	
Economic Openness	Calibration	Impact	Cumulative
Floating exchange rates (Benchmark)	$\gamma_e = 0$	0.68	1.02
Exchange rate peg	$\gamma_e \to 1$	1.05	1.63
100% trade	$\omega \to 0$	0.73	0.99
Zero trade	$\omega \to 1$	0.78	1.47
High capital mobility	$\chi = 0$	0.66	0.71
Low capital mobility	$\chi = 0.01$	0.70	1.22

Notes: Impact multipliers are calculated at $T = 0$ and cumulative multipliers for $T = 20$, e.g., a 5-year horizon. The shock is a one-percent increase in g_0 (of domestic output). If not stated otherwise, we calibrate the model with $\gamma_e = 0, \omega = 0.5$ and $\chi = 0.0019$.

Impact multipliers lie in the range of 0.67 to 1.05, while cumulative multipliers mostly lie above one, which is consistent with conventional findings. We make three main observations: *First*, exchange rate flexibility clearly decreases the fiscal multiplier, both in the short and the long run. While the impact multiplier under flexible exchange rates is below one (0.68 for the benchmark calibration), it lies above one (1.05) under pegged exchange rates. The cumulative multiplier is 1.02 under flexible exchange rates and 1.63 when the exchange rate is pegged. This first finding is in line with the empirical evidence obtained by Ilzetzki et al. (2013) and Corsetti et al. (2012b), who find that the government spending multiplier is larger in countries which manage an exchange rate peg than in those with flexible exchange rates.

Second, the cumulative multiplier depends negatively on the degree of trade openness. When the economy is relatively closed with $\omega \to 1$, the cumulative multiplier amounts to 1.47. On the contrary, when $\omega \to 0$ and the economy is open with respect to trade, the cumulative impact of a fiscal policy shock amounts to 0.99. This finding is consistent with the traditional Mundell-Fleming model. Empirical evidence on trade openness and fiscal multipliers is limited. Ilzetzki et al. (2013) find in their empirical work that open economies have negative long run multipliers while closed economies have cumulative multipliers of around 1.1. At least qualitatively, our results are in line with these empirical findings.

Third, the degree of capital mobility has a diminishing effect on the cumulative fiscal multiplier. On impact, there is no notable difference. If capital mobility is low (e.g., $\chi = 0.01$), the cumulative multiplier amounts to 1.22 and is higher than in the benchmark. This finding is consistent with conventional wisdom but stands in contrast to the theoretical results obtained by Pierdzioch (2004), who claims that the output effect of a fiscal policy shock need not be lower in the case of high capital mobility.

Figure 1 illustrates these three main findings and displays the robustness of the results. The degree of trade openness (home bias) creates significant differences in the cumulative multiplier, but has only negligible effects on impact. In the closed economy, fiscal policy is more effective than in the open economy after 20 periods. The difference in fiscal effectiveness becomes even larger regarding capital mobility. If capital is highly mobile between the domestic and foreign economy ($\chi = 0$), the fiscal multiplier has a hump-shape below 0.8. In the case of low capital mobility, the cumulative multiplier is upward-sloping and lies above one after five periods. Under fixed exchange rates ($\gamma_e \to 1$), the cumulative fiscal multiplier exhibits a "hump-shaped" pattern, with its maximum between 10 and fifteen periods. When the central bank lets the exchange rate float, the cumulative multiplier is below one on impact and converges to unity after 10 periods.

5 Mechanism of a government expenditure shock

In this section, the dynamics that drive the fiscal multiplier will be discussed in detail. With regard to the research question, we lay special emphasis on the role of economic openness.

5.1 Dynamics in the benchmark

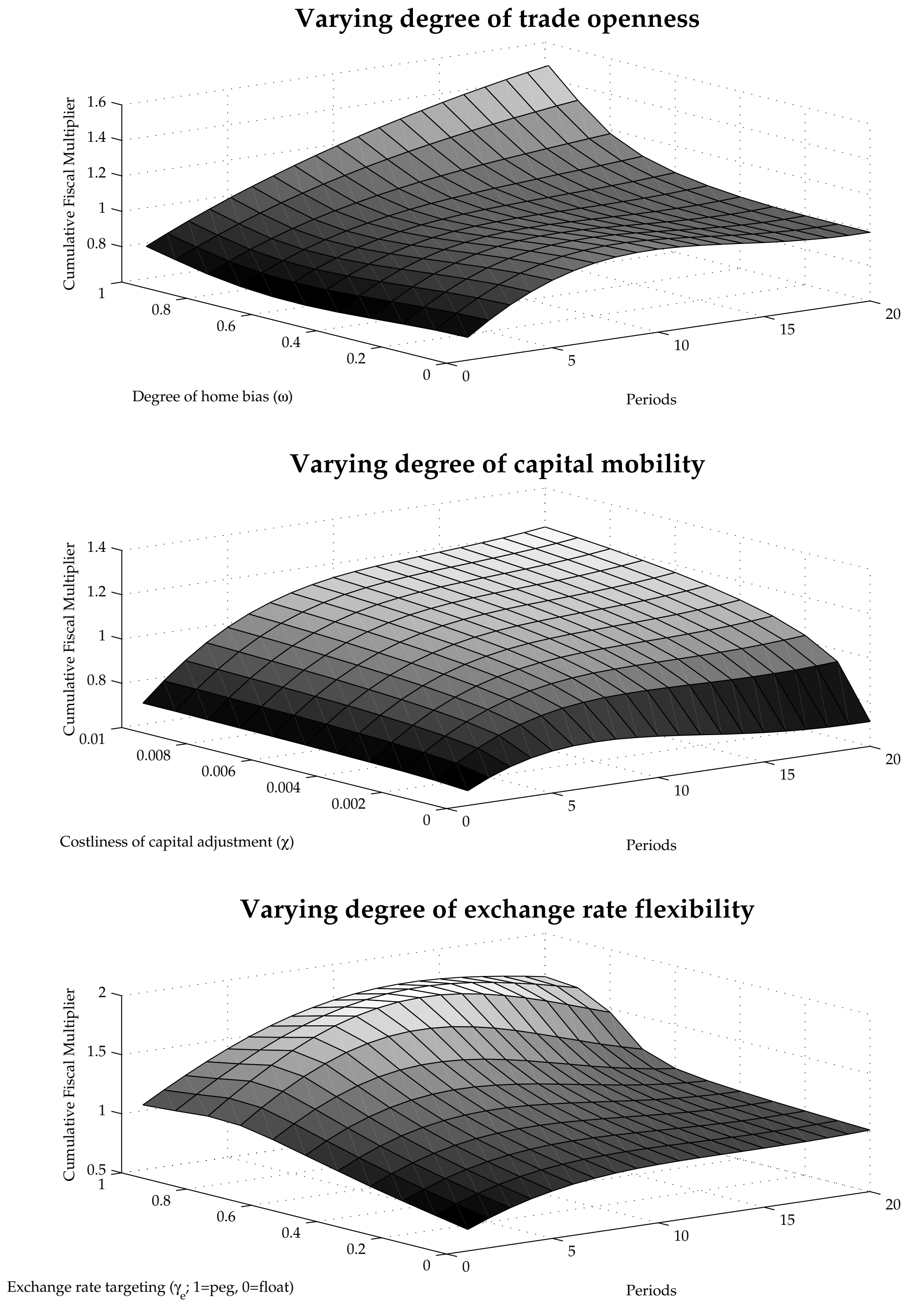
Figure 2 presents the impulse responses of aggregate demand and its components as well as a selection of other variables to a fiscal shock. The shock to government spending has a size of one percent of domestic output. The model is linearly approximated around the zero-inflation steady state and the impulse response functions (IRFs) represent level deviations from the steady state.[38] The central bank follows a conventional Taylor rule *without* exchange rate targeting. In a first step, we look at the model dynamics for the benchmark calibration given in Table 1.[39]

Following an increase in government expenditures, output increases. The dynamics of output exhibit a hump-shaped pattern. Both consumption and the trade balance 'crowd-out' the effect of the fiscal expansion. These dynamics of aggregate demand are consistent with the theoretical predictions of the traditional Mundell-Fleming model and in line with the reported evidence for

[38] This representation allows for a direct comparison of IRFs. Multipliers are presented in Tables 2 and 3 and Figure 1.

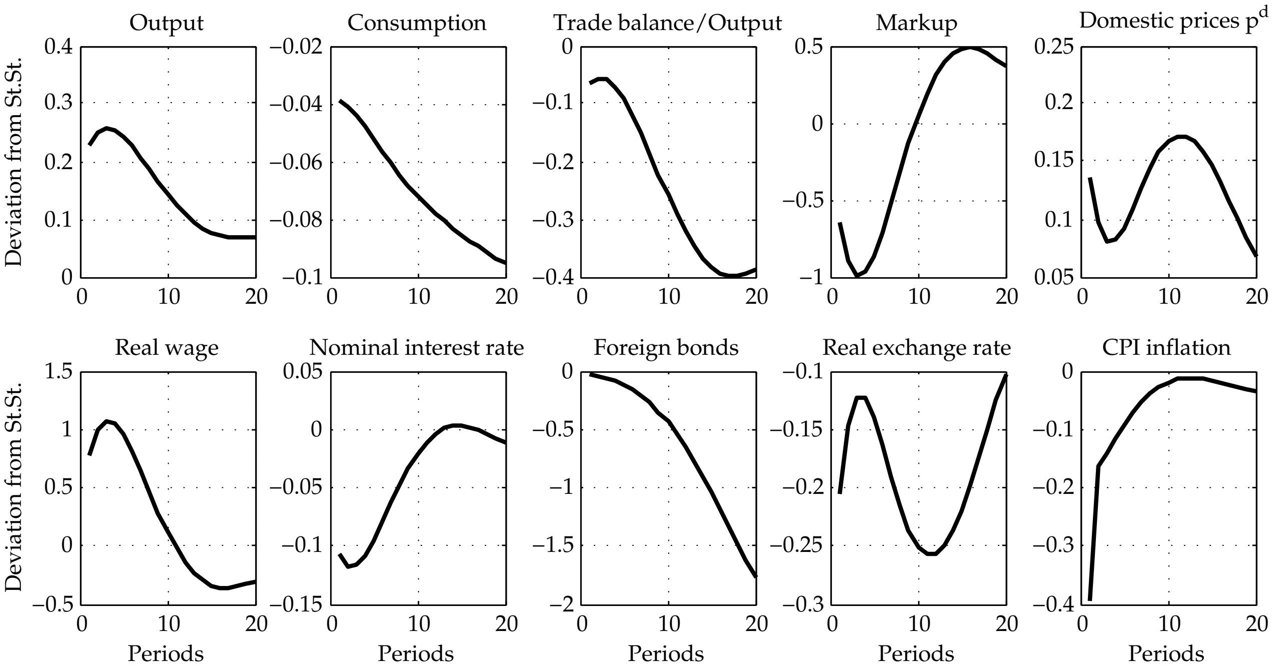
[39] The magnitude of the impulse responses is in line with the dynamics reported by Cantore et al. (2012).

Figure 1: Cumulative multiplier of output for different degrees of openness



Notes: Impact multipliers are calculated at $T = 0$ and cumulative multipliers for periods $T = 1 : 20$, e.g. a 5-year horizon. The shock is a one-percent increase in g_0 (of domestic output). If not stated otherwise, we calibrate the model with $\gamma_e = 0, \omega = 0.5$ and $\chi = 0.0019$. *Trade openness*: a higher value of ω implies lower trade openness. *Capital mobility*: a higher value of χ implies lower mobility of capital. *Exchange rate flexibility*: a higher value of γ_e implies lower flexibility.

Figure 2: Impulse response functions in the benchmark



Notes: Impulse responses show level deviations from steady state to a one percent increase in government expenditures (of domestic output). We scaled the IRFs up by 100 to facilitate the reading. The exchange rate is fully flexible, with $\gamma_e = 0$. The model is calibrated as in Table 1. As a reading example, consider the impulse response of output: An increase in government expenditures by one percent of domestic steady state output (equals 0.0033 units of domestic goods) raises output by 0.0023 units of domestic goods. This corresponds to an impact multiplier of 0.68, i.e., a percentage deviation from steady state of 68%.

countries with flexible exchange rates in Ilzetzki et al. (2013) and Corsetti et al. (2012b).[40] Markups react in a counter-cyclical fashion and decrease. The real wage and the level of domestic prices go up. This changes the terms of trade. Domestic households react by buying more foreign goods, while foreign consumers demand less of the domestic goods. The net inflow of goods corresponds to a net outflow of money such that the exchange rate appreciates. Ravn et al. (2012) identify these channels as the *pricing-to-habits and domestic-relative-price effects*.

The observed appreciation of the domestic currency outweighs the increasing prices of domestic goods, hence CPI inflation falls. Under flexible exchange rates, the central bank follows active monetary policy and reacts to changes in CPI inflation and output. It therefore lowers the nominal interest rate. The fall in the CPI together with the (less strongly) decreasing nominal interest rate leads to an increase in the real interest rate, which gives households an incentive to reduce their net foreign assets position. The demand for foreign bonds falls, capital flows into the domestic economy, so that the real exchange rate appreciates further. A similar behavior of the real exchange rate was also observed by Corsetti et al. (2012b) and Ilzetzki et al. (2013) and relates to the notion of monetary accommodation. With active monetary policy, the reaction of the monetary authority

[40] Note that we report a slightly negative consumption multiplier, which is in contrast to the dynamics reported in Ravn et al. (2012). As shown by Jacob (2015) their result is sensitive to the degree of nominal rigidities in the model and hinges on the assumption of non-separable preferences, which reduce the negative wealth effect of a fiscal expansion.

plays an important role in determining the expansionary effect of fiscal policy.[41]

We identify two main channels which are responsible for the generation of these dynamics. Both are related to the working of deep habits and the counter-cyclical markup. On the one hand we have a negative *wealth effect*, which is typical for business cycle models. On the other hand we have a *substitution effect*, which is due to the counter-cyclical firm markups. In the following we will discuss these two channels.

5.2 Wealth effect

A standard outcome of the traditional real business cycle literature is that an increase in government spending has a crowding-out effect on private consumption through its negative wealth effect on the household's budget.[42] As the government raises the tax rate in order to finance its expenditures, it takes resources away from each household. The government buys goods from the domestic firms and so consumes a fraction of total output. Yet, the goods bought by the government are not redistributed to the households or other agents in the economy such that they could be used in any utility-delivering or productive way.[43] Hence, households get poorer and therefore increase their work effort. Aggregate output increases in response. We can see in Figure 2 that consumption is crowded out, yet the effect is small. This implies that the negative wealth effect is partially compensated by the substitution effect, which is due to the counter-cyclical markups.

5.3 Substitution effect (counter-cyclical markups)

The role of counter-cyclical markups for the fiscal multiplier is linked to the mechanism of deep-habit formation which is explained in technical detail in Sections 2.1.1 and 2.3. In short, at the level of the individual good, i, the deep-habit mechanism implies that having consumed i in the past increases the marginal utility of future consumption of i for a given household. The monopolistically competitive firms take advantage and set the wage rate and the price of their goods such that their markups move in a counter-cyclical fashion. There are two reasons for this kind of behavior of the firms. First, they take into account the intra-temporal effect of an increase in aggregate demand, which raises the price elasticity of the demand each individual firm i faces. Second, by lowering today's markup, the firms can acquire customers that will return in the future.

As Figure 2 displays, it is mostly the changes in the real wage which affect the movements in the markup and to a lesser extent the changes in the price of domestic goods. These results are consistent with Ravn et al. (2012), who show that in response to a shock in government spending the markup of domestic firms decreases, a result which is mainly based on an increasing domestic wage rate (Ravn et al. (2012), Figures 3 and 4). Cantore et al. (2012) find that in response to a government

[41] See for example Davig & Leeper (2011) and Coenen et al. (2012) for discussions on how the effect of fiscal policy differs across the specification of monetary policy.

[42] See Baxter & King (1993) for a thorough investigation of the effect of fiscal spending on aggregate demand components using a standard real business cycle model.

[43] An alternative way of modeling is that households get direct utility from government expenditures, as it is done e.g. by Gali & Monacelli (2008).

spending shock, the real wage increases and does so virtually as a mirror image of the decreasing firm markup (Cantore et al. (2012), Figure 1). The 'deep' habit formation is the cornerstone of these kind of dynamics, as it introduces a substitution effect that is able to partly compensate the negative wealth effect of public absorption with respect to private consumption. The decline in markups shifts the labor demand curve outward, thereby increasing the real wage. In turn, households have an incentive to substitute consumption for leisure. The impact response of consumption in response to the fiscal shock may therefore be close to zero or only slightly negative.

In order to review the importance of the deep-habit mechanism for the output multipliers found in Table 2, it is worthwhile studying the case in which deep-habit formation is absent. If the intensity of habit formation, represented by the parameter θ, is turned down to zero, then the model goes back to a more classic mechanism. Table 3 reports the fiscal multipliers (impact and cumulative) under the benchmark calibration with deep-habit formation as in Table 2, and compares them to the case where deep-habit formation is absent ($\theta = 0$). Three observations stand out: (1) qualitatively, the degree of economic openness affects the multiplier similarly under all three specifications, although the effect is small when there is no deep habit formation; (2) without habit formation, $\theta = 0$, the fiscal multipliers are generally lower than in the benchmark, moreover the effectiveness of fiscal policy decreases with time under all calibrations; and (3) with formation but without persistence, $\theta = 0.86$, $\rho = 0$, the implications for the fiscal multiplier are similar to the benchmark, although quantitatively different.[44]

Table 3: Output multipliers and the role of the deep-habit mechanism

	Benchmark		**No formation $\theta = 0$**		**No persistence $\rho = 0$**	
Economic Openness	Impact	Cumulative	Impact	Cumulative	Impact	Cumulative
Floating exchange rates	0.68	1.02	0.20	0.18	0.46	1.19
Exchange rate peg	1.05	1.63	0.34	0.20	0.76	1.40
100% trade	0.70	0.99	0.21	0.18	0.53	1.19
Zero trade	0.70	1.10	0.43	0.32	0.59	1.93
High capital mobility	0.66	0.71	0.18	0.12	0.45	0.79
Low capital mobility	0.70	1.22	0.24	0.24	0.51	1.51

Notes: If not stated otherwise, the model calibration is as described in Table 1. The degrees of economic openness are calibrated as in Table 2. Impact multipliers are calculated at $T = 0$ and cumulative multipliers for $T = 20$. The shock is a one-unit increase in g_0.

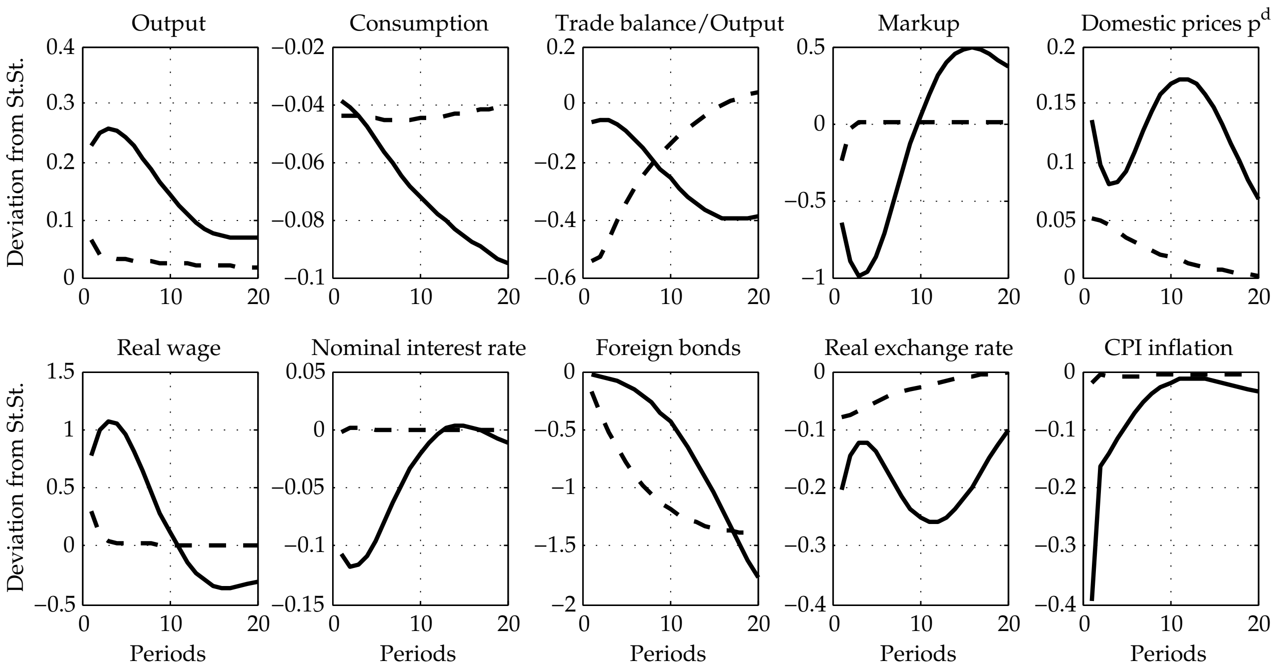
If agents do not form deep habits, then the demand which each individual firm i faces only depends on the price-elastic component. Suppose now domestic public expenditures increase. This shock causes aggregate demand to go up, but does not affect its price elasticity. Therefore, producers have less of an incentive to lower their markup than in the presence of habit formation. This incentive becomes even smaller as newly acquired customers cannot be inter-temporally bound to the producer. In turn, the upward shift in labor demand is smaller and the real wage does not

[44]As the persistence of habit formation is not the key driver of the model dynamics, rather the parameter on habit formation, θ, we restrict ourselves in the following to compare the case of no habit formation ($\theta = 0$) to the benchmark calibration.

increase by as much. The absence of habit formation diminishes the substitution effect on the fiscal multiplier.

Figure 3 illustrates the model dynamics when households do not form deep habits and compares them to the benchmark model. Taking a closer look at the components of aggregate demand, we can see that output reacts less strongly without deep habits. Further, although consumption falls more on impact, it falls less over time. Finally, the trade balance deteriorates more strongly on impact, converging back to zero after 20 periods. The dynamics of the trade balance are determined by the accommodation of the central bank and its effect on the real exchange rate. Without deep habits, CPI inflation only falls slightly. Therefore, the central bank does not lower the nominal interest rate by much. Nevertheless, the real interest rate increases by an amount that makes holding foreign bonds unattractive, hence capital flows into the domestic economy and the real exchange rate appreciates. As foreign goods become relatively cheaper, households shift their consumption towards the foreign good. Moreover, as the price of domestic goods increases, exports decrease. In turn, the trade balance deteriorates and crowds out the effect of the increase in government spending. In short, counter-cyclical markups and the formation of deep habits mitigate the negative wealth effect on the domestic households and lead consequently to more efficient fiscal policy.

Figure 3: Model dynamics with and without deep-habit formation



Notes: Solid lines for benchmark model with $\theta = 0.86$ and dotted lines for model without deep habits, $\theta = 0$.

One can ask the question whether it is true that real-world markups fall in response to a fiscal expansion. For example, Perotti (2008) provides evidence from several countries based on structural VARs (including the United States and the United Kingdom) which is consistent with the real wage increasing in response to a fiscal policy expansion. In the present model, similarly to the model of Ravn et al. (2012), the markup equals the inverse of the domestic real product wage. Therefore, real product wages which have been reported to increase in response to a positive government spending shock by Perotti (2008) are consistent with counter-cyclical markups.

6 Economic Openness

We characterize the degree of economic openness by three dimensions. First, the monetary authority controls the flexibility of the exchange rate through the Taylor rule. Second, trade openness is measured by the degree of home bias. The home bias parameter indicates how much weight the domestic households put on the domestic and the foreign good in its aggregate consumption bundle. Finally, we measure the degree of capital mobility by the cost which households incur to reallocate their portfolio of domestic and foreign bonds. As reported in Section 4, all dimensions of economic openness play an important role in determining the size of the fiscal multiplier. In the following, they will be discussed separately.

6.1 Exchange rate flexibility

A natural question arising from the empirical findings in Ilzetzki et al. (2013) is how the exchange rate regime affects the effectiveness of fiscal policy and whether a model is able to replicate the empirical fact that fiscal policy is more effective under pegged exchange rates than under a float.[45] As it is shown in Table 2, both the impact and the cumulative multipliers are significantly higher under fixed than under flexible exchange rates.

We compare the transmission mechanism of a fiscal policy shock for the two exchange rate regimes under consideration in Figure 4. Under floating exchange rates (solid lines), output reacts less strongly than under fixed exchange rates. Both the trade balance and (to a lesser extent) private consumption partly crowd out the effect of the fiscal expansion. These dynamics of aggregate demand are consistent with the reported evidence in Ilzetzki et al. (2013) and Ravn et al. (2012). If the exchange rate is pegged, the response of output (i.e., the impact multiplier) is larger than one.[46] The impact response of the trade balance is positive on impact, and the crowding-out of consumption is mitigated. This finding is related to (1) a currency effect and to (2) a subsequent intensification of the substitution effect described above.

6.1.1 Currency effect and exchange rate flexibility

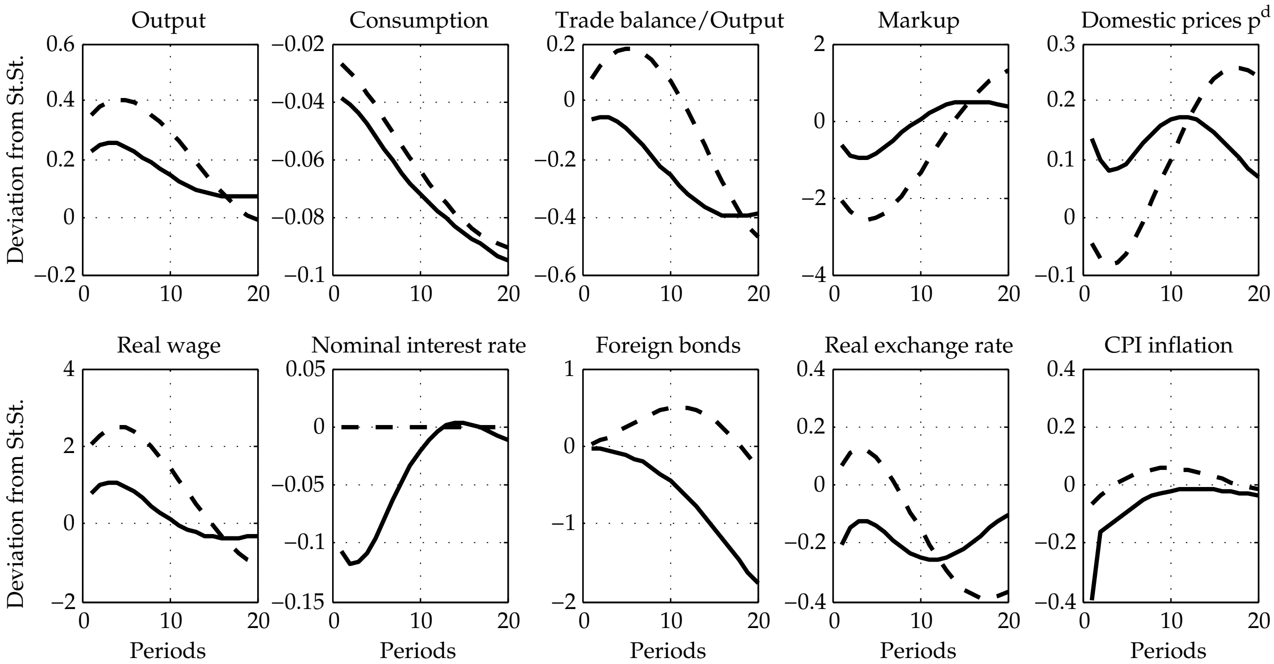
The currency effect is related to the movement of the real exchange rate and is closely linked to the stance of monetary policy. Under *flexible exchange rates*, the central bank reacts actively to changes in CPI inflation and output, but not to changes in the nominal exchange rate.[47] As we can see

[45]See also Corsetti et al. (2012b) and Born et al. (2013). Both studies report empirical findings which are consistent with the conventional wisdom that fiscal policy is more effective under fixed exchange rates.

[46]Consider the impulse response of output: An increase in government expenditures by one percent of domestic steady state output (equals 0.0033 units of domestic goods) raises output by 0.0035 units of domestic goods. This corresponds to an impact multiplier of 1.05, i.e., a percentage deviation from steady state of 105%.

[47]We tested the model also when the central bank does not target deviations in output, i.e., with γ_y set to 0. The qualitative implications of the model are robust to this specification.

Figure 4: Dynamics under different exchange rate regimes



Notes: Solid lines for *flexible exchange rates* with $\gamma_e = 0$ and dotted lines for *pegged exchange rates* for $\gamma_e \to 1$.

from Figure 4, a fiscal expansion increases output while CPI inflation falls. This implies that the nominal appreciation of the domestic currency outweighs the increasing prices of domestic goods. Therefore we see a real appreciation of the domestic currency.[48] Domestic households exploit this appreciation and buy more foreign goods, while foreign consumers react by demanding less of the domestic goods. Consequently the fall in the trade balance of the domestic economy partly crowds out the demand effect of the fiscal policy shock. With an increasing real interest rate, making the holding of foreign bonds relatively less attractive, households substitute foreign for domestic goods, which leads to an inflow of capital to the domestic economy.

By contrast, under *fixed exchange rates*, the nominal interest rate has to stay constant over time. CPI inflation increases after the impact, as domestic prices increase while the exchange rate is rigid. The real interest rate decreases and the holding of domestic bonds becomes relatively less attractive. Consequently, we experience an increase in the trade balance and an outflow of capital. This crowding-in effect of the trade balance is the main reason why fiscal policy in our model is more effective under fixed exchange rates.

6.1.2 Substitution effect and exchange rate flexibility

Besides the crowding-in of the trade balance through the currency effect, we also observe in Figure 4 that the crowding-out effect of consumption is less strong under fixed exchange rates. This fact is related to the deep-habit mechanism and the working of counter-cyclical markups. Because the

[48] See Davig & Leeper (2011), Coenen et al. (2012) or Christiano et al. (2011) for a discussion of the accommodation channel and its role for the transmission mechanism of fiscal policy shocks.

price elasticity of demand is affected through deep habits, domestic firms will lower their markups (see Figure 4). Under fixed exchange rates, the firms lower their markups more than under flexible exchange rates, since the effect on aggregate demand is larger than when the exchange rate is able to adjust. The decrease in the markup leads to an amplification effect in labor demand, causing the real wage to increase more strongly. The demand of the domestic households for the domestic goods goes up, reducing thereby the crowding-out effect of the fiscal policy shock. To sum up, lower exchange rate flexibility mitigates the adjustment channel of the nominal interest rate, causing markups to decrease more strongly and therefore reducing the crowding-out of private consumption. Hence, fiscal policy is more effective under fixed exchange rates.

6.2 Openness to trade

As reported in Section 4, openness to trade decreases the cumulative fiscal multiplier.[49] This result relies on the the pricing-to-habits effect and the domestic-relative-price effect explained in Section 5.1. We remember that in the benchmark case of floating exchange rates, a fiscal expansion leads to a decrease in the firm's markup and causes the real exchange rate to appreciate. On the one hand, the absorption of private consumption (the sum of domestically produced goods and imports) has a positive effect on the trade balance and therefore on the multiplier.[50] This effect *ceteris paribus* decreases with the degree of home bias in household consumption. On the other hand, the domestic-relative-price effect causes households to switch their expenditures towards foreign goods, whenever the economy is not in autarky. This decreases the trade balance and hence the fiscal multiplier. This effect *ceteris paribus* becomes weaker as home bias increases.

Figure 5 displays how the degree of trade openness affects the transmission mechanism of a fiscal policy shock and helps us understand the results in Table 2. Let us first consider the case where we are in autarky, that is households have 100% home bias ($\omega = 1$). As households only consume domestic goods, the trade balance is zero at all times and there is no domestic-relative-price effect. This means there is no crowding-out of the trade balance which otherwise would reduce the fiscal multiplier. Once the economy is opened ($\omega < 1$), we observe a substantial crowding-out of the trade balance. To sum up, we identify the dynamics of private consumption and the real exchange rate as the main drivers for the effectiveness of fiscal policy in an open economy framework. Our model highlights the important role of trade openness, as its implied effects have consequences for the crowding-out of the trade balance and in turn for the fiscal multiplier.

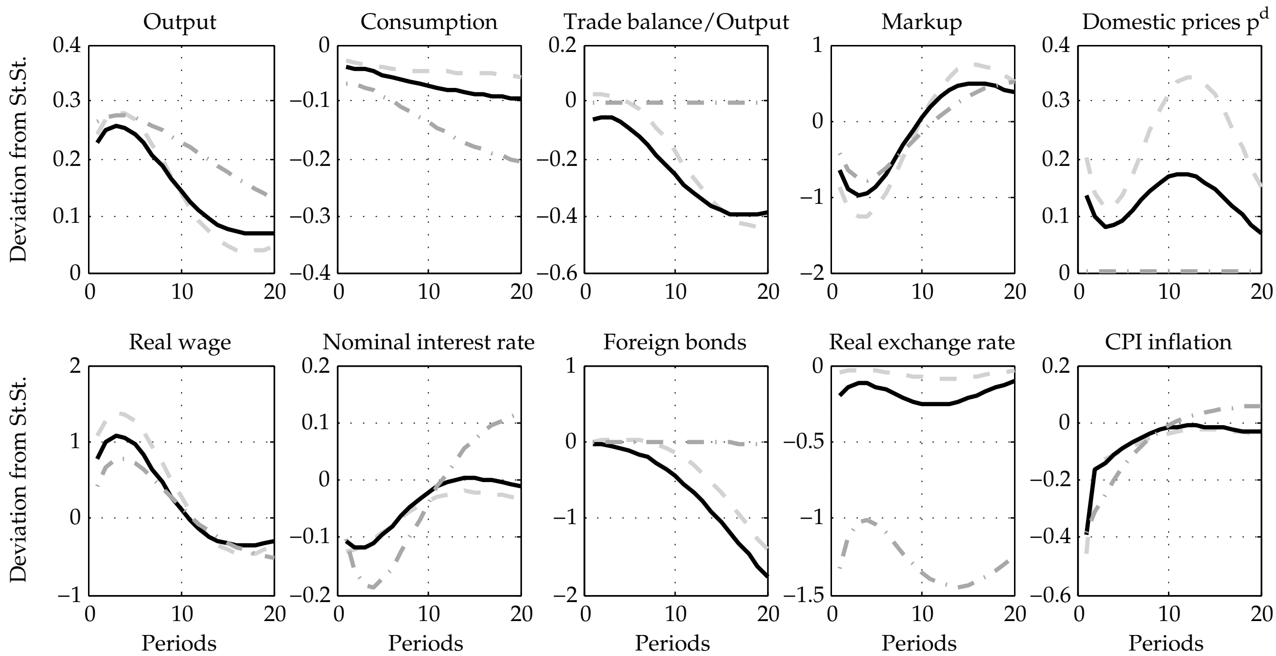
6.3 Capital Mobility

One of the main messages from the results presented in Table 2 is that the cumulative multiplier is larger when capital mobility is low. The degree of capital mobility affects the household's consumption and savings decision through the uncovered interest parity condition, which is given by

[49] See Corsetti & Müller (2006), Monacelli & Perotti (2006, 2010), Müller (2008), for related studies on the role of home bias for the transmission mechanism of fiscal policy shocks.

[50] The decrease in total private consumption implies both a reduction in the demand for imported goods and domestically produced goods. See Erceg, Guerrieri & Gust (2005) for a detailed discussion.

Figure 5: Dynamics under different degrees of trade openness



Notes: 100% trade $\omega \to 0$; equal consumption share for h and f $\omega = 0.5$; No trade $\omega \to 1$.

the combination of equations (2.9) and (2.10),

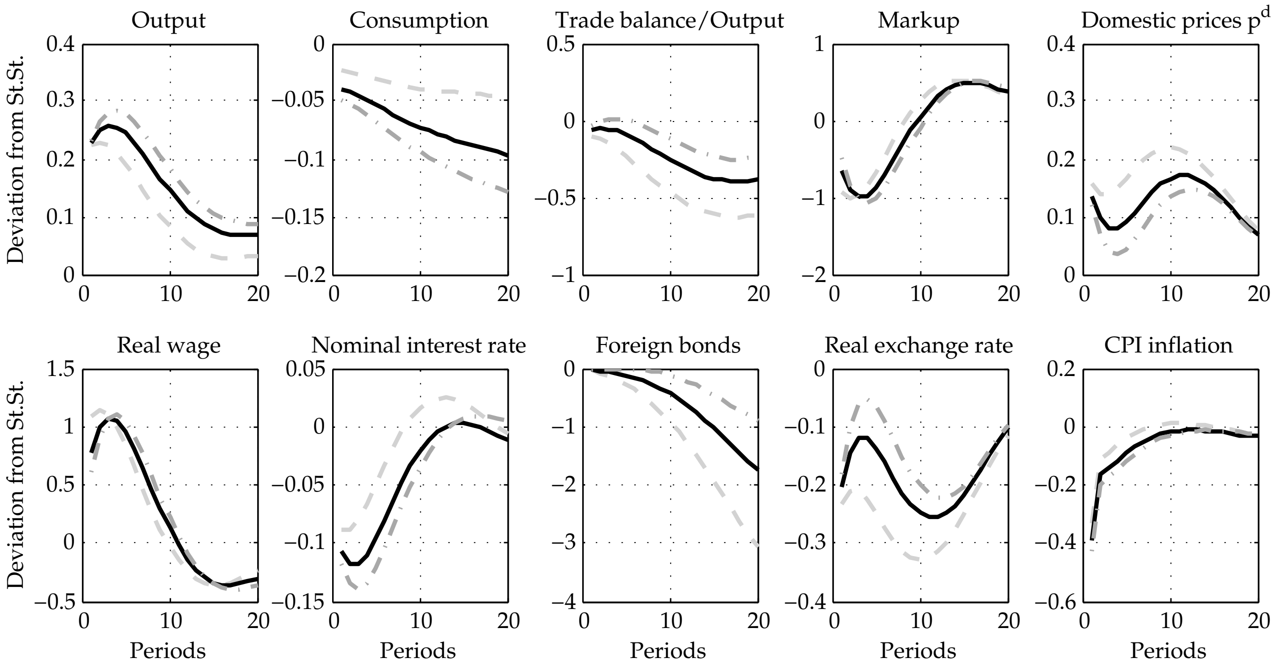
$$R_t = \frac{R_t^\star}{1+\chi b_t^f} \mathbb{E}_t \left(\frac{e_{t+1}}{e_t} \right). \tag{6.1}$$

This condition relates the domestic nominal interest rate to the foreign, subject to portfolio adjustment costs, and the expected change in the nominal exchange rate. As the economy is small with respect to the rest of the world, the foreign nominal interest rate is exogenous. As the initial net foreign assets position in $t = 0$ is zero, the degree of capital mobility only has an impact from $t > 0$ onwards. It takes at least one period for agents to decide on how to allocate their portfolio of domestic and foreign bonds, taking into account the expected changes in the exchange rate.

To understand how the degree of capital mobility affects the cumulative output multiplier, let us consider the dynamics depicted in Figure 6. Lowering the degree of capital mobility diminishes the otherwise larger impact on the net foreign asset position in response to a fiscal expansion (as it is described above in terms of the currency effect, see Section 6.1.1). High costs of reallocating bond holdings during a fiscal expansion are implemented via a high value of the χ parameter. Instead of lowering their demand for foreign bonds as when capital is perfectly mobile, households maintain their foreign bond holdings constant. Consequently, the domestic currency appreciates less strongly. While consumption decreases more significantly, we observe that the trade balance does not crowd out the increase in government expenditures. As domestic prices do not increase by as much, they lower the consumption of domestic goods by less than the consumption of imports.

These results challenge the findings by Pierdzioch (2004), who claims that higher capital mobility can also increase the effectiveness of fiscal policy, when monetary policy is characterized by a simple

Figure 6: Dynamics under different degrees of capital mobility



Notes: High mobility $\chi = 0.00$; Benchmark $\chi = 0.0019$; Low mobility $\chi = 0.01$.

money supply rule with price-level and output-gap targeting. We expand the analysis by Sutherland (1996) and Pierdzioch (2004) as we formalize monetary policy with a commonly used Taylor rule. Importantly, we show that in a model with counter-cyclical markups and active monetary policy, the degree of capital mobility is inversely related to the cumulative effectiveness of fiscal policy. This underlines the conventional wisdom of the Mundell-Fleming model.

7 Conclusion

This article adds to the recent debate on the dynamics of fiscal policy shocks and the size of government spending multipliers by providing a positive assessment of fiscal policy effectiveness in open economies. We incorporate the mechanism of deep-habit formation formalized by Ravn et al. (2006) in a New Keynesian small open economy framework to compare three dimensions of economic openness: (*i*) the flexibility of the exchange rate; (*ii*) the degree of trade openness; and (*iii*) the level of capital mobility.

In line with recent empirical evidence, we show that fiscal effectiveness is higher when the exchange rate is pegged. This finding has a direct implication on policy making because it relates to the question whether fiscal policy measures in Eurozone countries during the past financial crisis were effective. It also underscores the importance of monetary and fiscal policy interactions. With monetary accommodation under floating exchange rates a decline in the trade balance and a crowding-out of the effect of a fiscal expansion may result, even when counter-cyclical markups are present and the crowding-out effect of private consumption is thereby reduced.

A second finding with direct implications for policy making relates to the degree of trade openness. Our theoretical model confirms the empirical evidence reported by Ilzetzki et al. (2013), who indicate that fiscal multipliers are smaller in open economies than in closed ones. As Levy Yeyati, Sturzenegger & Reggio (2010) show, trade openness is strongly associated with the propensity to peg the exchange rate. Eurozone countries typically display larger trade openness than closed economies such as the United States. Hence, our results cast doubt on the effectiveness of fiscal policy measures during the past financial crisis in these countries.

Third, we stress that higher capital mobility leads to lower fiscal multipliers. This result advances the debate on fiscal policy effectiveness by highlighting the role of international financial market integration for the propagation of fiscal policy shocks. Our results are in line with conventional wisdom and Sutherland (1996), but in contrast to Pierdzioch (2004).

Although the results obtained in the present study reliably shed light on the influence of economic openness on the size of the fiscal multiplier, a limitation of the applied framework is the assumption of flexible wages. It would be an interesting extension to introduce nominal wage stickiness or to add labor market frictions to our proposed model. There is empirical evidence in Pappa (2009) that a fiscal expansion leads to an increase in real wage and employment; this gives rise to the question of how counter-cyclical markups and the fiscal multiplier would react if the adjustment of wages is rigid.

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A Appendix

A.1 FOC of the Households with Respect to Foreign Bonds

Equation (2.10), the first-order condition of the representative domestic household with respect to foreign bonds, B_t^f, is derived according to:

$$\begin{aligned}
0 \overset{!}{=} \frac{\partial \mathcal{L}}{\partial B_t^f} &= P_t e_t + \chi P_t e_t^2 B_t^f - \beta \frac{\Lambda_{t+1}}{\Lambda_t} e_{t+1} R_t^\star P_t \\
1 + \chi e_t B_t^f &= \beta \frac{\Lambda_{t+1}}{\Lambda_t} R_t^\star \frac{e_{t+1}}{e_t} \\
\underbrace{\Lambda_t}_{=\lambda_t/P_t} (1 + \chi \overbrace{b_t^f}^{e_t B_t^f}) &= \beta \underbrace{\Lambda_{t+1}}_{=\lambda_{t+1}/P_{t+1}} R_t^\star \frac{e_{t+1}}{e_t} \\
\lambda_t &= \beta \frac{R_t^\star}{1 + \chi b_t^f} \cdot \frac{e_{t+1}}{e_t} \cdot \frac{\lambda_{t+1}}{\pi_{t+1}}
\end{aligned}$$

A.2 FOCs of the Domestic Firms

Similarly to the model by Ravn et al. (2012), the Lagrangian of firm i is given by

$$\begin{aligned}
\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \Phi_{0,t} \Bigg\{ & [P_t^d(i) - W_t] \cdot [c_t^d(i) + g_t(i) + c_t^{d\star}(i)] - \frac{\varphi_p}{2} \left(\frac{P_t^d(i)}{P_{t-1}^d(i)} - 1 \right)^2 P_t h_t \\
& + P_t \nu_{c,t}(i) \left[\left(\frac{P_t^d(i)}{P_t} \right)^{-\eta} x_{c,t}^d + \theta^c s_{c,t-1}^d(i) - c_t^d(i) \right] \\
& + P_t \nu_{g,t}(i) \left[\left(\frac{P_t^d(i)}{P_t} \right)^{-\eta} x_{g,t}^d + \theta^g s_{g,t-1}^d(i) - g_t(i) \right] \\
& + P_t \nu_{c,t}^\star(i) \left[\left(\frac{P_t^d(i)}{e_t P_t^\star} \right)^{-\eta} c_t^{d\star} + \theta^\star s_{c,t-1}^{d\star}(i) - c_t^{d\star}(i) \right] \\
& + P_t \varrho_{c,t}(i) \left[s_{c,t}^d(i) - \rho s_{c,t-1}^d(i) - (1-\rho) c_t^d(i) \right] \\
& + P_t \varrho_{g,t}(i) \left[s_{g,t}^d(i) - \rho s_{g,t-1}^d(i) - (1-\rho) g_t(i) \right] \\
& + P_t \varrho_{c,t}^\star(i) \left[s_{c,t}^{d\star}(i) - \rho s_{c,t-1}^{d\star}(i) - (1-\rho) x_{c,t}^{d\star}(i) \right] \Bigg\}
\end{aligned}$$

The FOCs are derived with respect to $P_t^d(i)$, $c_t^d(i)$, $g_t(i)$, $c_t^{d\star}(i)$, $s_{c,t}^d(i)$,$s_{g,t}^d(i)$, and $s_{c,t}^{d\star}(i)$.

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial P_t^d(i)} = \; & y_t(i) - \varphi_p \left[\frac{P_t^d(i)}{P_{t-1}^d(i)} - 1 \right] \frac{P_t}{P_{t-1}^d(i)} h_t \\
& - \eta \frac{P_t}{P_t} \left[\frac{P_t}{P_t^d(i)} \right]^{1+\eta} \left[\nu_{c,t}(i) x_{c,t}^d + \nu_{g,t}(i) x_{g,t}^d \right] - \eta \frac{P_t}{e_t P_t^\star} \left[\frac{e_t P_t^\star}{P_t^d(i)} \right]^{1+\eta} \nu_{c,t}^\star(i) x_{c,t}^{d\star} \\
& + \Phi_{t,t+1} \mathbb{E}_t \left\{ \varphi_p P_{t+1} \frac{P_{t+1}^d(i)}{[P_t^d(i)]^2} \left[\frac{P_{t+1}^d(i)}{P_t^d(i)} - 1 \right] h_{t+1} \right\} \overset{!}{=} 0
\end{aligned}$$

where $\Phi_{t,t+1} = \beta\Lambda_{t+1}/\Lambda_t$, with Λ_t being the Lagrange multiplier. The demand functions of the domestic household and the government yield the following conditions:

$$\begin{aligned}
\left[\frac{P_t}{P_t^d(i)}\right]^{1+\eta} x_{c,t}^d &= \frac{P_t}{P_t^d(i)}[c_t^d(i) - \theta^c s_{c,t-1}^d(i)] \\
\left[\frac{P_t}{P_t^d(i)}\right]^{1+\eta} x_{g,t}^d &= \frac{P_t}{P_t^d(i)}[g_t(i) - \theta^g s_{g,t-1}^d(i)] \\
\left[\frac{e_t P_t^\star}{P_t^d(i)}\right]^{1+\eta} x_{c,t}^{d\star} &= \frac{e_t P_t^\star}{P_t^d(i)}[c_t^{d\star}(i) - \theta^\star s_{c,t-1}^{d\star}(i)]
\end{aligned}$$

Hence, the FOC with respect to $P_t^d(i)$ can be re-written as:

$$\begin{aligned}
y_t(i) - \varphi_p \left[\frac{P_t^d(i)}{P_{t-1}^d(i)} - 1\right] \frac{P_t}{P_{t-1}^d(i)} h_t \\
-\eta \frac{P_t}{P_t^d(i)} \Big\{ \nu_{c,t}(i)[c_t^d(i) - \theta^c s_{c,t-1}^d(i)] \\
+\nu_{g,t}(i)[g_t(i) - \theta^g s_{g,t-1}^d(i)] + \nu_{c,t}^\star(i)[c_t^{d\star}(i) - \theta^\star s_{c,t-1}^{d\star}(i)] \Big\} \\
+\beta\varphi_p \frac{\Lambda_{t+1}}{\Lambda_t} \mathbb{E}_t \left\{ P_{t+1} \frac{P_{t+1}^d(i)}{[P_t^d(i)]^2} \left[\frac{P_{t+1}^d(i)}{P_t^d(i)} - 1\right] h_{t+1} \right\} &\overset{!}{=} 0
\end{aligned}$$

Further FOCs are given by

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial c_t^d(i)} &= P_t^d(i) - W_t - P_t \nu_{c,t}(i) - (1-\rho) P_t \varrho_{c,t}(i) \overset{!}{=} 0 \\
\frac{\partial \mathcal{L}}{\partial g_t(i)} &= P_t^d(i) - W_t - P_t \nu_{g,t}(i) - (1-\rho) P_t \varrho_{g,t}(i) \overset{!}{=} 0 \\
\frac{\partial \mathcal{L}}{\partial c_t^{d\star}(i)} &= P_t^d(i) - W_t - P_t \nu_{c,t}^\star(i) - (1-\rho) P_t \varrho_{c,t}^\star(i) \overset{!}{=} 0 \\
\frac{\partial \mathcal{L}}{\partial s_{c,t}^d(i)} &= P_t \varrho_{c,t}(i) + \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} [P_{t+1}\nu_{c,t+1}(i)\theta^c - P_{t+1}\varrho_{t+1}(i)\rho]\right] \overset{!}{=} 0 \\
\frac{\partial \mathcal{L}}{\partial s_{g,t}^d(i)} &= P_t \varrho_{g,t}(i) + \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} [P_{t+1}\nu_{g,t+1}(i)\theta^g - P_{t+1}\varrho_{t+1}(i)\rho]\right] \overset{!}{=} 0 \\
\frac{\partial \mathcal{L}}{\partial s_{c,t}^{d\star}(i)} &= P_t \varrho_{c,t}^\star(i) + \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} [P_{t+1}\nu_{c,t+1}^\star(i)\theta^\star - P_{t+1}\varrho_{t+1}^\star(i)\rho]\right] \overset{!}{=} 0
\end{aligned}$$

Assuming that for a given type of good (domestic vs. foreign), a given type of consumer (private vs. public), and a given location of a consumer (domestic vs. foreign), initial habit stocks are identical across varieties i. Then, in a symmetric equilibrium, it must hold that $P_t^d(i) = P_t^d$ and therefore $c_t^d(i) = c_t^d$, $g_t(i) = g_t$, $c_t^{d\star}(i) = c_t^{d\star}$, $s_{c,t}^d(i) = s_{c,t}^d$, $s_{g,t}^d(i) = s_{g,t}^d$, and $s_{c,t}^{d\star}(i) = s_{c,t}^{d\star}$. That is, all the is drop.

Therefore, the first-order conditions of the general equilibrium are equal to

$$
\begin{aligned}
0 &= p_t^d y_t - \varphi_p \left(\pi_t^d - 1\right) \pi_t^d h_t \; - \; \eta \left[\nu_{c,t}(c_t^d - \theta^c s_{c,t-1}^d)\right. \\
&\quad \left. + \nu_{g,t}(g_t - \theta^g s_{g,t-1}^d) + \nu_{c,t}^\star (c_t^{d\star} - \theta^\star s_{c,t-1}^{d\star})\right] \\
&\quad + \beta \varphi_p \frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}^d \left(\pi_{t+1}^d - 1\right) h_{t+1} \\
p_t^d - w_t \frac{P_t^d}{P_t^d} &= \nu_{c,t} + (1-\rho)\varrho_{c,t} \\
p_t^d - w_t \frac{P_t^d}{P_t^d} &= \nu_{g,t} + (1-\rho)\varrho_{g,t} \\
p_t^d - w_t \frac{P_t^d}{P_t^d} &= \nu_{c,t}^\star + (1-\rho)\varrho_{c,t}^\star \\
\varrho_{c,t} &= \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{c,t+1} - \theta^c \nu_{c,t+1}\right)\right] \\
\varrho_{g,t} &= \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{g,t+1} - \theta^g \nu_{g,t+1}\right)\right] \\
\varrho_{c,t}^\star &= \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{c,t+1}^\star - \theta^\star \nu_{c,t+1}^\star\right)\right]
\end{aligned}
$$

where $\pi_t^d = P_t^d(i)/P_{t-1}^d(i)$, $\lambda_{t+1}/\lambda_t = \Lambda_{t+1}P_{t+1}/(\Lambda_t P_t)$, and $W_t = w_t P_t$. We define $p_t^d = P_t^d/P_t$ and $p_t^f = P_t^f/(P_t^\star)$, where $P_t^\star$ is the foreign CPI which is exogenous to the domestic small open economy. In combination with the definition of the domestic real exchange rate, $rer_t = e_t P_t^\star / P_t$, this yields $rer_t \, p_t^f = e_t P_t^f / P_t$. The last equality allows for simplification of the above mentioned budget constraints of the producer's problem. In a symmetric equilibrium, where there is no difference between any of the agents i, it must hold that:

$$
\begin{aligned}
c_t^d &= (p_t^d)^{-\eta} x_{c,t}^d + \theta^c s_{c,t-1}^d \\
c_t^f &= (rer_t p_t^f)^{-\eta} x_{c,t}^f + \theta^c s_{c,t-1}^f \\
g_t &= (p_t^d)^{-\eta} x_{g,t}^d + \theta^g s_{g,t-1}^d \\
c_t^{d\star} &= \left(\frac{p_t^d}{rer_t}\right)^{-\eta} x_{c,t}^{d\star} + \theta^\star s_{c,t-1}^{d\star} \\
s_{c,t}^d &= \rho s_{c,t-1}^d + (1-\rho) c_t^d \\
s_{c,t}^f &= \rho s_{c,t-1}^f + (1-\rho) c_t^f \\
s_{g,t}^d &= \rho s_{g,t-1}^d + (1-\rho) g_t \\
s_{c,t}^{d\star} &= \rho s_{c,t-1}^{d\star} + (1-\rho) c_t^{d\star}
\end{aligned}
$$

A.3 List of Conditions of the General Equilibrium

$$x_t^c = \left[\omega(x_{c,t}^d)^{1-1/\xi} + (1-\omega)(x_{c,t}^f)^{1-1/\xi}\right]^{\frac{1}{1-1/\xi}} \quad \text{(A.1)}$$

$$\lambda_t p_t^d = (c_t^{\text{obj}})^{\frac{1}{\xi}-\sigma}\omega(x_{c,t}^d)^{-\frac{1}{\xi}} \quad \text{(A.2)}$$

$$\lambda_t rer_t p_t^f = (c_t^{\text{obj}})^{\frac{1}{\xi}-\sigma}(1-\omega)(x_{c,t}^f)^{-\frac{1}{\xi}} \quad \text{(A.3)}$$

$$\lambda_t w_t = \psi h_t^{\phi} \quad \text{(A.4)}$$

$$\lambda_t = \beta R_t \, \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right) \quad \text{(A.5)}$$

$$\lambda_t = \beta \frac{R_t^\star}{1+\chi b_t^f} \, \mathbb{E}_t \left(\frac{e_{t+1}\lambda_{t+1}}{e_t \pi_{t+1}}\right) \quad \text{(A.6)}$$

$$c_t^d = (p_t^d)^{-\eta} x_{c,t}^d + \theta s_{c,t-1}^d \quad \text{(A.7)}$$

$$c_t^f = (rer_t p_t^f)^{-\eta} x_{c,t}^f + \theta s_{c,t-1}^f \quad \text{(A.8)}$$

$$g_t = (p_t^d)^{-\eta} x_{g,t}^d + \theta s_{g,t-1}^d \quad \text{(A.9)}$$

$$c_t^{d\star} = \left(\frac{p_t^d}{rer_t}\right)^{-\eta} x_{c,t}^{d\star} + \theta s_{c,t-1}^{d\star} \quad \text{(A.10)}$$

$$s_{c,t}^d = \rho s_{c,t-1}^d + (1-\rho) c_t^d \quad \text{(A.11)}$$

$$s_{c,t}^f = \rho s_{c,t-1}^f + (1-\rho) c_t^f \quad \text{(A.12)}$$

$$s_{g,t}^d = \rho s_{g,t-1}^d + (1-\rho) g_t \quad \text{(A.13)}$$

$$s_{c,t}^{d\star} = \rho s_{c,t-1}^{d\star} + (1-\rho) c_t^{d\star} \quad \text{(A.14)}$$

$$0 = p_t^d y_t - \varphi_p \left(\pi_t^d - 1\right) \pi_t^d h_t \;-\; \eta \left[\nu_t (c_t^d - \theta s_{c,t-1}^d + g_t - \theta s_{g,t-1}^d)\right. \quad \text{(A.15)}$$

$$\left. + \nu_t^\star (c_t^{d\star} - \theta s_{c,t-1}^{d\star})\right] + \; \beta \mathbb{E}_t \left[\varphi_p \frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}^d \left(\pi_{t+1}^d - 1\right) h_{t+1}\right] \quad \text{(A.16)}$$

$$w_t = p_t^d - \nu_t - (1-\rho)\varrho_t \quad \text{(A.17)}$$

$$w_t = p_t^d - \nu_t^\star - (1-\rho)\varrho_t^\star \quad \text{(A.18)}$$

$$\mu_t = p_t^d - w_t \quad \text{(A.19)}$$

$$\varrho_t = \beta \frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{t+1} - \theta \nu_{t+1}\right) \quad \text{(A.20)}$$

$$\varrho_t^\star = \beta \frac{\lambda_{t+1}}{\lambda_t} \left(\rho \varrho_{t+1}^\star - \theta \nu_{t+1}^\star\right) \quad \text{(A.21)}$$

$$P_t c_t = P_t^d c_t^d + e_t P_t^f c_t^f \quad \text{(A.22)}$$

$$y_t = h_t \quad \text{(A.23)}$$

$$P_t^d h_t = P_t^d c_t^d + e_t P_t^f c_t^f + P_t^d g_t + TB_t + P_t \frac{\chi}{2}\left(b_t^f\right)^2 + P_t^d \frac{\varphi_p}{2}\left(\frac{P_t^d}{P_{t-1}^d} - 1\right)^2 h_t \quad \text{(A.24)}$$

$$b_t^f = \frac{e_t}{e_{t-1}\pi_t} R_{t-1}^\star b_{t-1}^f \underbrace{+ p_t^d c_t^{d\star} - rer_t c_t^f}_{=TB_t} \quad \text{(A.25)}$$

$$TB_t = P_t^d c_t^{d\star} - e_t P_t^f c_t^f \quad \text{(A.26)}$$

$$1 = \gamma\, p_t^d + (1-\gamma)\, rer_t\, p_t^f \tag{A.27}$$

$$rer_t = \frac{e_t \pi_t^\star}{e_{t-1}\pi_t} rer_{t-1} \tag{A.28}$$

$$\left(x_{c,t}^{d\star}\right)^{-\sigma} = \beta R_t^\star\, \mathbb{E}_t \left[\frac{\left(x_{c,t+1}^{d\star}\right)^{-\sigma}}{\pi_{t+1}^\star} \right] \tag{A.29}$$

$$R_t = \left[\left(\frac{P_t}{P_{t-1}} \right)^{\gamma_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\gamma_y} \left(\frac{e_t}{e_{t-1}} \right)^{\frac{\gamma_e}{1-\gamma_e}} \bar{R} \right]^{1-\rho_R} (R_{t-1})^{\rho_R} \tag{A.30}$$

$$p_t^d = \frac{\pi_t^d}{\pi_t} p_{t-1}^d \tag{A.31}$$

where $\pi_t^d = P_t^d/(P_{t-1}^d)$, $W_t = w_t P_t$, $p_t^d = P_t^d/P_t$, $p_t^f = P_t^f/(P_t^\star)$, $p_t^{d\star} = P_t^{d\star}/P_t$, $rer_t = e_t P_t^\star/P_t$, $rer_t p_t^f = e_t P_t^f/P_t$, and $b_t^f = e_t B_t^f$. Note that $\theta^c = \theta^g = \theta^\star = \theta$ implies that in equilibrium $\nu_c = \nu_g = \nu$ and $\varrho_c = \varrho_g = \varrho$. The exogenous processes are given by

$$x_{g,t}^d = \gamma^g x_{g,t-1}^d + (1-\gamma^g)\bar{x}_{g,t}^d + \varepsilon_{t+1}^g \tag{A.32}$$

$$x_{c,t}^{d\star} = \gamma^{d\star} x_{c,t-1}^{d\star} + (1-\gamma^{d\star})\bar{x}_c^{d\star} + \varepsilon_{t+1}^{d\star} \tag{A.33}$$

$$p_t^f = \gamma^f p_{t-1}^f + (1-\gamma^f)\bar{p}^f + \varepsilon_{t+1}^f \tag{A.34}$$