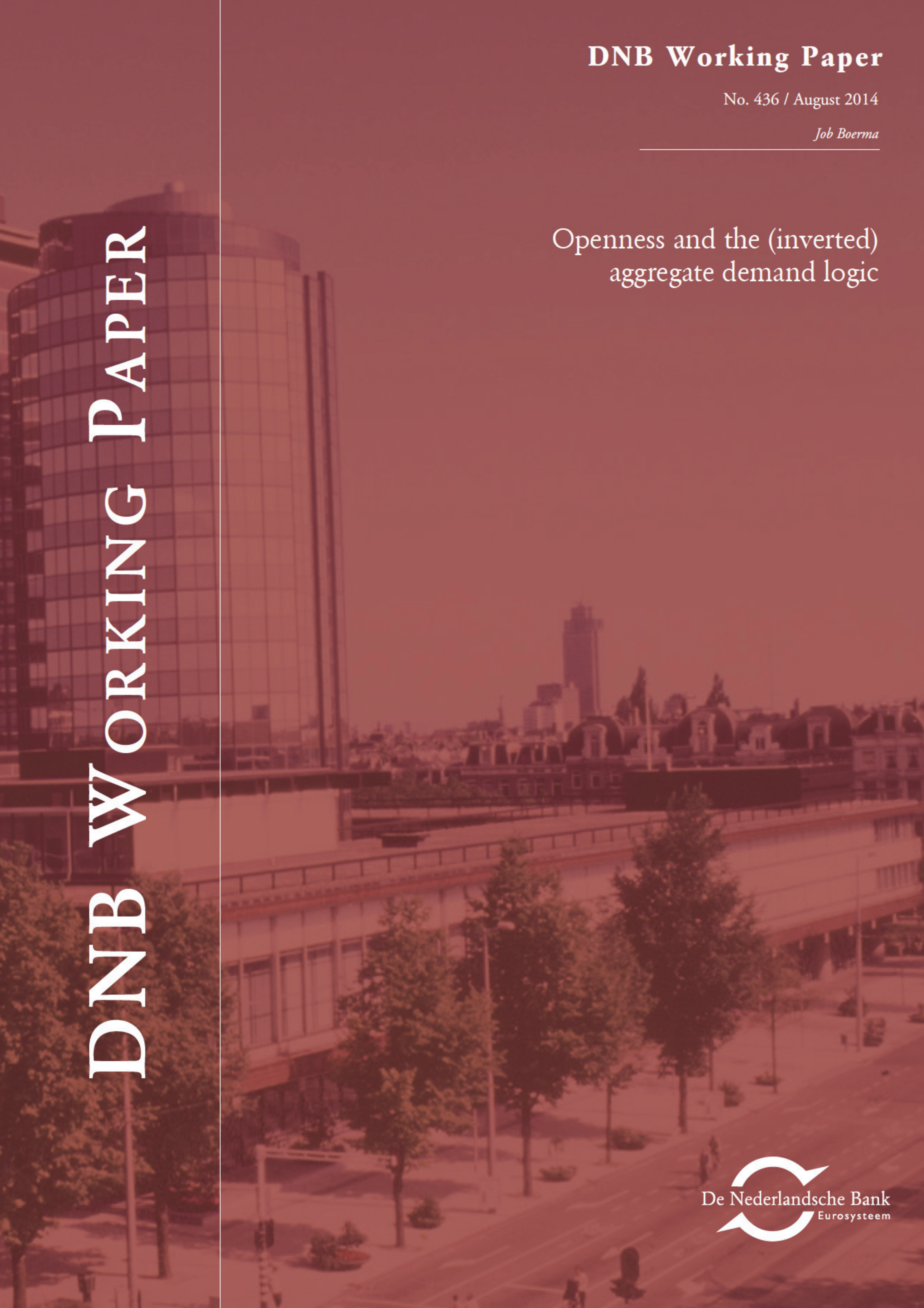

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Openness and the (inverted) aggregate demand logic

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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

Openness and the (inverted) aggregate demand logic *

Job Boerma [a]

[a] *Nuffield College, Oxford, United Kingdom, job.boerma@outlook.com*

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Abstract

I build a small open economy version of the Calvo-type staggered price-setting model with limited asset market participation, and I show that the inverted aggregate demand logic is less likely to apply to small open economies. The equilibrium dynamics of the model are reduced to a representation in the output gap and domestic inflation, and depend on the degree of asset market participation in a non-linear way. If asset market participation decreases above a certain threshold, the relationship between the real interest rate and aggregate output strengthens. Below this threshold, the link between the real interest rate and aggregate demand inverts: aggregate domestic output contracts in response to a decrease in the real interest rate. Policy rules have to satisfy an inverted Taylor Principle to ensure a unique equilibrium in this type of economy. When an economy is open, the 'standard' Taylor Principle is strictly more likely to apply. The Taylor Principle is restored regardless of the level of asset market participation when the redistributive dividend tax rate, or the share of domestic firms under foreign ownership, exceeds a certain threshold.

Keywords: Taylor Principle, openness, indeterminacy, limited asset market participation.
JEL classification: E44, E52, F41.

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1 Introduction

This paper is concerned with the transmission of monetary policy, and the determinacy properties of simple interest rate rules, in small open economies with limited asset market participation (LAMP). I show that LAMP, the fact that not all households participate in financial markets, has non-trivial implications for the conduct of monetary policy. If only a small fraction of agents participates in asset markets, the relationship between the real interest rate and aggregate output inverts. Increases in the real interest rate have an expansionary effect on aggregate demand. Following Bilbiie (2008), this inverted relationship between aggregate output and the real interest rate is called the *inverted aggregate demand logic* (IADL). When the IADL applies, the central bank has to adopt a passive policy rule to ensure equilibrium uniqueness.

LAMP is introduced into the standard representative agent framework by allowing for a share of 'rule-of-thumb' consumers. Rule-of-thumb consumers do not have access to saving and borrowing instruments, so their current consumption is equal to their current income. Because the Ricardian Equivalence Theorem does not hold in a model with 'rule-of-thumb' consumers, I refer to these households as non-Ricardian.[1]

In a widely cited paper, Bilbiie (2008) shows that LAMP alters the transmission mechanism of monetary policy in the canonical New Keynesian model through (i) a real wage channel and (ii) a profits income channel. Depending on the fraction of non-Ricardian agents, LAMP reinforces or overturns the contractionary demand effect of a real interest rate increase. To build intuition, suppose that the policy rate rises for no fundamental reason. This interest rate shock induces Ricardian households to postpone consumption and to work more hours. Firms accommodate this fall in demand by cutting prices and by reducing labor demand. The decrease in labor demand, and increase in labor supply, result in a lower real wage. The decline in the real wage is greater when the labor supply is inelastic, and when the level of asset market participation is low. The fall in the real wage leads to a further decline in aggregate demand since non-Ricardian agents consume

[1]This label originates from the introduction of 'rule-of-thumb' households in the literature on the macroeconomic effects of government debt by Mankiw (2000). This agent is sometimes referred to as 'hand-to-mouth consumer', 'non-asset holder', or 'current-income consumer'.

their labor income each period. The real wage channel thus reinforces the contractionary output effect of the initial policy rate increase.

Bilbiie (2008) shows that the contractionary effect of monetary policy on output is overturned by a profit income effect on aggregate demand when there are few Ricardian agents. Domestic real profits increase because the fall in the real wage, and hence the fall in marginal costs, exceeds the decline in aggregate demand. The increase in domestic firm profits is a positive income shock to the firm owners (i.e. the Ricardian consumers), and leads to an increased demand for aggregate output. I refer to this transmission channel as the profits income channel. The direct impact of firm profits on Ricardian consumption demand decreases with the level of financial market participation.

The total impact of a variation in the interest rate on aggregate demand depends on the level of financial exclusion. When financial market participation is high, the real wage effect dominates the profits income effect, and the impact of a monetary policy shock is reinforced. When asset market participation is limited, the profits income channel dominates the wage channel. In this case, a real interest rate increase has an expansionary effect on aggregate output. This prediction is the IADL, and has important implications for the conduct of monetary policy. When the IADL applies, the monetary authority has to adjust its interest rate less than one-for-one in response to variations in inflation to ensure equilibrium determinacy. This is the *inverted Taylor Principle.*

This paper extends this analysis to a small open economy framework. In particular, I show that the IADL, and the inverted Taylor Principle, are strictly less likely to apply in small open economies because the terms of trade channel of monetary policy is also contractionary for a rise in the real interest rate. I show this result in a Calvo-type sticky-price model of a small open economy with LAMP, which nests the models of Bilbiie (2008) and Galí and Monacelli (2005).

How does the degree of openness modify the transmission mechanism of monetary policy? The key is that openness dampens the response of aggregate demand for domestic goods to variations in domestic firm profits. Variations in profits income that overturn the initial interest rate effect on Ricardian demand, may not offset the total impact demand variation. In a small open economy, the impact effect on aggregate demand in response to a variation in the interest rate is given by the change in Ricardian demand, and the change in external demand driven by movements in the exchange rate. Because the exchange rate channel of monetary policy transmission is also contractionary for a rise in the real interest rate, the IADL is less likely to apply to small open economies.

The intuition for the IADL in a small open economy is similar to the intuition in Bilbiie (2008). Again, suppose that a non-fundamental policy rate increase causes an initial contraction in aggregate demand. Domestic firms accommodate the fall in demand by reducing their demand for domestic labor, or by cutting their prices. Consumer prices fall because domestic firms cut prices, and because domestic prices of foreign goods decline due to an appreciation of the nominal exchange rate. Real wages decline for the labor market to clear, implying a reduction in nominal wages. This reduction in the nominal wage rate increases domestic firm profits. The distribution of firm profits stimulates Ricardian consumption demand, and reduces Ricardian labor supply. The rise in Ricardian demand increases the demand for domestic production, and may offset the initial contraction in external and internal demand when there are few Ricardian households, i.e. when asset market participation is very limited.

The introduction of non-Ricardian households into a small open economy model is motivated by cross-country data on household participation in financial markets, and by cross-country variation in the degree of openness. The data is summarized in Table 1, and described in detail in Appendix A. Table 1 shows that the level of financial inclusion, as measured by the percentage of adults with a bank account at a formal financial institution, varies significantly across countries.[2] In low income countries, only 19% of the population has access to basic financial products. In high income countries this figure amounts to 89%. High income countries also import a greater share of their consumption bundle.

To further anticipate the results, I find that the IADL is more likely to apply to developing economies. The inverted Taylor Principle is most relevant for central banks in developing countries. Figure 1 illustrates this result. This map is generated using

[2]This 'narrow' definition of asset market participation precludes the use of LAMP as a free parameter to capture the impact of financial frictions, uncertainty, and suboptimal decision-making on the aggregate marginal propensity to consume. See Chari et al. (2009) for a discussion of 'structurally dubious' parameters and shocks that are frequently used to improve the fit of DSGE models.

Country Classification	No. of Countries	Financial Exclusion, λ	Openness, α
Low Income	25/36	0.81	0.40
Lower Middle Income	31/48	0.72	0.45
Upper Middle Income	33/55	0.50	0.46
High Income	40/78	0.11	0.55

Table 1: Cross-Country Data on Financial Inclusion, and Openness.
This table summarizes data on the level of financial exclusion, and the degree of openness, across economies. The third column shows that household participation in asset markets is increasing with the level of income per capita. 81% of the households in low income countries do not have access to basic financial services. The fourth column shows that households in high income countries import a greater share of their consumption goods. 40% of the products consumed by households in low income economies are produced abroad.
Source: World Bank Development Indicators, World Bank Global Financial Inclusion Database, and author's own calculations.

the country-specific data underlying Table 1, and displays in which countries the IADL applies. An interest rate increase contracts aggregate output in the majority of high income economies (in green), whereas the IADL (in blue) holds in most developing economies.

Figure 1 also shows that the degree of openness is an important variable for this classification. Monetary authorities in the countries colored in light green could mistakenly adopt passive Taylor rules if they do not to take into account the impact of openness on the monetary policy transmission mechanism, assuming they do take into account LAMP. This group of countries includes high growth economies such as Brazil, South Africa, Turkey, and Vietnam.

Closest in spirit to this work are papers by Ascari et al. (2010), Galí et al. (2004), and Eser (2009). Ascari et al. (2010) argue that the IADL is less likely to materialize when nominal wages are sticky. An aggregate demand contraction leads, in the presence of nominal wage rigidity, to a smaller decline in the real wage. As a result, the variation in firm profits in response to a real interest rate change is dampened, and hence the profits income effect is mitigated. The profits income effect is therefore less likely to overturn the initial aggregate demand variation, i.e. the IADL is less likely to hold.[3]

[3] Ascari et al. (2010) claim that the IADL only holds for extreme parameter values. Buffie (2013) rejects this claim, and shows that the threshold value of financial exclusion for the IADL to apply in Ascari et al. (2010) decreases from 71% to 50% for reasonable parameter values.

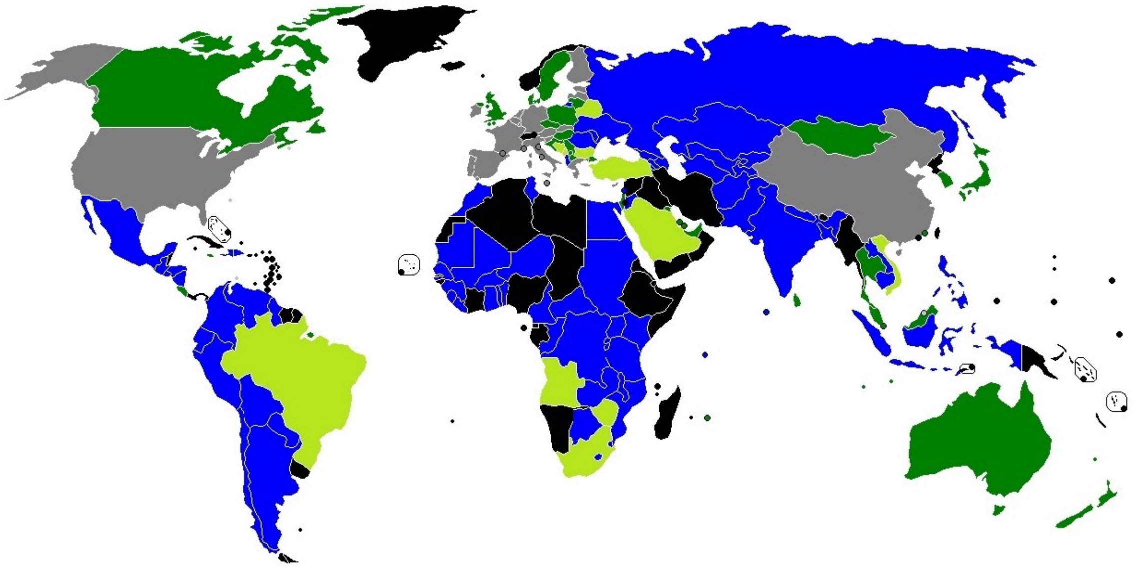

Figure 1: The Inverted Aggregate Demand Logic across Countries.
This map shows in which countries the IADL applies. Depending on the degree of openness, and the level of LAMP, an increase in the policy rate may have an expansionary (in blue), or contractionary (in green), effect on aggregate demand. The IADL is most likely to apply in developing economies. Monetary authorities in the countries that are colored in light green mistakenly pursue a passive Taylor rule if they do not to take into account the impact of openness on the monetary policy transmission mechanism. Countries that are colored in grey are (part of) a monetary policy area that is not considered 'small', and there is no data available on the countries colored in black. This map does not calibrate for the level of foreign ownership, and the redistributive dividend tax rate.
Source: World Bank Development Indicators, World Bank Global Financial Inclusion Database, and author's own calculations.

Galí et al. (2004) point at the limitations of the Taylor Principle as a criterion for a determinate rational expectations equilibrium in the presence of hand-to-mouth consumers, and physical capital accumulation. Contemporaneous policy rules have to satisfy a *reinforced* Taylor Principle to ensure equilibrium determinacy when LAMP exceeds a certain threshold. The central bank has to increase the policy rate significantly more than one-for-one in response to a rise in inflation. Forward-looking Taylor rules have to satisfy the inverted Taylor Principle to ensure equilibrium determinacy when the level of LAMP is high.

This paper complements the work of Galí et al. (2004) and Ascari et al. (2010) by focusing on the interaction between LAMP and the exchange rate channel of monetary policy transmission. Galí et al. (2004) analyse the interaction between financial exclusion and the investment channel, while Ascari et al. (2010) focus on the interaction between LAMP and sticky nominal wages.

Eser (2009) evaluates the implications of heterogeneity in the degree of financial inclusion for optimal monetary policy, and equilibrium determinacy, in a currency union. Eser (2009) shows that the IADL is more likely to apply in a monetary union when the degree of financial exclusion varies across member states. Eser (2009) models the currency union as in Galí and Monacelli (2008), i.e. as a continuum of small open economies. This paper differs from Eser (2009) by focusing on the determinacy properties of simple interest rate rules in small open economies, and by modeling foreign ownership of domestic firms, and redistributive dividend taxes.

This paper is structured as follows. Section 2 and 3 describe the model, and its log-linearised representation. Section 4 derives the dynamic IS equation, and the New Keynesian Phillips Curve. In Section 5, I discuss the conditions for equilibrium determinacy for a set of simple policy rate rules. Section 6 shows that the 'standard' Keynesian logic, and the Taylor Principle, are restored when the level of foreign ownership, or the redistributive dividend tax rate, exceeds a certain threshold level. Section 7 concludes. The technical details are in the appendices.

2 A Small Open Economy Model with LAMP

The model economy is a standard cashless dynamic general equilibrium model for a small open economy, extended to include LAMP. The model builds on the framework of Galí and Monacelli (2005), who model the world economy as a continuum of small open economies on the unit interval. The main focus is on a single economy, which I call Home (H), and its interactions with the rest of the world, which I call Foreign (F). Since each economy is of zero measure, domestic policy decisions do not affect the behaviour of the rest of world. The economies have identical preferences, technology and market structure, but face imperfectly correlated productivity shocks. Only the domestic economy is populated with a fraction of non-asset holders.[4]

[4]The fraction of non-asset holders is exogenous and time-invariant. See Alvarez et al. (2002) for a model of endogenously segmented asset markets. In their model, agents incur a fixed cost each period they participate in the asset markets. As a result, households choose infrequent times to participate in these markets.

Some households are excluded from asset markets, while others trade in a complete international financial market for state-contingent securities. These securities include shares in foreign firms, yet not in domestic firms. Agents that are excluded from financial markets can neither borrow nor save, and hence they do not smooth consumption over time. These households consume their current labor income each period. These consumers are labelled non-Ricardian, denoted N, as they break the Ricardian (R) Equivalence.

To focus on the implications of LAMP for the transmission of monetary policy in a small open economy, I specify the baseline model close to the standard New Keynesian small open economy model. For ease of exposition, this section only discusses the parts of the model that differ from the benchmark economy by Galí and Monacelli (2005). The common elements, e.g. the *Law of One Price*, *Purchasing Power Parity*, and *Uncovered Interest Rate Parity*, are discussed in Appendix B.

2.1 Households

2.1.1 Ricardian Households

A small open economy is inhabited by a continuum of infinitely-lived households on the unit interval, which have homogeneous additively separable log-CRRA preferences $U(\cdot)$. The index $h \in [0,1]$, refers to household h, one among the continuum of *domestic* households. A share $(1-\lambda)$ of the domestic households, where $\lambda \in [0,1)$, is Ricardian. These agents are forward looking and have access to the complete international asset market. The Ricardian household's decision problem is to choose a path of consumption and labor supply that maximizes

$$\mathbb{U} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t^R - \vartheta \frac{N_t^{R^{1+\varphi}}}{1+\varphi} \right) ,$$

where $\beta \in (0,1)$ is the subjective discount factor, $\vartheta > 0$ denotes the (time-invariant) relative value of leisure to consumption, and $\varphi \geq 0$ is the inverse of the Frisch labor supply elasticity.[5] N_t^A denotes the hours of work by agent $A \in [i, T]$, where type $T \in [N, R]$, at time t. The index i, where $i \in [0,1]$ is used to refer to (the representative agent in) *foreign*

[5]When $\varphi = 0$, the felicity function is linear in hours worked, and the labor supply elasticity is infinite (Hansen (1985)).

economy i.

The composite consumption index for agent A, denoted by C_t^A is given by the Armington aggregator

$$C_t^A \equiv \left[(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{A\ \frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{A\ \frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} ,$$

where $C_{H,t}^A$ denotes consumption of an index of domestically produced goods given by

$$C_{H,t}^A \equiv \left(\int_0^1 C_{H,t}^A(k)^{\frac{\varepsilon-1}{\varepsilon}} dk \right)^{\frac{\varepsilon}{\varepsilon-1}} ,$$

where $k \in [0,1]$ is an individual good variety and $\varepsilon > 1$ denotes the elasticity of substitution between good varieties produced in the domestic economy. Similarly, $C_{F,t}^A$ is an index of foreign consumption goods defined by

$$C_{F,t}^A \equiv \left(\int_0^1 C_{i,t}^{A\ \frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}} ,$$

where $C_{i,t}$ is, in turn, an index for the consumption of individual good varieties imported from country i. This index is given by $C_{i,t}^A \equiv \left(\int_0^1 C_{i,t}^A(k)^{\frac{\varepsilon-1}{\varepsilon}} dk \right)^{\frac{\varepsilon}{\varepsilon-1}}$.

Parameter $\alpha \in [0,1]$ is inversely related to the degree of home bias in preferences and plays a critical role in this paper. It is interpreted as an index for openness to international trade in final goods. When $\alpha \to 0$, the share of foreign goods in the composite consumption index approaches zero. The degree of openness, α, is identical across economies, and $\alpha = 0$ denotes an economy in autarky, i.e. a closed economy. In contrast, if $\alpha = 1$ there is no home bias in consumption. There is no international trade in intermediate goods.

Parameter γ denotes the elasticity of substitution between consumption bundles produced in different foreign economies, and parameter $\eta > 0$ measures the elasticity of substitution between the domestic and foreign consumption index, from the perspective of the domestic households. A more tractable case, which I use for illustrative purposes in Section 5 and onwards, is obtained by setting $\eta = \gamma = 1$.

Ricardian agents trade state-contingent claims in a complete international asset market, hold shares in domestic intermediate good producers, consume domestic and foreign goods, and supply labor. Their infinite sequence of budget constraints is therefore

$$B_t^R + \Omega_{t+1}^R V_t + P_t C_t^R \leq Z_t^R + \Omega_t^R (V_t + P_t D_t) + W_t N_t^R ,$$

where B_t^R is the nominal value of a portfolio of all state-contingent assets, *including* shares in foreign firms, yet *excluding* shares in domestic firms. Ω_{t+i}^R denotes domestic share holdings at $t+i$, and V_t is the average market value of shares in domestic intermediate good producers, with corresponding real dividend payoff D_t. P_t is the domestic consumer price index, Z_t^R measures beginning of period wealth, not including the payoff of domestic shares, and W_t is the nominal wage. The different price indices derive from expenditure minimization, and are discussed in Appendix B. I write $P_{F,t}^{H,A}$ to denote the price of the imported composite consumption index F faced by agent A denominated in currency H.

Under the assumption of complete international asset markets, arbitrage is not possible. This implies that there exists a stochastic discount factor $\Lambda_{t,t+1}$ that uniquely relates the price of a portfolio at time t with the uncertain payoff at time $t+1$. The no arbitrage condition holds for the portfolio of domestic firm shares as well as for the portfolio of state-contingent assets and foreign shares. Formally,

$$B_t^R = \mathbb{E}_t[\Lambda_{t,t+1} Z_{t+1}^R] \quad \text{and} \quad V_t = \mathbb{E}_t[\Lambda_{t,t+1}(V_{t+1} + P_{t+1} D_{t+1})] \ .$$

Absence of arbitrage also implies that the gross short-term risk-free nominal interest rate is given by[6]

$$\frac{1}{R_t} = \mathbb{E}_t[\Lambda_{t,t+1}]. \tag{1}$$

Using the no arbitrage condition for the complete set of state-contingent securities and international firm shares, the period budget constraint is written as

$$\mathbb{E}_t[\Lambda_{t,t+1} Z_{t+1}^R] + \Omega_{t+1}^R V_t + P_t C_t^R \leq Z_t^R + \Omega_t^R (V_t + P_t D_t) + W_t N_t^R \ . \tag{2}$$

Ricardian households maximize utility $\mathbb{U}(\cdot)$ subject to the sequence of constraints

[6] Absence of arbitrage in complete international financial markets implies that the price of a one-period asset portfolio with random payoff Z_{t+1}^R must be given by $\sum \mathcal{J}_{t,t+1} Z_{t+1}^R$. Here $\mathcal{J}_{t,t+1}$ is the price of an Arrow security at time t and the sum is over all possible states at $t+1$. The price of the portfolio can thus, as in Galí (2008), be written as $\mathbb{E}_t\left[\frac{\mathcal{J}_{t,t+1}}{\xi_{t,t+1}} Z_{t+1}^R\right]$. Hence, I have that $\Lambda_{t,t+1} \equiv \frac{\mathcal{J}_{t,t+1}}{\xi_{t,t+1}}$, where $\xi_{t,t+1}$ denotes the conditional probability of a specific state materializing at time $t+1$. The price of a risk-free asset is therefore equal to $\mathbb{E}_t[\Lambda_{t,t+1}]$. See Varian (1987), and Ljungqvist and Sargent (2004), for a more elaborate introduction to the arbitrage principle, and asset pricing in complete asset markets.

(2) choosing C_t^R, N_t^R, and Z_{t+1}^R.[7] This problem gives the optimality conditions for the Ricardian agents:

$$\vartheta C_t^R N_t^{R\varphi} = \frac{W_t}{P_t} \ , \tag{3}$$

which is the intratemporal labor condition, and

$$\beta R_t \mathbb{E}_t \left[\left(\frac{C_{t+1}^R}{C_t^R} \right)^{-1} \left(\frac{P_t}{P_{t+1}} \right) \right] = 1 \ , \tag{4}$$

the Euler equation for consumption.[8]

2.1.2 Non-Ricardian Households

The agents in the interval $[0, \lambda]$ are non-Ricardian. These agents are excluded from the international financial market, they do not borrow and do not save, and therefore consume their disposable income each period.[9] The non-Ricardian households solve a contemporaneous problem:

$$\begin{aligned} &\max_{C_t^N, N_t^N} \ln C_t^N - \vartheta \frac{{N_t^N}^{1+\varphi}}{1+\varphi} \\ &\text{subject to } P_t C_t^N \leq W_t N_t^N \ . \end{aligned} \tag{5}$$

This problem is solved by the intratemporal labor condition

$$\vartheta C_t^N N_t^{N\varphi} = \frac{W_t}{P_t} \ . \tag{6}$$

[7] Ω_{t+1}^R is not a choice variable because of ownership restrictions on shares in domestic intermediate good producers. This restriction is discussed in more detail in Section 3.3.

[8] The Frisch labor supply elasticity measures the elasticity of hours worked with respect to the wage rate, given a constant marginal utility of wealth, i.e. $\epsilon_{N^R,W} = \frac{\partial N_t^R}{\partial W_t} \frac{W_t}{N_t^R} \Big|_\lambda$. Differentiation of the intratemporal labor condition gives $\epsilon_{N^R,W} = \frac{1}{\varphi}$, which shows that φ is indeed the inverse of the Frisch labor supply elasticity.

[9] The non-Ricardian agents are consumers that are unable to borrow, and unable to save. Non-Ricardian agents can alternatively be regarded as households that are myopic *and* face a no borrowing constraint. Given myopia, the agents would not save for the future, even if they had access to a savings technology that would allow them to. This modeling technique can also be viewed as an approximation for more complicated dynamics driving household consumption such as, e.g., precautionary savings (see, i.a., Caballero (1990)), liquidity constraints (see Deaton (1991)), and self-control problems (see, i.a., Levine and Fudenberg (2006)).

The intratemporal labor condition states that agents choose hours such that the marginal rate of substitution between consumption and leisure equals the real wage. Substituting the labor supply condition (6) into the budget constraint (5) gives:

$$N_t^N = N^N = \vartheta^{-\frac{1}{1+\varphi}} .$$

When utility is logarithmic in consumption, the hours of labor supplied by a non-Ricardian household are time-invariant. Non-Ricardian labor supply is perfectly inelastic when the income and substitution effects of real wage changes exactly balance. The consumption of non-Ricardian households therefore co-moves perfectly with the real wage. Appendix C shows that the results in this paper are robust to specifications of the instantaneous utility function that imply an elastic labor supply of non-Ricardian agents.

2.2 International Risk Sharing

Under the assumption of complete international capital markets, the expected real return on asset holdings is the same for all Ricardian households. To express this formally, I first rewrite the Euler equation (4), using (1) and footnote 6, as

$$\frac{\mathcal{J}_{t,t+1}}{P_t} C_t^{R^{-1}} = \beta \mathbb{E}_t \left[\xi_{t,t+1} C_{t+1}^{R}{}^{-1} \frac{1}{P_{t+1}} \right] .$$

This optimality condition states that a Ricardian household purchases an Arrow security up to the point where the real utility loss of buying this security today is equal to the discounted expected one-period-ahead utility gain from additional consumption (made possible by the security's potential payout). Note that the prices and payoffs of the Arrow securities are denominated in the domestic currency. For households in economy i, the optimality condition reads

$$\frac{\mathcal{J}_{t,t+1}}{\mathcal{E}_t{}^i P_t^{i,i}} C_t{}^{i^{-1}} = \beta \mathbb{E}_t \left[\xi_{t,t+1} C_{t+1}^{\,i}{}^{-1} \frac{1}{\mathcal{E}_{t+1}^{\,i} P_{t+1}^{i,i}} \right] .$$

Under the assumption of complete capital markets, the expected one-period-ahead utility gain is equal across Ricardian agents, regardless of their origin country i. This implies that

$$C_t^R = \mathcal{Q}_{i,t} C_t{}^i, \tag{7}$$

where $\mathcal{Q}_{i,t}$ is the bilateral real exchange rate (B.8). This expression is referred to as the *International Risk Sharing* condition. An important implication of complete international capital markets is that domestic Ricardian consumption can only increase relative to foreign consumption if the real exchange rate depreciates. Equation (7) implies that only Ricardian households share risk internationally. The non-Ricardian agents do not, because they do not have access to the securities that would enable them to do so.

2.3 Firms

The domestic *intermediate goods* sector is home to a continuum of monopolistically competitive firms indexed by $k \in [0,1]$. Each intermediate good firm produces a differentiated good, also denoted by k, using an identical linear production technology. The production technology is, as in Bilbiie (2008), defined by

$$Y_t(k) = \begin{cases} A_t N_t(k) - F & \text{if } A_t N_t(k) > F \\ 0 & \text{if } A_t N_t(k) \leq F \end{cases},$$

where A_t denotes the domestic technology level, $N_t(k)$ is the labor input for the production of variety k, and F represents a time-invariant fixed real production cost that is identical across firms. The technology level A_t follows a stationary AR(1) process $a_t = \rho_a a_{t-1} + \varepsilon_t^a$, where $\rho_a \in [0,1)$. The intermediate good producer is the main actor on the production side of the economy, as will become clear in the remainder of this section.

2.3.1 Production Technology

The demand for domestically produced intermediate goods comes from the perfectly competitive domestic *final goods* sector. The representative final goods producer chooses input quantities of each intermediate good to maximize profits. The final goods firm uses a CES production technology, and thus solves the following profit maximization problem:

$$\max_{Y_t(k)} P_{H,t} Y_t - \int_0^1 P_{H,t}(k) Y_t(k) dk$$
$$\text{subject to } \; Y_t \equiv \left[\int_0^1 Y_t(k)^{\frac{\varepsilon-1}{\varepsilon}} dk \right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{8}$$

This yields the following demand function for each intermediate good k:[10]

$$Y_t(k) = \left(\frac{P_{H,t}(k)}{P_{H,t}} \right)^{-\varepsilon} Y_t \; . \tag{9}$$

Substituting (9) into the production technology of each intermediate good producer k, and integrating over all k firms gives the following expression for aggregate production:

$$Y_t \Delta_t = A_t N_t - F \; ,$$

where $\Delta_t \equiv \int_0^1 \left(\frac{P_{H,t}(k)}{P_{H,t}} \right)^{-\varepsilon} dk$ is the domestic relative price dispersion defined analogous to Woodford (2003), and $N_t \equiv \int_0^1 N_t(k) dk$. This equation represents the aggregate production function for the domestic economy, and is written in log-linear form as

$$y_t = (1 + \digamma) a_t + (1 + \digamma) n_t \; , \tag{10}$$

where $\digamma \equiv \frac{F}{Y}$, the share of fixed production costs to steady state output.[11] From Section 3 onwards, I assume that the fraction of fixed costs to steady state output equals the firm markup μ, which ensures that there are zero profits in steady state. This assumption implies an equitable steady state and simplifies the algebra and intuition of the model. In an equitable steady state, the levels of consumption, labor supply, and hence utility, are identical across the two types of agents.

2.3.2 Cost Minimization

The intermediate good producer minimizes costs conditional on meeting demand for its good k, (9). The optimality condition for this problem is

$$\Xi_t = (1 - \zeta) \frac{W_t}{A_t} \; ,$$

where Ξ_t denotes the Lagrange multiplier on the constraint (9), and ζ is an exogenous labor subsidy. The Lagrange multiplier measures the *marginal cost of production*, since

[10]This solution implies the PPI for the domestic economy, and analogously the PPI for each foreign economy i, given in Appendix B.

[11]I use lowercase letters to denote the log-deviation of a variable from its corresponding steady state value, e.g. $x_t = \log X_t - \log X \approx \frac{X_t - X}{X}$. I only deviate from this definition when the steady state value X is equal to zero. In this case, I use $x_t \approx \frac{X_t}{Y}$, i.e. the variable in proportion to steady state state output.

it is, *at optimum*, equal to the derivative of $(1-\zeta)W_t N_t(k)$ with respect to $Y_t(k)$. The real marginal cost of production (expressed in terms of domestic prices) at time t, denoted $\underline{MC}_t$, can therefore be written in log-deviations from steady state as

$$\underline{mc}_t = -\upsilon + \overline{w}_t - p_{H,t} - a_t \ , \tag{11}$$

where $-\upsilon \equiv \log(1-\zeta)$, and $\overline{w}_t$ is the log *nominal* wage rate.

2.3.3 Real Firm Profits

Real profits of intermediate good producer k, using production technology (8), are

$$D_t(k) \equiv \begin{cases} \frac{P_{H,t}(k)}{P_{H,t}} Y_t(k) - (1-\zeta)\frac{W_t}{P_{H,t}} N_t(k) & \text{if } A_t N_t(k) > F \\ 0 & \text{if } A_t N_t(k) \leq F \end{cases}$$

Substituting the demand function for variety k (9), and the definition for the producer price index given in (B.1), aggregate real profits of the domestic intermediate goods sector are given by

$$D_t \equiv \int_0^1 D_t(k)dk = Y_t - (1-\zeta)\frac{W_t}{P_{H,t}} N_t \ .$$

In log-linear terms, using P_H as the numéraire, aggregate domestic profits are

$$\begin{aligned} d_t &= y_t + \upsilon - w_t - n_t + p_{H,t} \\ &= -\frac{1+F}{1+\mu}\underline{mc}_t + \frac{\mu}{1+\mu} y_t \ , \end{aligned}$$

where the last equality follows by substituting in (10), and (11). Each period, aggregate profits are distributed as dividends to the asset holders.

2.3.4 Optimal Price Setting

Following Calvo (1983), only a $1-\theta$ fraction of all intermediate good firms can adjust its price each period. The others, θ, leave their prices unchanged.[12] These price setting

[12] Independent of history, a firm is allowed to adjust its price with probability $1-\theta$ each period. Given the assumption of a continuum of firms, and by appealing to the law of large numbers, this implies that a fraction $1-\theta$ of all firms may adjust its price each period.

assumptions are standard in the New Keynesian literature, and yield the *New Keynesian inflation equation*:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \Psi \underline{mc}_t \ , \tag{12}$$

where $\Psi \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}$.[13]

2.4 Monetary Policy

The central bank conducts monetary policy by following an *instrument rule*. Instrument rules prescribe levels of and changes in the instruments available to the monetary authority as a function of a set of macroeconomic indicators. More specifically, monetary policy is implemented by using simple feedback rules for the short-term nominal interest rate, the monetary authority's single instrument. I first suppose that the monetary authority follows a period-by-period (quarters) interest rate rule of form

$$r_t = \rho + \phi_{\pi_H} \mathbb{E}_t \pi_{H,t+1} + \varepsilon_t \ , \tag{13}$$

where $\rho \equiv \log \frac{1}{\beta}$ is the time discount rate, and ε_t denotes monetary policy shocks, i.e. movements in the policy rate different from systematic responses to, in this case, expected producer price inflation.[14] The elasticity of the policy rate with respect to indicator ι, denoted by ϕ_ι, is assumed non-negative.

3 Equilibrium

3.1 Aggregate Demand and Output

In equilibrium, the goods market clears, equating the supply and demand of goods:

$$Y_t(k) = C_{H,t}(k) + \int_0^1 C_{H,t}^i(k) di \quad \forall k \in [0,1] \ ,$$

[13]The derivation of the New Keynesian inflation equation is not affected by the presence of non-Ricardian consumers, and is therefore identical to the derivation shown in Appendix B of Galí and Monacelli (2005).

[14]The underlying assumption is that the monetary authority can adjust the money supply to set any nominal interest rate. The nominal rate pins down the real interest rate (conditional on domestic inflation expectations), which determines economic activity in the model. This assumption justifies the use of a *cashless* DSGE model.

where $C_{H,t}(k) \equiv \lambda C^N_{H,t}(k) + (1-\lambda)C^R_{H,t}(k)$ denotes aggregate domestic consumption of domestically produced good variety k. The optimal allocation of any given expenditure level within each category of goods gives the demand functions. The demand functions are defined analogously for all agents, and are identical to the demand functions in Galí and Monacelli (2005). These functions are identical for both domestic consumer types given homogeneous preferences, and perfect competition in the final goods market. Using these demand functions, the clearing condition for good variety k is rewritten as:

$$Y_t(k) = \left(\frac{P_{H,t}(k)}{P_{H,t}}\right)^{-\varepsilon} \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha \int_0^1 \left(\frac{P_{H,t}}{P^i_{F,t}}\right)^{-\gamma} \left(\frac{P^{\ i}_{F,t}}{P_t^{\ i}}\right)^{-\eta} C_t^{\ i} di\right],$$

where $C_t \equiv \lambda C^N_t + (1-\lambda)C^R_t$. By recalling the definition for aggregate domestic demand (8), and by substituting in (B.8), (7), and the definitions for the bilateral ($\mathcal{S}_{i,t}$) and effective terms of trade in Appendix B.3, the aggregated goods market clearing condition is written as

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-\alpha)C_t + \alpha C^R_t \int_0^1 \left(S_{i,t}S_t^{\ i}\right)^{\gamma-\eta} \mathcal{Q}^{\eta-1}_{i,t} di\right], \tag{14}$$

where $\mathcal{S}_t^{\ i} \equiv \frac{P^{\ i}_{F,t}}{P^{\ i}_{i,t}}$ is the effective terms of trade of economy i vis-à-vis i's rest of the world.[15] In the special case where $\eta = \gamma = 1$, the clearing condition simplifies to $Y_t = \left[(1-\alpha)C_t + \alpha C^R_t\right] \mathcal{S}^{\alpha}_t$.[16] This condition is identical to (26) in Galí and Monacelli (2005) when $C^R_t = C_t$. This equality holds by definition when $\lambda = 0$.

The aggregate goods market clearing condition (14) is approximated around the symmetric steady state by

$$y_t = (1-\alpha)c_t + \alpha c^R_t + \alpha(\gamma-\eta)\int_0^1 s_t^{\,i} di + \alpha\gamma s_t + \alpha(\eta-1)q_t \, .$$

By substituting in (B.9), using that $\int_0^1 s_t^{\,i} di = 0$, and by defining $\omega \equiv \gamma + (\eta-1)(1-\alpha)$,

[15] Note that I differentiate between $P_{F,t}$ and $P^{\ i}_{F,t}$ in deriving (14). Even though each economy has zero mass, and therefore has negligible influence on the other economy's foreign PPI, the two PPI are not assumed to be identical. Algebraically, this is shown by expanding $\mathcal{S}_{i,t}\mathcal{S}_t^{\ i}$. Defining economy i's bilateral and effective terms of trade analogous to those for the domestic economy yields $\mathcal{S}^{i,i}_{\neg i,t} \equiv \frac{P^{i,i}_{\neg i,t}}{P^{i,i}_{i,t}} = \frac{P_{\neg i,t}^{\ i}}{P_{i,t}^{\ i}} = \mathcal{S}_{\neg i,t}^{\ i}$ and $\mathcal{S}^{i,i}_t \equiv \frac{P^{i,i}_{F,t}}{P^{i,i}_{i,t}} = \frac{P^{\ i}_{F,t}}{P^{\ i}_{i,t}} = \mathcal{S}_t^{\ i}$. This implies that $\mathcal{S}_{i,t}\mathcal{S}_t^{\ i} = \frac{P_{i,t}}{P_{H,t}}\frac{P^{\ i}_{F,t}}{P^{\ i}_{i,t}} = \frac{\mathcal{E}_{i,t}P^{i,i}_{F,t}}{P_{H,t}} = \frac{P^{\ i}_{F,t}}{P_{H,t}} \neq \mathcal{S}_t$, or $P^{\ i}_{F,t} \neq P_{F,t}$.

[16] If $\eta = 1$, the CPI becomes $P_t = P^{1-\alpha}_{H,t}P^{\alpha}_{F,t}$, which implies that $\frac{P_{H,t}}{P_t} = \left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\alpha} = \mathcal{S}^{-\alpha}_t$.

I obtain the log-linear expression for the domestic goods market clearing condition:[17]

$$y_t = (1-\alpha)c_t + \alpha c_t^R + \alpha\omega s_t \ . \tag{15}$$

A condition analogous to (15) holds for every foreign economy $i \in [0,1]$. Because only the domestic economy is populated by non-Ricardian agents, I write $y_t^i = c_t^i + \alpha\omega s_t^i$ for each economy i. Integrating over every economy yields the world goods market clearing condition:

$$y_t^* \equiv \int_0^1 y_t^i di = \int_0^1 c_t^i di \equiv c_t^* \ , \tag{16}$$

where variables with an asterisk $(*)$ refer to the entire world economy. y_t^* and c_t^* are thus indices for world output, and global consumption. The goods market clearing condition for the world economy requires all world output to be consumed.

3.2 Labor Market

Labor is immobile and there is zero population growth. The labor market clears instantaneously, equating total labor demand to total labor supply. Formally, the labor market clearing condition is given by

$$N_t = \lambda N_t^N + (1-\lambda)N_t^R \ . \tag{17}$$

Total hours worked in the domestic economy are a weighted average of the hours worked by each household type.

3.3 Domestic Equity Market

All ownership shares of domestic intermediate good producers are held by the Ricardian households in the domestic economy. Market clearing of domestic shares requires

$$\int_0^1 V_t(k)dk \equiv V_t = \int_0^1 \int_0^1 V_t^h(k)dkdh \ ,$$

[17] The definitions for the bilateral and effective terms of trade in Appendix B.3 imply that $\int_0^1 s_t^i di = 0$. This is shown by: $\int_0^1 s_t^i di = \int_0^1 \int_0^1 s_{j,t}^i dj di = \int_0^1 \int_0^1 (p_{j,t} - p_{i,t})\, dj di = \int_0^1 \int_0^1 p_{j,t} dj di - \int_0^1 \int_0^1 p_{i,t} di dj = \int_0^1 p_{j,t} dj - \int_0^1 p_{i,t} di = 0$.

where $V_t^h(k)$ denotes the value of domestic agent h's holdings in domestic intermediate goods firm k. Note that $V_t^h(k) = \Omega_t^h(k)V_t(k)$, where $\Omega_t^h(k)$ is the ownership share of agent h in firm k. Because all domestic intermediate good producers are identical, the optimal portfolio weight for each firm will be identical, i.e. $\Omega_t^h(k) = \Omega_t^h$ for all k. Since all domestic Ricardian agents are also identical, implying that $\Omega_t^h(k) = \Omega_t^R(k)$ for all k, h, the equity market clearing condition becomes

$$V_t = \int_0^{1-\lambda} \int_0^1 \Omega_t^h(k)V_t(k)dkdh = (1-\lambda)V_t\Omega_t^R \, .$$

Domestic equity market clearing thus implies that

$$\Omega_t^R = \Omega^R = \frac{1}{1-\lambda} \quad \forall t.$$

Domestic share holdings of each domestic Ricardian agent are, at every point in time t, equal to $\frac{1}{1-\lambda}$. Total domestic assets are held by a fraction $(1-\lambda)$ of the domestic households.

3.4 Trade Balance

Following Galí and Monacelli (2005), $nx_t \equiv \left(\frac{1}{Y}\right)\left(Y_t - \frac{P_t}{P_{H,t}}C_t\right)$ is the trade balance in terms of domestic output, as a fraction of steady state output Y. Net exports are approximated around the symmetric steady state by

$$nx_t = y_t - c_t - \alpha s_t \, .$$

Combined with the goods market clearing condition (15), and the definition for aggregate consumption, this is written as:

$$\begin{aligned} nx_t &= \alpha(\omega-1)s_t + \alpha\lambda(c_t^R - c_t^N) \\ &= \alpha(\omega-1)s_t - \alpha\lambda\varphi n_t^R \, , \end{aligned}$$

where the final equality is obtained by substituting in labor supply conditions (3) and (6).

The external balance of a small open economy with LAMP depends on the terms of trade and the level of domestic consumption inequality. When $\omega = 1$, e.g. in case $\eta = \gamma = 1$, the trade balance is exclusively determined by the difference between Ricardian and non-Ricardian consumption. Absent any domestic consumption inequality, when $\lambda = 0$, the expression for net exports simplifies to (31) in Galí and Monacelli (2005).

4 Aggregate Dynamics

The equilibrium conditions of the model, summarized in Appendix D, can be reduced to a two-equation dynamic system consisting of a New Keynesian Phillips Curve and a dynamic IS equation. If financial market participation $(1-\lambda)$ is high, the aggregate dynamics are isomorphic to the standard New Keynesian dynamics. If financial market participation is low, the slope of the dynamic IS-curve changes sign: aggregate domestic output expands in reaction to a real interest rate rise. In line with Bilbiie (2008), this inverted relationship between aggregate demand and the real interest rate is called the *inverted aggregate demand logic* (IADL). The next section shows the implications of the IADL for the conduct of monetary policy in a small open economy. The two-equation system collapses to the systems of Galí and Monacelli (2005) and Bilbiie (2008) for certain parameter values.

Algebraic manipulation of the equilibrium conditions yields, as is shown in Appendix E, the following relation between Ricardian consumption, aggregate domestic output, domestic productivity, and the effective terms of trade:

$$c_t^R = \delta_\alpha y_t + (1+\mu)(1-\delta_\alpha)a_t - \alpha\omega s_t \text{ , where } \delta_\alpha \equiv 1-(1-\alpha)\frac{\varphi}{1+\mu}\frac{\lambda}{1-\lambda} \text{ .} \tag{18}$$

In Appendix E, (18) is used to obtain the IS-curve of a small open economy with LAMP:

$$\tilde{y}_t = \mathbb{E}_t\tilde{y}_{t+1} - \frac{1}{\sigma_\alpha\delta_\alpha}(r_t - \mathbb{E}_t\pi_{H,t+1} - r_t^n) \text{ ,} \tag{19}$$

where $\tilde{y}_t \equiv y_t - y_t^n$ is the output gap, i.e. the log deviation of domestic production from its flexible price counterpart, and r_t^n is the natural rate of interest. Parameter $\sigma_\alpha \equiv \frac{1}{1+\alpha\Theta}$, where $\Theta \equiv \omega - 1$.

The IS-curve shows that the effect of domestic real interest rate changes on aggregate domestic output depends on the degree of asset market participation in a non-linear way.[18] If financial exclusion (λ) increases below a certain threshold, denoted λ_α^*, the link between the policy rate and aggregate output strenghtens. Monetary policy becomes more effective, i.e. small interest rate increases have strong contractionary effects. When financial exclusion is above the critical threshold, the usual relation between the interest rate

[18] The elasticity of output with respect to changes in the real interest rate, $-\frac{1}{\sigma_\alpha\delta_\alpha}$, is visualized in Appendix H.

and aggregate demand inverts. Aggregate output responds positively to increases in the real interest rate. Following Bilbiie (2008), this inverted relations between the real interest rate and aggregate output is the inverted aggregate demand logic.

The threshold value beyond which the IADL holds, critically depends on the degree of openness α, the fraction of fixed costs to steady state output μ, and the Frisch elasticity of labor supply $\frac{1}{\varphi}$. Using (18), I obtain the threshold value for the IADL to occur in a small open economy:

$$\lambda_\alpha^* = \frac{1}{1 + (1-\alpha)\frac{\varphi}{1+\mu}} \, . \tag{20}$$

Now, consider what (20) implies for the threshold value given different values of the Frisch elasticity of labor supply, and the degree of openness.

Figure 2 reveals that the IADL is strictly less likely to apply to small open economies. Figure 2 shows the sensitivity of the threshold value λ_α^* with respect to the degree of home bias in consumption, and the Frisch labor supply elasticity. The threshold value is decreasing in the degree of home bias, and is thus greater than the threshold level in Bilbiie (2008). Bilbiie (2008) analyses the case of a closed economy, i.e. when $\alpha = 0$. This limiting case provides a lower bound to the threshold level for the IADL to apply, as is shown in Figure 2 by the solid black line. The upper bound to the threshold is $\lambda_\alpha^* = 1$, which is given by the limit in which home bias in consumption disappears ($\alpha \to 1$). An increases in the real interest rate contracts aggregate output, regardless of the proportion of non-Ricardian agents in the economy. In the limit where all domestic agents are non-Ricardian ($\lambda \to 1$), monetary policy is ineffective. All households consume their periodic income, independent of the interest rate.

In the benchmark small open economy, the IADL only applies if more than half of the domestic households is non-Ricardian. This threshold is obtained by calibrating the expression for λ_α^* using parameter values that are standard in the New Keynesian literature.[19] In Figure 2, this benchmark is indicated by the blue bullet. The black bullet

[19] I use a Frisch elasticity of labor supply of $\frac{1}{2}$, implying $\varphi = 2$, and an average price duration of one year ($\theta = \frac{3}{4}$). The ratio of fixed costs to steady state output is set at $\frac{1}{5}$, implying $\mu = \frac{1}{5}$, and the subjective discount factor is set at $\beta = .99$, which implies a riskless quarterly rate of return of about 1% in steady state. Following Galí and Monacelli (2005), the degree of openness is set at $\frac{2}{5}$.

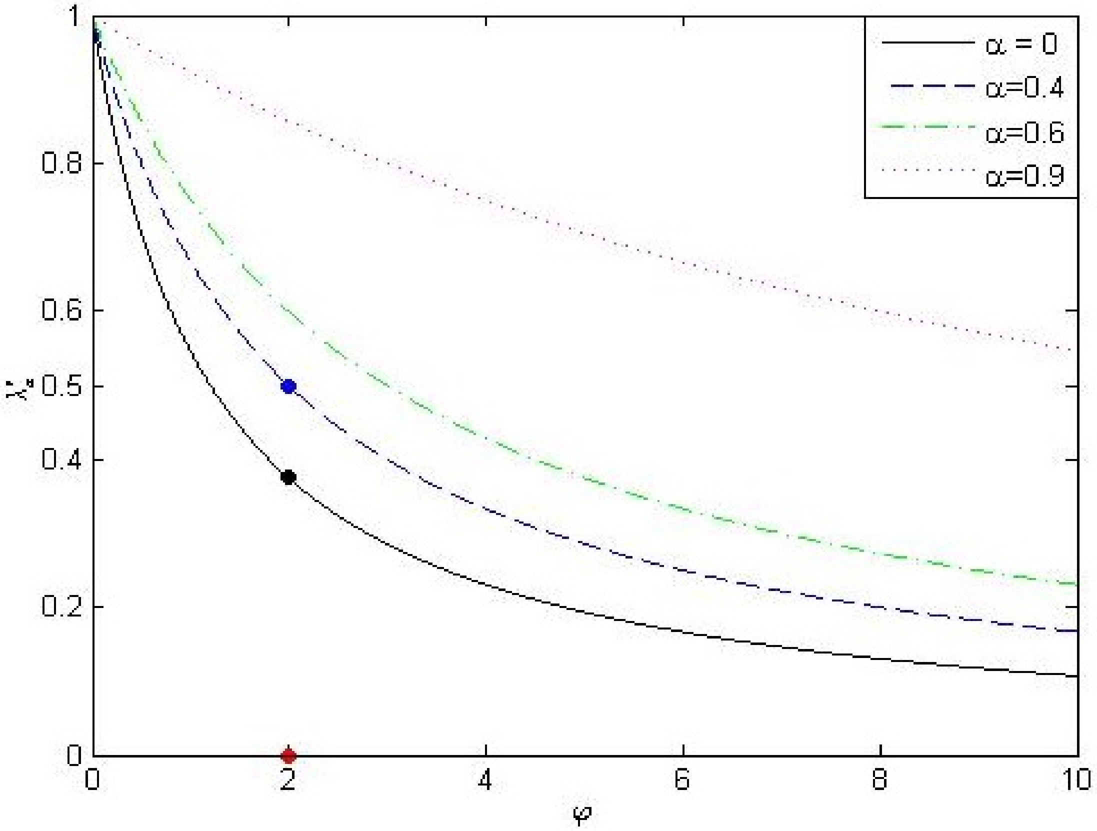

Figure 2: Threshold value of λ for the IADL to apply.

The IADL applies when the level of financial exclusion λ exceeds the threshold level λ^*_α. The IADL thus applies in the parameter space *above* the curve. The figure shows the sensitivity of the threshold value λ^*_α with respect to different values of the Frisch labor supply elasticity $\frac{1}{\varphi}$, and the degree of openness α. This analysis shows that a central bank may hold the incorrect belief that policy rate decreases lead to an expansion of aggregate domestic output if they fail to take into account the degree of financial exclusion, and the degree of openness. For $\alpha = 0$, the critical level is identical to the threshold in Bilbiie (2008). The graph also shows that the IADL never applies when $\lambda = 0$, such as in, e.g., Galí and Monacelli (2005), as indicated by the red bullet.

denotes the threshold share of non-Ricardian households for the IADL to apply in a closed economy, which is equal to $\lambda^* = \frac{3}{8}$. This threshold level plays a pivotal role in Bilbiie (2008).

Figure 1 shows that the IADL is more likely to hold in developing economies. Positive variations in the domestic real interest rate contract aggregate domestic output of high income economies (in green), but expand the domestic output of low and middle income economies (in blue). Figure 1 is constructed by comparing the calibrated threshold value for the IADL to apply, λ^*_α, to the actual degree of financial exclusion for each country, by using the data discussed in Appendix A. I use the data on openness to calibrate the threshold value λ_α^*, and the data on the penetration rate of bank accounts to measure the degree of financial inclusion. The IADL does not hold when the calibrated threshold value exceeds the actual degree of financial exclusion, i.e. when $\lambda_\alpha^* > \lambda$.

The New Keynesian Phillips Curve relates domestic inflation to its one period ahead forecast, and the output gap. The Phillips Curve is derived, as shown in Appendix F, by combining the inflation equation (12), with an expression for the deviation of real marginal costs from their natural level. This yields:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_\alpha \tilde{y}_t \ , \tag{21}$$

where $\kappa_\alpha \equiv \Psi \Upsilon$, with $\Upsilon \equiv 1 + \frac{\varphi}{1+\mu}\left[1 + \alpha \frac{\lambda}{1-\lambda}\right]$. In words, Υ denotes the elasticity of the real wage, from the firms' perspective, with respect to the output gap.[20]

The New Keynesian Phillips Curve shows that openness increases the responsiveness of inflation to variations in the output gap when λ is non-zero. Positive changes in output raise the firms' marginal costs, and hence increase the producer price level.

The building blocks of this model are the dynamic IS equation (19), the New Keynesian Phillips Curve (21), the natural interest rate, and the monetary policy rule. The Phillips Curve, the IS-curve, and the natural rate of interest describe the non-policy block of the model, which has the standard recursive structure. The Phillips Curve determines producer price inflation given the output gap, and the IS-curve determines the output gap given the real interest rate, and the natural rate of interest. The natural interest rate depends on variables that are exogenous to the model. A policy rate rule is added to the non-policy block in order to close the model. The specification of this policy rule is of key importance for the dynamics of the model economy, as I explain in the next section.

Appendix G shows that the model economy nests the non-policy block of Bilbiie (2008) for $\alpha = 0$, and the non-policy block of Galí and Monacelli (2005) for $\lambda = 0$, and $\mu = \digamma = 0$.

[20]This is shown by substituting (18), the labor market clearing condition (17), the CPI (B.4), and the effective terms of trade (B.5) into the labor supply equation for Ricardian households (3).

5 Determinacy Properties of Simple Interest Rate Rules

LAMP has strong implications for the stabilization properties of simple monetary policy rules. This section addresses the necessary and sufficient conditions for a locally unique stationary equilibrium under three alternative monetary policy regimes. I find that the monetary authority may need to follow a passive policy rule in order to ensure equilibrium uniqueness when the level of financial exclusion is high.

5.1 The Inverted Taylor Principle

I first analyse equilibrium determinacy under an expected domestic inflation-based Taylor rule.[21] This interest rate rule yields the simplest determinacy conditions, and is therefore a natural reference point for analysing macroeconomic stability in a small open economy. The policy rule aims to fully stabilize producer price inflation, and is formally written as

$$r_t = \rho + \phi_{\pi_H} \mathbb{E}_t \pi_{H,t+1} + \varepsilon_t \ , \tag{13}$$

where ε_t follows an i.i.d. normal process with mean zero and variance σ_ε.

By combining the policy rule (13), the IS-curve (19), and the Phillips Curve (21), the equilibrium conditions are written into the following system of difference equations:

$$\boldsymbol{z}_t = \boldsymbol{A}_D \mathbb{E}_t \boldsymbol{z}_{t+1} + \boldsymbol{B}_D(\hat{r}_t - \varepsilon_t) \ ,$$

where $\boldsymbol{z}_t \equiv (\tilde{y}_t, \pi_{H,t})'$ is a vector of control variables, and $\hat{r}_t \equiv r_t^n - \rho$. The coefficient matrix $\boldsymbol{A}_D$, and the coefficient vector $\boldsymbol{B}_D$, are given by:

$$\boldsymbol{A}_D = \begin{bmatrix} 1 & \frac{1-\phi_{\pi_H}}{\delta_\alpha} \\ \kappa_\alpha & \beta + \kappa_\alpha \frac{1-\phi_{\pi_H}}{\delta_\alpha} \end{bmatrix} \quad \text{and} \quad \boldsymbol{B}_D = \begin{bmatrix} \frac{1}{\delta_\alpha} \\ \frac{\kappa_\alpha}{\delta_\alpha} \end{bmatrix} .$$

Given that both the output gap and domestic inflation are nonpredetermined variables, the dynamic system has a locally unique solution if and only if both eigenvalues of $\boldsymbol{A}_D$ lie within the unit circle.[22] Using Woodford (2003), I derive Proposition 1.[23]

[21] The stabilization properties of a current domestic inflation-based Taylor rule are considerably more complicated, and are evaluated in Appendix I.1.

[22] See Blanchard and Kahn (1980).

[23] More specifically, the proofs of Propositions 1-3 make use of the general results regarding the eigenvalues of matrices set out in the Addendum to Chapter 4 of Woodford (2003).

Proposition 1 (*The Inverted Taylor Principle in a Small Open Economy*)**.** Under interest rate rule (13), the necessary and sufficient condition for a rational expectations equilibrium to be locally unique is that:

Case 1 When $\delta_\alpha > 0 : \phi_{\pi_H} \in \left(1, 1 + \delta_\alpha \frac{2(1+\beta)}{\kappa_\alpha}\right)$;

Case 2 When $\delta_\alpha < 0 : \phi_{\pi_H} \in \left(1 + \delta_\alpha \frac{2(1+\beta)}{\kappa_\alpha}, 1\right) \cap [0, \infty)$.

Case I corresponds to the standard Keynesian case. The Taylor Principle prescribes the necessary and sufficient condition for equilibrium determinacy. The central bank has to increase its policy rate more than one-for-one in response to an increase in expected domestic inflation to avoid multiple equilibria. The interest rate should, however, not respond too vigorously to changes in domestic inflation expectations as this leads to an indeterminate rational expectations equilibrium.[24]

Case II is the 'non-Keynesian' case discussed in Bilbiie (2008). The policy rate rule should satisfy the *inverted Taylor Principle* in order to ensure equilibrium determinacy. The monetary authority has to adjust its policy rate less than one-for-one in reaction to changes in domestic inflation expectations. Case II also implies that there may exists a level $\lambda > \lambda' > \lambda_\alpha$ such that determinacy can be achieved by an interest rate peg, that is, by the policy rule $r_t = \rho$. Absent any changes in the world interest rate, a fixed exchange rate regime may thus imply a determinate rational expectations equilibrium. Proposition 1 is graphically summarized in Figure 3.

5.2 Intuition for the Inverted Taylor Principle: A Sunspot Shock

When a central bank aims to stabilize inflation or output, macroeconomic fluctuations that arise purely from self-fulfilling expectations are undesirable. Sound monetary policy thus excludes equilibrium fluctuations due to self-fulfilling expectations. This section explains why policy rules of shape (13), satisfying the conditions stipulated in Proposition 1, rule out self-fulfilling fluctuations. Formally, this is seen by substituting (13) into the dynamic IS equation (19):

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\delta_\alpha}(\phi_\pi - 1)\mathbb{E}_t \pi_{H,t+1} + \frac{1}{\delta_\alpha}(\hat{r}_t - \varepsilon_t) \; .$$

[24] This property of expectation-based policy rules is discussed in detail in Bernanke and Woodford (1997).

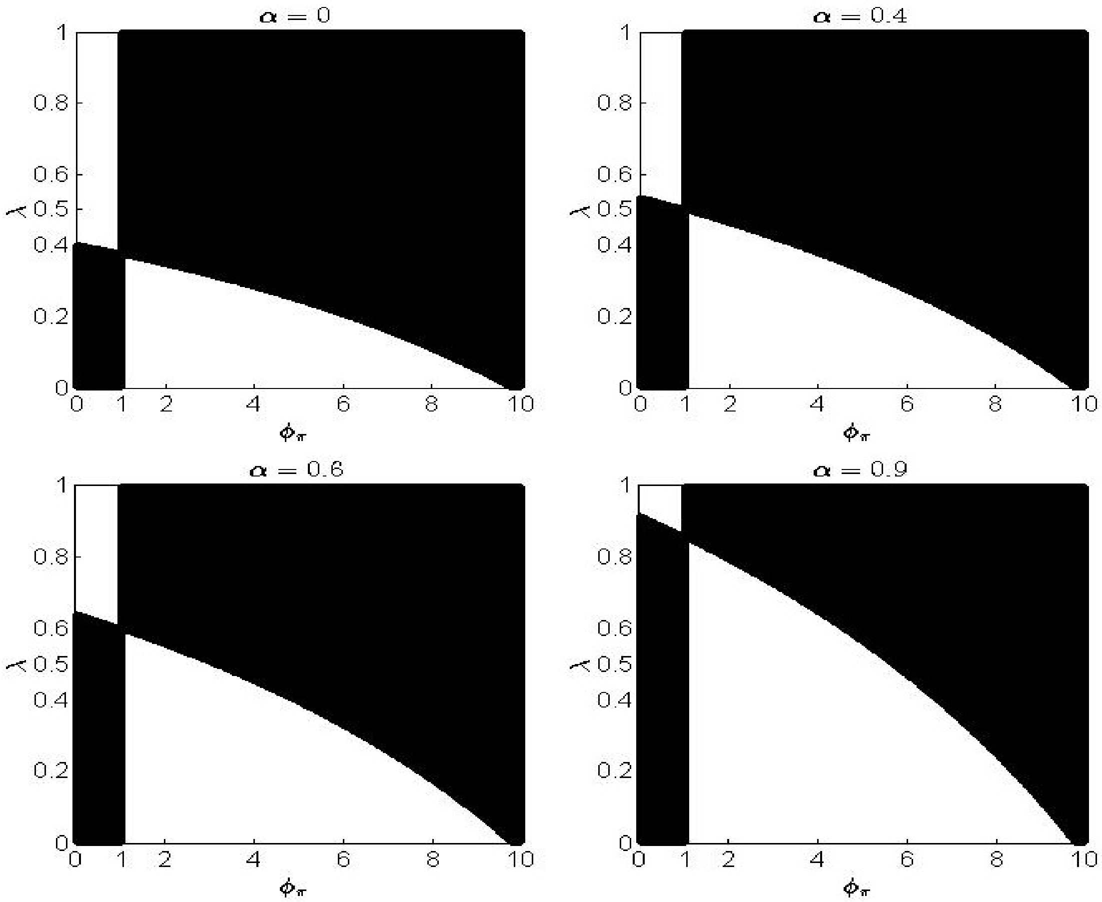

Figure 3: Determinacy under Policy Rule (13) as a Function of the Degree of Openness and Financial Exclusion. This figure shows the indeterminacy regions (filled areas) under policy rule (13) as a function of λ, ϕ_{π_H}, and α under the baseline parameterization (with $\theta = \frac{2}{3}$).

Suppose there is a pure sunspot shock to domestic inflation expectations. A positive sunspot shock generates, in case of the IADL and active monetary policy ($\delta_\alpha < 0$ and $\phi_\pi > 1$), an increase in domestic output today. This increase in the output gap feeds back into producer price inflation through the New Keynesian Phillips Curve. The initial non-fundamental shock is now validated, i.e. domestic inflation today co-moves with non-fundamental expectations of domestic inflation. Active monetary policy leads to equilibrium indeterminacy.

In the case of the IADL, a passive Taylor rule does imply equilibrium determinacy. A positive sunspot shock to domestic inflation now generates a decline in domestic output. Through the Phillips curve, this decline in aggregate demand has a deflationary impact on producer prices. The initial non-fundamental shock to inflation expectations is hence contradicted by the passive policy rule.

The result above is driven by three demand effects generated by changes in the domestic real interest rate. These demand effects are key drivers for the results in this paper. First, an increase in the real interest rate induces Ricardian households to postpone consumption. Ceteris paribus, this intertemporal substitution effect leads to a decline in aggregate demand today. Second, an increase in the domestic real interest leads, in general equilibrium, to greater domestic firm profits. Because profits are distributed as dividends to asset holders, a higher real interest rate also generates a positive income effect on the Ricardian demand for consumption goods. Third, a rise in the real interest rate leads to an appreciation of the real exchange rate, decreasing foreign demand for domestic goods. The relative magnitude of the three demand effects depends on the level of financial inclusion. The greater the level of financial inclusion, the smaller the relative magnitude of the dividend effect.

Micro-level analysis of the monetary policy transmission mechanism clarifies the micro-drivers of the demand effects in a small open economy with LAMP. Again, I suppose that a pure sunspot shock hits domestic inflation expectations.

When monetary policy is passive, a positive sunspot shock to domestic inflation expectations leads to a decline in the real interest rate, and a depreciation of the real exchange rate ($s_t \uparrow$). This leads to an increase in both internal and external demand for domestic goods. Notice that (i) these effects are impact effects, and that (ii) the internal demand increase for domestic goods depends on the degree of home bias in consumption. To evaluate aggregate demand effects, I have to take into account the dynamics generated by the optimizing behaviour of the non-Ricardian agents.

The impact effects described above result in an increased demand for domestic production. Producers that can reset their prices, $1 - \theta$, raise their prices, while the others increase their demand for labor. The real wage has to rise for Ricardian agents to meet the increased demand for their labor. Nominal wages have to rise more strongly than consumer prices. Real wages have to increase more when the labor supply of Ricardian agents is more inelastic, i.e. the greater the inverse of the Frisch labor supply elasticity φ, and when the proportion of Ricardian households is smaller. The increase in the real wage reinforces the impact increase in aggregate demand since non-Ricardian consumers simply spend their labor income each period.

Real profits of domestic firms decline as wages increase more sharply than domestic prices, i.e. as the real marginal costs increase. Because firm profits are distributed to the Ricardian agents as dividends, the decline in real profits implies a negative income shock to all Ricardian agents. This negative income shock leads to a decrease in the Ricardian agents' demand for consumption. If this income shock is concentrated on a small fraction of Ricardian agents, i.e. when the level of financial exclusion is high, this shock overturns the initial demand increase. As a result, there are no inflationary pressures, which contradicts the initial non-fundamental shock. The intuition for the IADL is visualized in Appendix H, in which I show the response of the small open economy to a nominal interest rate shock.

In a small open economy, the impact of the negative profits income effect has to be concentrated on a smaller share of Ricardian agents to overturn the initial increase in demand for domestic production initiated by the sunspot shock. The negative dividends effect now has to overturn both the Ricardian and the external demand increase, while the transmission channel between profits and domestic Ricardian demand is mitigated by the share of foreign consumption to $(1 - \alpha)$. In a closed economy, a decline in firm profits reduces, ceteris paribus, the demand for domestic goods one-for-one, in a small open economy by $\frac{1-(1-\alpha)\lambda}{1-\lambda}$. As a result, I find that $\lambda_\alpha^* > \lambda^*$.

This analysis exposes the sensitivity of the IADL to the magnitude of the profit income shock. When the link between real firm profits and Ricardian consumption is less strong, the IADL is less likely to apply. Section 6 describes two mechanisms that weaken the link between real profits and Ricardian consumption: redistributive dividend taxes, and foreign ownership of domestic intermediate good producers. The section shows that the IADL does not apply if the dividend tax rate, or the rate of foreign ownership of domestic firms, exceeds a certain threshold value.

5.3 CPI Targeting and Indeterminacy

This section evaluates macroeconomic dynamics in an open economy under the assumption that the domestic monetary authority aims to stabilize consumer price inflation. This policy regime, and the regime discussed in the next section, actively take into account the terms of trade channel of the monetary policy transmission mechanism. Under both regimes, I show that active interest rate rules may ensure equilibrium determinacy when the level of financial exclusion is high. In this section, the domestic central bank pursues an expected CPI inflation-based Taylor rule of shape:

$$r_t = \rho + \phi_\pi \mathbb{E}_t \pi_{t+1} + \varepsilon_t \ . \tag{22}$$

Using the Euler Equation for Ricardian households (4), (B.7), (B.9), the international risk sharing condition (7), and (16), I write this interest rate rule as:

$$r_t = \rho + \phi_\pi \frac{1-\alpha}{1-\alpha\phi_\pi} \mathbb{E}_t \pi_{H,t+1} + \phi_\pi \frac{\alpha}{1-\alpha} \mathbb{E}_t \Delta y^*_{t+1} + \frac{1}{1-\alpha\phi_\pi} \varepsilon_t \ .$$

The implied macroeconomic dynamics under policy rule (22) are described by the system

$$\boldsymbol{z}_t = \boldsymbol{A}_C \mathbb{E}_t \boldsymbol{z}_{t+1} + \boldsymbol{B}_C \boldsymbol{\nu}_t \ ,$$

where $\boldsymbol{\nu}_t \equiv (\hat{r}_t, \Delta y^*_{t+1}, \varepsilon_t)'$. The coefficient matrices $\boldsymbol{A}_C$ and $\boldsymbol{B}_C$ are given by

$$\boldsymbol{A}_C = \begin{bmatrix} 1 & \frac{1}{\delta_\alpha}\left(\frac{1-\phi_\pi}{1-\alpha\phi_\pi}\right) \\ \kappa_\alpha & \beta + \kappa_\alpha \frac{1}{\delta_\alpha}\left(\frac{1-\phi_\pi}{1-\alpha\phi_\pi}\right) \end{bmatrix} \text{ and } \boldsymbol{B}_C = \frac{1}{\delta_\alpha} \begin{bmatrix} 1 & -\phi_\pi \frac{\alpha}{1-\alpha} & -\frac{1}{1-\alpha\phi_\pi} \\ \kappa_\alpha & -\phi_\pi \kappa_\alpha \frac{\alpha}{1-\alpha} & -\frac{\kappa_\alpha}{1-\alpha\phi_\pi} \end{bmatrix} .$$

The equilibrium of this system of differential equations is determinate if and only if both roots of the characteristic polynomial of $\boldsymbol{A}_C$ are unstable.

Proposition 2. Under interest rate rule (22), the necessary and sufficient condition for a rational expectations equilibrium to be locally unique is that:

Case 1 When $\delta_\alpha > 0 : \phi_\pi \in (1, 1+\chi)$;

Case 2
(A) When $-\frac{\kappa_\alpha}{2(1+\beta)} < \delta_\alpha < 0$: $\phi_\pi \in (1+\chi, 1)$;
(B) When $-\frac{\kappa_\alpha}{2\alpha(1+\beta)} < \delta_\alpha < -\frac{\kappa_\alpha}{2(1+\beta)}$: $\phi_\pi \in (0, 1)$;
(C) When $\delta_\alpha \in \left(-\infty, -\frac{\kappa_\alpha}{2\alpha(1+\beta)}\right]$: Either $\phi_\pi \in (0,1)$ or $\phi_\pi > 1+\chi$,

where $\chi \equiv \frac{2\delta_\alpha(1+\beta)(1-\alpha)}{\kappa_\alpha + 2\delta_\alpha \alpha(1+\beta)} = \frac{\kappa_\alpha + 2\delta_\alpha(1+\beta)}{\kappa_\alpha + 2\delta_\alpha\alpha(1+\beta)} - 1$.

In Case 1, the 'standard' economy, monetary policy has to be active in order to ensure a determinate rational expectations equilibrium. Once again, the monetary authority should not respond too vigorously to changes in the consumer price level as this leads to equilibrium indeterminacy. The set of parameter values for ϕ_π that assure equilibrium determinacy is strictly decreasing in the degree of openness, as $\frac{\partial\chi}{\partial\alpha} < 0$. When $\alpha \to 1$, $\chi \to 0$, i.e. the range for ϕ_π to ensure a determinate equilibrium becomes infinitesimally small. Equilibrium indeterminacy is more likely to occur when the degree of home bias in consumption is low.

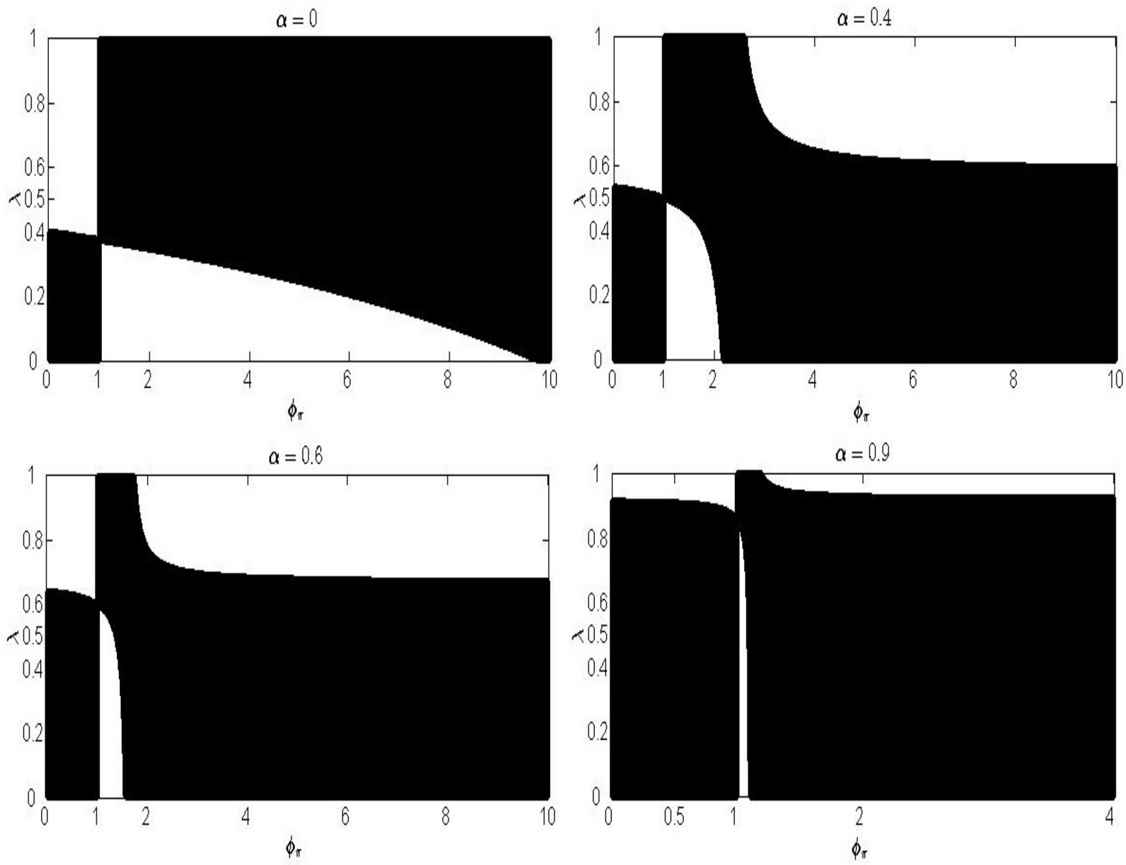

Figure 4: Determinacy under Policy Rule (22) as a Function of the Degree of Openness and Financial Exclusion. This figure shows the indeterminacy regions (filled areas) under policy rule (22) as a function of λ, ϕ_{π_H}, and α, under the baseline parameterization (with $\theta = \frac{2}{3}$). The x-axis of the bottom right panel is rescaled to ensure the visibility of the determinacy region.

In Case 2C, active monetary policy is again consistent with a unique rational expectations equilibrium. Using the standard set of parameter values, and setting $\lambda = 0.9$ such that $\delta_\alpha < -\frac{\kappa_\alpha}{2\alpha(1+\beta)}$, I find that $\chi \approx 1.58$ or $\phi_\pi > 2.58$. This result is relevant for monetary authorities in low income countries, in which asset market participation is very limited.[25] Local monetary authorities have to be careful, however, when pursuing such active policy rules, because they may imply equilibrium indeterminacy when the country's financial sector develops ($\lambda \downarrow$). Proposition 2 is depicted in Figure 4.

5.4 Output Stabilization and Indeterminacy

The third interest rate rule I analyse is the 'original' *Taylor Rule.*[26] The Taylor Rule systematically reacts to both domestic inflation and the output gap according to

$$r_t = \rho + \phi_{\pi_H} \mathbb{E}_t \pi_{H,t+1} + \phi_{\tilde{y}} \tilde{y}_t + \varepsilon_t \ . \tag{23}$$

Substituting policy rule (23) into the IS-curve (19), and the Phillips Curve (21), yields the following system of difference equations:

$$\boldsymbol{z}_t = \boldsymbol{A}_O \mathbb{E}_t \boldsymbol{z}_{t+1} + \boldsymbol{B}_O (\hat{r}_t^n - \varepsilon_t) \ .$$

The coefficient matrix $\boldsymbol{A}_O$, and the coefficient vector $\boldsymbol{B}_O$, are now given by

$$\boldsymbol{A}_O = \begin{bmatrix} \frac{\delta_\alpha}{\delta_\alpha + \phi_{\tilde{y}}} & \frac{1-\phi_{\pi_H}}{\delta_\alpha + \phi_{\tilde{y}}} \\ \frac{\kappa_\alpha \delta_\alpha}{\delta_\alpha + \phi_{\tilde{y}}} & \beta + \kappa_\alpha \frac{1-\phi_{\pi_H}}{\delta_\alpha + \phi_{\tilde{y}}} \end{bmatrix} \quad \text{and} \quad \boldsymbol{B}_O = \frac{1}{\delta_\alpha + \phi_{\tilde{y}}} \begin{bmatrix} 1 \\ \kappa_\alpha \end{bmatrix} .$$

The system has a locally unique solution for the output gap and inflation if and only if both eigenvalues of $\boldsymbol{A}_O$ are inside the unit circle.

[25] According to the World Bank Global Financial Inclusion Database described in Appendix A, the penetration rate of basic transaction accounts at official financial institutions for individuals aged 25+ is below 10% in African economies such as Burundi, the Central African Republic, Chad, Guinea, Mali, Niger, the Republic of Congo, Senegal, and Sudan.

[26] I refer to (23) as the 'original' Taylor Rule because the policy rate reacts to the rate of domestic inflation π_H, as well as the domestic output gap $\tilde{y}$, as in Taylor (1993). Taylor (1993) exclusively considers policy rules of shape (23) by choosing the GDP deflator as the measure for inflation. Some authors reserve the term Taylor Rule for the contemporaneous version of policy rule (23) with parameter values $\phi_\pi = 1\frac{1}{2}$ and $\phi_{\tilde{y}} = \frac{1}{2}$. Taylor (1993) finds that these parameter values best describe the behaviour of the Federal Reserve during the Greenspan period. I define policy rule (23) to respond to expected domestic inflation and the *current* output gap, as in Bernanke and Woodford (1997), in order to facilitate comparison with the results in Section 4.2 of Bilbiie (2008). In Appendix I.2, I analyse the stabilization properties of the forward-looking Taylor Rule $r_t = \rho + \phi_{\pi_H} \mathbb{E}_t \pi_{H,t+1} + \phi_{\tilde{y}} \mathbb{E}_t \tilde{y}_{t+1} + \varepsilon_t$. The parameter values of this policy function are estimated by Clarida et al. (2000) for the postwar United States economy.

Proposition 3. Under policy rule (23), the necessary and sufficient condition for a rational expectations equilibrium to be locally unique is that:

Case 1 When $\delta_\alpha > 0 : \phi_{\pi_H} \in \left[1 - \frac{1-\beta}{\kappa_\alpha}\phi_{\tilde{y}}, 1 + \frac{1+\beta}{\kappa_\alpha}(2\delta_\alpha + \phi_{\tilde{y}})\right]$;

Case 2 (A) When $\phi_{\tilde{y}} < -\delta_\alpha(1-\beta) : \ \phi_{\pi_H} \in \left[1 + \frac{1+\beta}{\kappa_\alpha}(2\delta_\alpha + \phi_{\tilde{y}}), 1 - \frac{1-\beta}{\kappa_\alpha}\phi_{\tilde{y}}\right]$;

$\delta_\alpha < \mathbf{0}$ (B) When $\phi_{\tilde{y}} > -\delta_\alpha(1+\beta) : \ \phi_{\pi_H} \in \left[1 - \frac{1-\beta}{\kappa_\alpha}\phi_{\tilde{y}}, 1 + \frac{1+\beta}{\kappa_\alpha}(2\delta_\alpha + \phi_{\tilde{y}})\right]$;

(C) When $-\delta_\alpha(1-\beta) < \phi_{\tilde{y}} < -\delta_\alpha(1+\beta) :$ Indeterminacy $\forall \phi_\pi \in \mathbb{R}_+$.

Proposition 3 shows that the Taylor Principle is restored for moderate levels of LAMP, and for strong responses to changes in the output gap. Case 1 corresponds to the standard Keynesian case. Case 2A presents another version of the inverted Taylor Principle. The Taylor Principle is also a suitable guideline for monetary policy in Case 2B, when λ is relatively low, and $\phi_{\tilde{y}}$ is relatively high. Using the standard parameter values, and setting $\phi_{\tilde{y}} = \frac{1}{2}$ as proposed by Taylor (1993), this proposition shows that the Taylor Principle applies up to $\lambda \approx \frac{5}{9}$.

When the monetary authority's reaction to changes in the output gap is relatively mild, the equilibrium is indeterminate regardless of the policy parameter for inflation ϕ_{π_H}. The likelihood of this scenario is decreasing in the degree of openness. Under the baseline parameterization for the IADL this case is nonetheless highly probable. For $\lambda = \frac{3}{5}$, the equilibrium is indeterminate regardless of ϕ_{π_H} when $\phi_{\tilde{y}} \in [.005, .995]$.

Proposition 3 is important from a historical perspective as it limits the ability of this model to explain the passive behavior of the Federal Reserve in the pre-Volcker era. The proposition shows that the Fed's principle of behaviour under G. William Miller and Arthur Burns did not rule out self-fulfilling expectations for any reasonable level of asset market participation. This theory would only have been able to provide an explanation for the Fed's lenient policy, as estimated by Clarida et al. (2000), if the level of financial exclusion had been as high as 94.4% in the 1970s.[27]

[27]This result is obtained by calibrating Proposition 3 using the previously specified set of parameter values for the LAMP economy (setting $\alpha = 0$ for a closed economy), and by calibrating the reaction function using the parameter estimates on the forward-looking Taylor Rule in Clarida et al. (2000), $\phi_{\tilde{y}} = 0.27$ and $\phi_{\pi_H} = 0.83$. Given these parameter values, I find that the Fed's policy rule would have ensured equilibrium

6 Restoring the Taylor Principle

This section describes two mechanisms that mitigate the relationship between real firm profits and Ricardian consumption: a redistributive dividend tax, and foreign ownership of domestic firms. As suggested in Section 5.2, the IADL is less likely to apply when the impact of the profits income channel is dampened.[28] I find that the IADL does not occur if the tax rate, or the rate of foreign ownership, exceeds a certain threshold value. This section focuses on the case where $\delta_\alpha < 0$, i.e. where the IADL holds in absence of taxes and foreign ownership.

6.1 Redistributive Dividend Taxes

A redistributive dividend tax weakens the link between firm profits and Ricardian consumption by creating a wedge between gross and net dividends received by asset holders. This wedge enters into the model by introducing a government following a balanced-budget redistributive fiscal policy rule. The only source of government revenue is the dividend tax (levied using a time-invariant tax rate τ), there are no government expenditures, and the initial (and thus permanent) public debt stock equals zero. All tax revenues are transferred to the current-income consumers. Formally, the fiscal rule is expressed as $\tau D_t = \lambda TR_t^N$, where TR_t^N denote government transfers to non-Ricardian agents. As a function of steady state domestic output, defining $tr_t^N \equiv \frac{TR_t^N}{Y}$, this rule is written as

$$\tau d_t = \lambda tr_t^N \ . \tag{24}$$

The dividend tax, and government transfers, straightforwardly enter into the budget constraints of the Ricardian (2), and the non-Ricardian (5), consumers.[29] Both constraints

determinacy if and only if $\lambda > \frac{84}{89}$. In Appendix I.2, I reach a similar conclusion using the forward-looking Taylor Rule.

[28] In Appendix J, I show that the IADL is more likely to hold when a fraction of the consumption goods are non-tradables. In casu, only the producers of traded goods experience an internal *and* external demand increase in response to a fall in the interest rate.

[29] Following Bilbiie (2008), I refer to τ as the tax rate on gross dividends. τ can also be interpreted as the proportion of state-owned enterprises in the domestic economy. [This is identical to the fiscal rule modeled above when profits of publicly owned corporations are exclusively distributed to non-Ricardian households.] Both interpretations should be kept in mind when calibrating the model.

are used, as is shown in Appendix K, to derive the following relationship between Ricardian consumption, aggregate output, productivity, and the effective terms of trade:

$$c_t^R = \delta_\tau y_t + (1+\mu)(1-\delta_\tau)a_t - \alpha\omega s_t \text{ , where } \delta_\tau \equiv \frac{1}{1-\tau}\left[1 - \tau\frac{\alpha+\mu}{1+\mu} + \varphi\frac{1-\alpha}{1+\mu}\frac{\tau-\lambda}{1-\lambda}\right] .$$

This expression is analogous to (18), and leads to Proposition 4 below.

Proposition 4. There exists a minimum threshold for the dividend tax rate τ^* such that $\delta_\tau > 0$ for all $\lambda \in [0,1)$, where $\delta_\alpha < 0$ in absence of this redistributive tax policy. This threshold tax rate is given by

$$1 > \tau^* > 1 - \frac{1+\varphi}{\frac{\varphi}{1-\lambda} - \frac{\mu+\alpha}{1-\alpha}}.$$

Note that $\frac{\varphi}{1-\lambda} - \frac{\mu+\alpha}{1-\alpha} > 1 + \varphi > 0$ when $\delta_\alpha < 0$.

Using the parameter values specified above, and setting $\lambda = \frac{3}{5}$ such that $\delta_\alpha < 0$, I find that the Taylor Principle does not invert if the redistributive dividend tax rate exceeds 25%. This tax rate dilutes the gross dividend income effect such that the IADL no longer applies. The threshold tax rate is higher when the impact of the dividend shock on each Ricardian agent is more pronounced. Given that the impact of a dividend shock on each Ricardian agent is increasing in λ and φ, the threshold tax rate to reverse the IADL is increasing in the value of these parameters. The threshold dividend tax is decreasing in α, and therefore strictly smaller than in a closed economy. The threshold tax value amounts to $\frac{3}{8}$ when $\alpha = 0$.

6.2 Foreign Ownership

Similar to a redistributive dividend tax, foreign ownership of domestic firms creates a wedge between the profits earned by domestic firms and the dividends received by the domestic Ricardian consumers. Foreign ownership of domestic intermediate good firms resembles a dividend tax. The difference is that the 'tax proceeds' are distributed to foreign agents.

Since the focus is on the impact of foreign ownership on the IADL in the domestic economy, there is no difference between dividends received by household i and dividends received by government i as long as the government spends the dividend income on the preferred consumption bundle of household i. I exploit this equivalence by supposing that foreign governments receive part of the domestic firm profits, and spend these dividends as foreign households. Formally, this is expressed by

$$G_t^* \equiv \int_0^1 G_t^i di = \varkappa D_t,$$

where G_t^i denotes public expenditures by government i, and $\varkappa$ is the time-invariant share of domestic firms under foreign ownership.

The allocation of any public expenditure level within each category of goods by government i is thus identical to the allocation by household i. The government demand functions are therefore identical to the respective household demand functions. Using the government demand functions, (8), (B.8), (7), and the definitions for the bilateral and effective terms of trade in Appendix B.3, I write the domestic goods market clearing condition as:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-\alpha)C_t + \alpha \int_0^1 \left(S_{i,t} S_t{}^i\right)^{\gamma-\eta} \mathcal{Q}_{i,t}^{\eta-1} \left(C_t^R + \mathcal{Q}_{i,t} G_t^i\right) di\right].$$

The aggregate goods market clearing condition is, analogous to (14), approximated around the symmetric steady state by

$$\begin{aligned} y_t &= (1-\alpha)c_t + \alpha c_t^R + \alpha\omega s_t + \alpha g_t^* \\ &= (1-\alpha)c_t + \alpha c_t^R + \alpha\omega s_t + \alpha\varkappa d_t \ , \end{aligned} \tag{25}$$

where the last equality follows from $g_t^* \equiv \frac{G_t^*}{Y} = \varkappa d_t$.

In case of foreign ownership, only part $(1-\varkappa)$ of the ownership shares in domestic intermediate good producers is held by the Ricardian households in the domestic economy. Domestic equity market clearing thus implies that

$$\Omega_t^R = \Omega^R = \frac{1-\varkappa}{1-\lambda} \quad \forall t. \tag{26}$$

Domestic share holdings of each domestic Ricardian agent are, at every point in time, equal to $\frac{1-\varkappa}{1-\lambda}$. Domestic assets that are not held by foreign agents are held in equal proportions by the domestic Ricardian households.

Algebraic manipulation of the clearing condition (25), and the domestic portfolio holdings of Ricardian households (26) gives, as is shown in Appendix K, the following relation between Ricardian consumption, aggregate domestic output, domestic productivity, and the effective terms of trade:

$$c_t^R = \delta_{\tau,\varkappa} y_t + (1+\mu)(1-\delta_{\tau,\varkappa})a_t - \alpha\omega s_t \text{ , where } \delta_{\tau,\varkappa} \equiv \delta_\tau + \alpha \frac{1}{1-\tau}\frac{\varkappa}{1-\varkappa}\frac{1+\varphi}{1+\mu} \, .$$

This formulation is similar to (18), and leads to the following result.

Proposition 5. There exists a threshold share for foreign ownership of domestic firms $\varkappa^*$ such that $\delta_{\tau,\varkappa} > 0$ for all $\lambda \in [0,1)$, where $\delta_\tau < 0$ in absence of foreign ownership. This threshold share is given by

$$1 > \varkappa^* > 1 - \frac{\alpha(1+\varphi)}{(1-\alpha)\varphi\frac{\lambda-\tau}{1-\lambda} - (1+\mu) + \tau(\alpha+\mu) + \alpha(1+\varphi)} \, .$$

Note that $(1-\alpha)\varphi\frac{\lambda-\tau}{1-\lambda} - (1+\mu) + \tau(\alpha+\mu) > 0$ when $\delta_\tau < 0$.

When the fraction of domestic firm shares under foreign ownership exceeds the threshold $\varkappa^*$, the profit income effect is weakened such that the IADL no longer applies. The intuition for this result is identical to the intuition underlying Proposition 4. The threshold fraction for foreign ownership is higher when the impact of a domestic profit variation on Ricardian consumption is larger. Because the impact of a variation in domestic firm profits on each Ricardian household is increasing in λ and φ, the threshold rate of foreign ownership is increasing in these parameters.

Absent any redistributive tax policy, the Taylor Principle does not invert in case more than $\frac{1}{3}$ of the domestic good producers is owned by foreign agents. This threshold is obtained by calibrating Proposition 5 for the baseline set of parameter values, and by setting $\tau = 0$.

7 Conclusion

The Taylor Principle, the prescription that the nominal interest rate has to increase by more than one percentage point for each percentage point increase in inflation, is widely viewed as a criterion for stabilizing monetary policy. However, Bilbiie (2008) and Galí et al. (2004) point at the limitations of the Taylor Principle when a large proportion of the households is excluded from the financial markets. Bilbiie (2008) shows that a rise in the real interest rate leads to an expansion of aggregate demand when the level of financial exclusion is high. When this IADL applies, policy rules may have to satisfy an inverted Taylor Principle to ensure equilibrium uniqueness.

This paper revisits the IADL in a small open economy, and argues that the IADL is strictly less likely to apply in this framework. A fall in the real interest rate is less likely to contract aggregate output because (i) the terms of trade channel is also expansionary for a decline in the real interest rate rise, and because (ii) openness dampens the response of aggregate demand for domestic goods to variations in Ricardian demand. The Taylor Principle is thus more likely to hold as the necessary condition for a determinate equilibrium. Furthermore, the Taylor Principle is restored as the necessary condition for equilibrium determinacy regardless of the level of financial exclusion when the fraction of domestic firms under foreign ownership, or the redistributive tax rate, exceeds a certain threshold.

These results are reassuring for the conduct of monetary policy in high income economies, but represent a warning sign to monetary authorities in low and middle income countries. Monetary authorities should neither ignore the degree of openness, nor the level of financial exclusion, when designing their monetary policy. Central banks that only take into account the level of financial inclusion could mistakenly adopt a passive policy rule, while central banks that only take into account the degree of openness could wrongly pursue an active policy rule. Such mistakes, leading to an indeterminate equilibrium, are more likely to occur when the level of financial exclusion is high.

The focus of this paper has been on the stabilization properties of simple interest rate rules for small open economies. This analysis has ignored the welfare implications of each of the policy rules. The next step in this research agenda is therefore to analyse optimal monetary policy in a small open economy with LAMP.[30] In future work, I also intend to evaluate the possibilities for policy coordination between countries with heterogeneous levels of financial exclusion.[31]

[30] The welfare-based optimal simple interest rate rule in Galí and Monacelli (2005) is a domestic inflation-based Taylor rule. Preliminary results indicate that this result does not hold when asset market participation is limited, or when the central bank can systematically respond to inflation expectations.

[31] Pappa (2004) addresses this question in a two-country model with full asset market participation.

Appendix A Data

The data I use to generate Table 1, and Figure 1, is collected by the World Bank. The indicator for financial exclusion is obtained directly from the World Bank's Global Financial Inclusion Database; the author's estimate for home bias in consumption is calculated using the World Bank Development Indicators. This appendix describes the data, and my calculations, in more detail.

A.1 Financial Exclusion

The indicator I use to calibrate the level of financial exclusion across economies is the share of adults, i.e. the fraction of individuals aged 25 or older, with a bank account at a formal financial institution.[32] This statistic is drawn from survey data covering more than 150,000 individuals across 148 countries. These 148 countries represent over 97% of the world population. The survey covers a representative sample of about 1,000 individuals in every economy, and was conducted in 2011. The surveys were conducted by telephone, or face-to-face (in case less than 80% of the country population has telephone coverage). The individual respondents' answers are weighted on the basis of household characteristics to ensure that the indicators are representative for each country. Given the initial random sampling, these adjustments are expected to be minor.

[32] Households commonly participate in financial markets by storing money in a savings account, paying by credit card, contributing to a pension scheme, paying insurance premia, borrowing via loans and mortgages, etc.. All transactions involving financial markets require a bank account, and all actions that involve a bank account are related to financial markets. Because ownership of a bank account is costly, households only choose to open, or hold, a bank account to participate in financial markets. A suitable statistic for asset market participation is therefore the penetration rate of bank accounts.

The introduction of LAMP has also been motivated by estimated parameter values for the share of current-income consumers, most prominently by the values estimated in Campbell and Mankiw (1989). They estimate the proportion of 'hand-to-mouth' consumers to be in the range of 35% to 50% for the United States between 1953 and 1986. Campbell and Mankiw (1991) extends this analysis to Canada, France, Japan, Sweden, and the United Kingdom, using quarterly data that spans from 1972 to 1988. Their estimates confirm that there is heterogeneity in the fraction of hand-to-mouth consumers across countries. The estimates range from 0.2 in Canada, to 0.35 in Sweden, to almost 1 in France.

The data display significant heterogeneity in the level of financial exclusion across economies. 19% of the population has access to basic financial products in low income countries, compared to 87% in high income countries. The country classifications are based on countries' gross national income per capita per annum. More specifically, the classifications are: Low Income ($1,035 or less), Lower Middle Income ($1,036 - $4,085), Upper Middle Income ($4,086 - $12,615), and High Income (more than $12,615).

A.2 Openness

The degree of openness α is approximated by $\frac{M}{C+I+G}$, i.e. domestic imports over domestic spending. Using the national income identity, $Y \equiv C + I + G + X - M$, and the equation that divides total expenditures on an open economy's output, $Y \equiv C_H + I_H + G_H + X$, I write $M = C_F + I_F + G_F$. This equation states that the domestic expenditures on imports are the sum of domestic spending on foreign goods and services. The fraction of domestic spending on foreign goods and services to total domestic spending is therefore equal to $\frac{M}{C+I+G}$. Assuming that this 'foreign share' is equal across consumption, investment, and government purchases, gives an estimate for openness of $\alpha = \frac{M}{C+I+G}$.

Using the World Bank Development Indicators, I calibrate $\alpha = \frac{M}{C+I+G}$ for the 129 countries in the sample (for which I have data on both λ and α). In specific, I use data on (i) final consumption expenditures for $C + G$, on (ii) imports of goods and services for M, and on (iii) the external balance to recover investments $I = Y - (C + G) - (X - M)$. All inputs are expressed as fractions of the gross domestic product. I synchronize the data on openness with the data on LAMP by using data over 2011. The data used in this paper was downloaded from the World Bank database on January 7, 2014.

Appendix B Open Economy Dimensions

This section describes the open economy dimensions of the model. I introduce the *Law of One Price*, *Purchasing Power Parity*, and other definitions that are used to derive tractable equilibrium conditions. The definitions are identical to those used in Galí and Monacelli (2005).

B.1 Price Indices

First, it is useful to differentiate between the Consumer Price Index and the Producer Price Index. The CPI aggregates the prices of goods consumed domestically, while the PPI aggregates the prices of goods produced domestically. Formally,

$$P_t^A = \left[(1-\alpha)P_{H,t}^{A\;1-\eta} + \alpha P_{F,t}^{A\;1-\eta}\right]^{\frac{1}{1-\eta}} \quad \text{and} \quad P_{H,t}^A = \left(\int_0^1 P_{H,t}^A(k)^{1-\varepsilon}dk\right)^{\frac{1}{1-\varepsilon}} . \tag{B.1}$$

Analogous to the consumption index for foreign goods, the price index for imported goods is

$$P_{F,t}^A = \left(\int_0^1 P_{i,t}^{A\;1-\gamma}di\right)^{\frac{1}{1-\gamma}} , \tag{B.2}$$

where $P_{i,t}^A = \left(\int_0^1 P_{i,t}^A(k)^{1-\varepsilon}dk\right)^{\frac{1}{1-\varepsilon}}$. Notice that all prices are denominated in the currency of domestic economy H. The Law of One Price implies that these relationships are indeed independent of currency denomination.

B.2 The Law of One Price

The Law of One Price holds for each individual good at every point in time. A good sells at the same price in every country. Formally, this no arbitrage condition requires that

$$P_{i,t}(k) = \mathcal{E}_{i,t}P_{i,t}^i(k) \;\; \forall i,k \in [0,1] ,$$

where $\mathcal{E}_{i,t}^H$ denotes the bilateral nominal exchange rate between domestic currency H and currency i. An appreciation of currency H is represented by a decrease in $\mathcal{E}_{i,t}^H = \mathcal{E}_{i,t}$.

Assuming that the Law of One Price holds, I rewrite the PPI for foreign goods (B.2) as follows:

$$P_{F,t}^A = \left(\int_0^1 \left[\int_0^1 \mathcal{E}_{i,t}^{1-\varepsilon}P_{i,t}^{i,A}(k)^{1-\varepsilon}dk\right]^{\frac{1-\gamma}{1-\varepsilon}} di\right)^{\frac{1}{1-\gamma}} = \left(\int_0^1 \mathcal{E}_{i,t}^{1-\gamma}P_{i,t}^{i,A\;1-\gamma}di\right)^{\frac{1}{1-\gamma}} .$$

A log-linear approximation of the PPI for foreign goods around a steady state satisfying *Purchasing Power Parity* (PPP), i.e. around a steady state in which $P_H = P_F = P_i$ for all i, gives

$$p_{F,t} = e_t + p_t^* , \tag{B.3}$$

where $e_t \equiv \int_0^1 e_{i,t} di$ and $p_t^* \equiv \int_0^1 p_{i,t}^i di = \int_0^1 p_t^{i,i} di$, where $p_{i,t}^i \equiv \int_0^1 p_{i,t}^i(k) dk$. The price change in the bundle of foreign goods is equal to the change in H's *nominal effective exchange rate* e_t plus the change in the *world (local currency) price index* p_t^*. The CPI can similarly be written as

$$p_t = (1-\alpha)p_{H,t} + \alpha p_{F,t} \ . \tag{B.4}$$

B.3 Terms of Trade

The *bilateral terms of trade* between economies H and i is defined by the ratio of their PPI:

$$\mathcal{S}_{i,t} \equiv \frac{P_{i,t}}{P_{H,t}} \ .$$

The *effective terms of trade* is the price of the composite index of foreign goods in terms of domestically produced goods prices. It is defined as:

$$\mathcal{S}_t \equiv \frac{P_{F,t}}{P_{H,t}} = \left(\int_0^1 \mathcal{S}_{i,t}^{1-\gamma} di \right)^{\frac{1}{1-\gamma}} \ .$$

Log-linearised to first order, around a steady state satisfying PPP, the effective terms of trade is written as

$$s_t = p_{F,t} - p_{H,t} \tag{B.5}$$

$$= e_t + p_t^* - p_{H,t} \ , \tag{B.6}$$

where the last equality follows from (B.3).

B.4 Inflation

Price inflation of goods bundle l denominated in currency i is defined as:

$$\Pi_{l,t}^i \equiv \frac{P_{l,t}^i}{P_{l,t-1}^i} \ ,$$

which is approximated by the expression

$$\pi_{l,t}^i = p_{l,t}^i - p_{l,t-1}^i \ .$$

Combining (B.4) and (B.5) with this expression for inflation, the gap between domestic PPI inflation and domestic CPI inflation is written as a function of the terms of trade:

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \ , \tag{B.7}$$

where $\Delta s_t \equiv s_t - s_{t-1}$. The gap between CPI and PPI inflation is proportional to the change in the terms of trade, and decreasing in the degree of home bias in consumption.

Lastly, the *bilateral real exchange rate* between economies i and j, $\mathcal{Q}^j_{i,t}$, is the ratio of the countries' CPI denominated in the same currency,

$$\mathcal{Q}^j_{i,t} \equiv \frac{\mathcal{E}^j_{i,t} P^{i,i}_t}{P^{j,j}_t} \ . \tag{B.8}$$

Note that $\mathcal{Q}_i = 1$ for all i in a steady state in which PPP holds. For the domestic economy, the bilateral real exchange rate is rewritten in log-linear form as

$$q_{i,t} = e_{i,t} + p^{i,i}_t - p_t \ .$$

Integrating over all economies i, the (log) *effective real exchange rate*, $q_t \equiv \int_0^1 q_{i,t} di$, is

$$\begin{aligned} q_t &= e_t + p^*_t - p_t \\ &= (1-\alpha) s_t \ , \end{aligned} \tag{B.9}$$

where the final equality follows from combining (B.4) and (B.5) with (B.6). The (log) effective real exchange rate and the (log) effective terms of trade are proportional. The two coincide under autarky ($\alpha = 0$). On the other hand, if there is no home bias in consumption, when $\alpha = 1$, the effective real exchange rate $\mathcal{Q}_t$ is equal to unity for all t.

B.5 Uncovered Interest Rate Parity and the Terms of Trade

Absence of arbitrage in complete international asset markets implies that the price of a riskless asset denominated in foreign currency, in terms of the domestic currency, is given by $\frac{\mathcal{E}_t}{R^*_t} = \mathbb{E}_t \left[\Lambda_{t,t+1} \mathcal{E}_{t+1}\right]$.[33] Combining this arbitrage condition with the expression for the short-term risk-free nominal interest rate (1), gives the *uncovered interest rate parity* (UIRP) condition. The UIRP condition states that there is no potential for uncovered

[33]This expression is a corollary of footnote 6.

interest arbitrage profits in complete international financial markets. Formally, I write

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\left(R_t - R_t^*\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\right)\right] = 0 \ ,$$

where R_t^* denotes the gross return on a risk-free asset denominated in foreign currency. Log-linearised around the symmetric steady state, the UIRP condition is written as

$$r_t - r_t^* = \mathbb{E}_t\Delta e_{t+1} \ ,$$

where $r_t^* \equiv \int_0^1 r_t^i di$ is the (log) *effective world interest rate.* Conditional on expectations, an increase in the domestic interest rate leads to an appreciation of the domestic currency. Combining (B.6) with the UIRP condition, the (log) terms of trade is given by

$$s_t = \left(r_t^* - \mathbb{E}_t\pi_{t+1}^*\right) - \left(r_t - \mathbb{E}_t\pi_{H,t+1}\right) + \mathbb{E}_t s_{t+1} \ .$$

The change in the effective terms of trade of the domestic economy is given by the difference between the domestic and world *real interest rate.* An increase in the domestic real interest rate leads to an appreciation of the real exchange rate ($s_t \downarrow$) when UIRP holds.

Appendix C Robustness: CRRA Utility Function

This appendix analyses whether the results in the main text are specific to the log-CRRA specification of the felicity function. Using a general CRRA periodic utility function, I show that the results are robust to changes in σ, the degree of relative risk aversion. Like φ, $\sigma \geq 0$ is homogeneous across agents. Formally, the maximization problem of Ricardian households reads:

$$\max_{C_t^R, N_t^R} \frac{C_t^{R\,1-\sigma}}{1-\sigma} - \vartheta\frac{N_t^{R\,1+\varphi}}{1+\varphi}$$

subject to (2).

Using the first order conditions to the Ricardian household problem, I obtain the following optimality conditions:

$$w_t = \sigma c_t^R + \varphi n_t^R \ , \text{ and}$$

$$c_t^R = \mathbb{E}_t c_{t+1}^R - \frac{1}{\sigma}(r_t - \mathbb{E}_t\pi_{t+1} - \rho) \ ,$$

the intratemporal labor condition, and the Euler equation, for Ricardian agents. Similarly, the labor supply condition for non-Ricardian households reads

$$w_t = \sigma c_t^N + \varphi n_t^N \ .$$

Substituting in the budget constraint for non-Ricardian households (5), I write

$$n_t^N = \frac{1-\sigma}{\sigma+\varphi} w_t \equiv \varpi w_t \ , \tag{C.1}$$

where ϖ is the Marshallian labor supply elasticity. It measures the change in labor supply in response to a change in the real wage rate, holding non-labor income fixed. Because both σ and φ are positive, the denominator of ϖ is positive. The numerator of ϖ is negative when $\sigma > 1$, implying that an increase in the real wage reduces the labor supply of non-Ricardian households. Most empirical studies find that $1-\sigma$ is small and positive, which implies that the uncompensated labor supply elasticity is small and positive as well (Keane (2011)).

A little algebra, following the steps described in Appendix E, and using (C.1), shows that the IADL applies when λ exceeds the threshold value

$$\lambda^*_{\alpha,\sigma} = \frac{1}{1 + \Big[(1-\alpha) - \varpi(\mu+\alpha)\Big]\frac{\varphi}{1+\mu}} \ .$$

The threshold collapses to (20) when $\sigma = 1$, i.e. when utility is logarithmic in consumption, implying that $\varpi = 0$. Given that ϖ is small and positive, the threshold level is higher than in the case of log utility. The quantitative differences, however, are minor. Without loss of generality, I continue to use the log-CRRA specification of the felicity function in the main text.

Appendix D Model Summary

When $\mu = \digamma$, the set-up of the baseline model can, in log-linear form, be summarized as follows:

Budget Constraint, R	$c_t^R = w_t + n_t^R + \frac{1}{1-\lambda} d_t$	(2)
Labor Supply, R	$w_t = c_t^R + \varphi n_t^R$	(3)
Euler Equation, R	$c_t^R = \mathbb{E}_t c_{t+1}^R - (r_t - \mathbb{E}_t \pi_{t+1} - \rho)$	(4)
Budget Constraint, N	$c_t^N = w_t + n_t^N$	(5)
Labor Supply, N	$w_t = c_t^N$	(6)
International Risk Sharing	$c_t^R = c_t^* + (1-\alpha) s_t$	(7)
Domestic Production Technology	$y_t = (1+\mu) a_t + (1+\mu) n_t$	(10)
Domestic Real Marginal Costs	$\underline{mc}_t = -v + \overline{w}_t - p_{H,t} - a_t$	(11)
Domestic Real Profits	$d_t = -\underline{mc}_t + \frac{\mu}{1+\mu} y_t$	
New Keynesian Inflation Equation	$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \Psi \underline{mc}_t$	(12)
Monetary Policy	$r_t = \rho + \phi_{\pi_H} \mathbb{E}_t \pi_{H,t+1} + \varepsilon_t$	(13)
Domestic Goods Market Clearing	$y_t = (1-\alpha) c_t + \alpha c_t^R + \alpha \omega s_t$	(15)
Foreign Goods Market Clearing	$y_t^* = c_t^*$	(16)
Labor Market Clearing	$n_t = \lambda n_t^N + (1-\lambda) n_t^R$	(17)
Trade Balance	$nx_t = \alpha(\omega - 1) s_t - \alpha \lambda \varphi n_t^R$	
Uncovered Interest Rate Parity	$r_t = r_t^* + \mathbb{E}_t \Delta e_{t+1}$	
Aggregate Consumption	$c_t = \lambda c_t^N + (1-\lambda) c_t^R$	

Table 2: Summary of the Baseline Model.

This table summarizes the log-linearised equilibrium conditions of the benchmark model set out in the main text.

Appendix E Derivation of the IS-Curve

This appendix describes the derivation of equation (18), and of the dynamic IS-curve (19), in Section 4. Equation (18) relates Ricardian consumption to aggregate domestic output, domestic productivity, and the effective terms of trade. To derive this equation, I first substitute the non-Ricardian labor supply condition (5) into aggregate domestic consumption:

$$c_t = (1-\lambda) c_t^R + \lambda w_t \,.$$

Using this expression, I write

$$c_t = c_t^R + \lambda\varphi n_t^R$$
$$= c_t^R + \varphi\frac{\lambda}{1-\lambda}\frac{1}{1+\mu}y_t - \varphi\frac{\lambda}{1-\lambda}a_t \;, \tag{E.1}$$

by substituting in the Ricardian labor supply condition (3), the labor market clearing condition (17), and the domestic production technology (10). By rearranging this expression, and by substituting in the goods market clearing condition (15), I obtain:

$$c_t^R = \left[1-(1-\alpha)\frac{\varphi}{1+\mu}\frac{\lambda}{1-\lambda}\right]y_t + (1-\alpha)\varphi\frac{\lambda}{1-\lambda}a_t - \alpha\omega s_t$$
$$= \delta_\alpha y_t + (1+\mu)(1-\delta_\alpha)a_t - \alpha\omega s_t \;, \tag{18}$$

where $\delta_\alpha \equiv 1-(1-\alpha)\frac{\varphi}{1+\mu}\frac{\lambda}{1-\lambda}$.

The second part of this appendix derives the dynamic IS-curve by developing the Euler equation for Ricardian consumption. By substituting in (18), and (B.7), the Euler equation for Ricardian consumption (4) is written as:

$$\delta_\alpha y_t = \delta_\alpha \mathbb{E}_t y_{t+1} + (1+\mu)(1-\delta_\alpha)\mathbb{E}_t\Delta a_{t+1} - \alpha\Theta\mathbb{E}_t\Delta s_{t+1} - (r_t - \mathbb{E}_t\pi_{H,t+1} - \rho) \;, \tag{E.2}$$

where $\Theta \equiv \omega - 1$.

To simplify (E.2), I rewrite the terms of trade s_t by substituting the international risk sharing condition (7), and the world goods market clearing condition (16), into (18). This yields:

$$s_t = \sigma_\alpha\left[\delta_\alpha y_t - y_t^* + (1+\mu)(1-\delta_\alpha)a_t\right] \;, \tag{E.3}$$

where $\sigma_\alpha \equiv \frac{1}{1+\alpha\Theta}$. By substituting the log terms of trade into (E.2), the dynamic IS-curve is derived as:

$$\tilde{y}_t = \mathbb{E}_t\tilde{y}_{t+1} - \frac{1}{\sigma_\alpha\delta_\alpha}(r_t - \mathbb{E}_t\pi_{H,t+1} - \rho) + \frac{1-\delta_\alpha}{\delta_\alpha}(1+\mu)\mathbb{E}_t\Delta a_{t+1} + \frac{\alpha\Theta}{\delta_\alpha}\mathbb{E}_t\Delta y_{t+1}^* + \mathbb{E}_t\Delta y_{t+1}^n \;,$$

where $\tilde{y}_t \equiv y_t - y_t^n$ is the output gap. Defining the small open economy's natural rate of interest, r_t^n, as

$$r_t^n \equiv \rho - \sigma_\alpha(1-\delta_\alpha)(1+\mu)(1-\rho_a)a_t + \alpha\Theta\sigma_\alpha\mathbb{E}_t\Delta y_{t+1}^* + \sigma_\alpha\delta_\alpha\mathbb{E}_t\Delta y_{t+1}^n$$
$$= \rho - \sigma_\alpha\left[(1-\delta_\alpha)(1+\mu) + \Gamma_a\delta_\alpha\right](1-\rho_a)a_t + \sigma_\alpha\left[\alpha\Theta + \delta_\alpha\Gamma_*\right]\mathbb{E}_t\Delta y_{t+1}^* \;,$$

where the final equality follows from (F.2) in Appendix F, I obtain

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\sigma_\alpha \delta_\alpha}(r_t - \mathbb{E}_t \pi_{H,t+1} - r_t^n) \ , \tag{19}$$

the dynamic IS equation presented in the main text.

Appendix F Derivation of the New Keynesian Phillips Curve

This appendix discusses the derivation of the New Keynesian Phillips Curve (NKPC), the dynamic equation that relates current producer price inflation to its one-period-ahead expectation, and the output gap. To obtain the NKPC, I first write the New Keynesian inflation equation (12) in terms of deviations from the variables' natural level:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \Psi \widetilde{\underline{mc}}_t \ ,$$

where $\widetilde{\underline{mc}}_t \equiv \underline{mc}_t - \underline{mc}_t^n$. To simplify the New Keynesian inflation equation, it is convenient to first express the domestic real marginal costs as:

$$\begin{aligned} \underline{mc}_t &= -v + \overline{w}_t - p_{H,t} - a_t \\ &= -v + c_t^* + \varphi n_t^R + s_t - a_t \\ &= -v + y_t^* + s_t + \frac{\varphi}{(1-\lambda)(1+\mu)} y_t - \left(1 + \frac{\varphi}{1-\lambda}\right) a_t \ , \end{aligned}$$

where, in turn, I substituted in (B.5), (B.4), the Ricardian labor supply condition (3), the international risk sharing condition (7), the domestic production technology (10), and the labor market clearing condition (17). I further simplify this equation by substituting in (E.3), which yields:

$$\underline{mc}_t = -v + \Upsilon y_t + \Big[1 - \sigma_\alpha\Big] y_t^* + \left[\sigma_\alpha (1+\mu)(1-\delta_\alpha) - \left(1 + \frac{\varphi}{1-\lambda}\right)\right] a_t \ , \tag{F.1}$$

where $\Upsilon \equiv 1 + \frac{\varphi}{1+\mu}\left[1 + \alpha \frac{\lambda}{1-\lambda}\right]$.

In the flexible price limit, when θ approaches 0 from above, the real marginal costs are constant and equal to the negative of the mark-up, i.e. $\underline{mc}_t^n = \underline{mc}^n = -\mu$.[34] The

[34]This expression follows from the price-setting rule of the domestic producers. The price-setting rule of domestic firms is derived within the derivation of the New Keynesian inflation equation, as is shown in Appendix B of Galí and Monacelli (2005).

natural level of output in the small open economy is therefore given by:

$$y_t^n = \Gamma_0 + \Gamma_* y_t^* + \Gamma_a a_t \ , \tag{F.2}$$

where $\Gamma_0 \equiv \frac{v-\mu}{\Upsilon}$, $\Gamma_* \equiv -\frac{1-\sigma_\alpha}{\Upsilon}$, and $\Gamma_a \equiv \frac{1}{\Upsilon}\left[\left(1+\frac{\varphi}{1-\lambda}\right) - \sigma_\alpha(1+\mu)(1-\delta_\alpha)\right]$.

Using (F.1), and the fact that y_t^* is invariant to developments in the domestic economy, I write the deviation of the real marginal costs from its natural level as:

$$\widetilde{mc}_t = \Upsilon \tilde{y}_t$$

The New Keynesian inflation equation is now rewritten to obtain the NKPC presented in the main text:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_\alpha \tilde{y}_t \ , \tag{21}$$

where $\kappa_\alpha \equiv \Psi \Upsilon$.

Appendix G Special Cases of the Two-Equation System

In this appendix, I show that the dynamic system in the main text nests the non-policy blocks of Bilbiie (2008), and Galí and Monacelli (2005).

G.1 Closed Economy

In case of a closed economy, when $\alpha = 0$, the dynamic two equation system collapses to Bilbiie (2008). The New Keynesian Phillips Curve collapses to the NKPC in Bilbiie (2008), since $\Upsilon_{\alpha=0} = 1 + \frac{\varphi}{1+\mu}$. Given that $\sigma_\alpha = 1$, and $\delta_{\alpha=0} = \delta$, the dynamic IS equation becomes

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\delta}(r_t - \mathbb{E}_t \pi_{H,t+1} - r_t^n) \ ,$$

where the natural rate of interest simplifies to $r_t^n = \rho - (1-\rho_a)\left[1 + \mu\left(1 - \frac{\delta}{\Upsilon_{\alpha=0}}\right)\right] a_t$.

G.2 Representative Agent

When all households have access to the complete international financial market, and when the steady state fixed costs equal zero, the model collapses to the model by Galí and

Monacelli (2005). In Galí and Monacelli (2005), $\lambda = 0$, and $\mu = 0$, which implies that $\delta_\alpha = 1$, and hence that $\Upsilon_{\lambda=0} = \sigma_\alpha + \varphi$. In this case, the NKPC simplifies to

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \Psi(\sigma_\alpha + \varphi)\tilde{y}_t \ .$$

Noting that $\lambda = 0$ also implies that $\Gamma_a = \frac{1+\varphi}{\sigma_\alpha+\varphi}$, and that $\Gamma_* = \frac{\sigma_\alpha - 1}{\sigma_\alpha+\varphi}$, the dynamic IS-curve is written as:

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\sigma_\alpha}(r_t - \mathbb{E}_t \pi_{H,t+1} - r_t^n) \ ,$$

where $r_t^n = \rho - \sigma_\alpha \Gamma_a (1 - \rho_a) a_t + \frac{\alpha \Theta \sigma_\alpha \varphi}{\sigma_\alpha + \varphi} \mathbb{E}_t \Delta y_{t+1}^*$.

Appendix H Additional Figures

This appendix presents additional figures to visualize the theory set out in the main text. More specifically, this section shows (i) how the elasticity of output with respect to the real interest rate is affected by the degree of openness, and the level of financial exclusion, and (ii) how the model economy responds to a monetary policy shock.

H.1 Elasticity of Output with respect to the Real Interest Rate

The dynamic IS-curve (19) shows that the elasticity of output with respect to the real interest is a non-linear function of the level of financial exclusion. More specifically, the elasticity of domestic output with respect to the domestic real interest rate is given by $-\frac{1}{\sigma_\alpha \delta_\alpha}$. Calibrating this elasticity using the standard set of parameter values, implying that $\sigma_\alpha = 1$, gives Figure 5.

Figure 5 shows that the standard relation between the real interest rate and aggregate output strengthens when the level of financial exclusion increases below the respective threshold. Monetary policy becomes more effective: small variations in the interest rate lead to significant variations in aggregate demand. The vertical asymptotes to the elasticity are given by the threshold values in Figure 2 for $\varphi = 2$.

When the level of financial exclusion exceeds the threshold value, the relation between the real interest rate and aggregate demand inverts: aggregate output expands in response to a rise in the real interest rate. The impact of policy rate variations decreases when the level of LAMP increases above the threshold. In the limit where all agents are 'hand-to-mouth' consumers, monetary policy is sterilized: variations in the real interest rate have no impact on aggregate domestic demand.

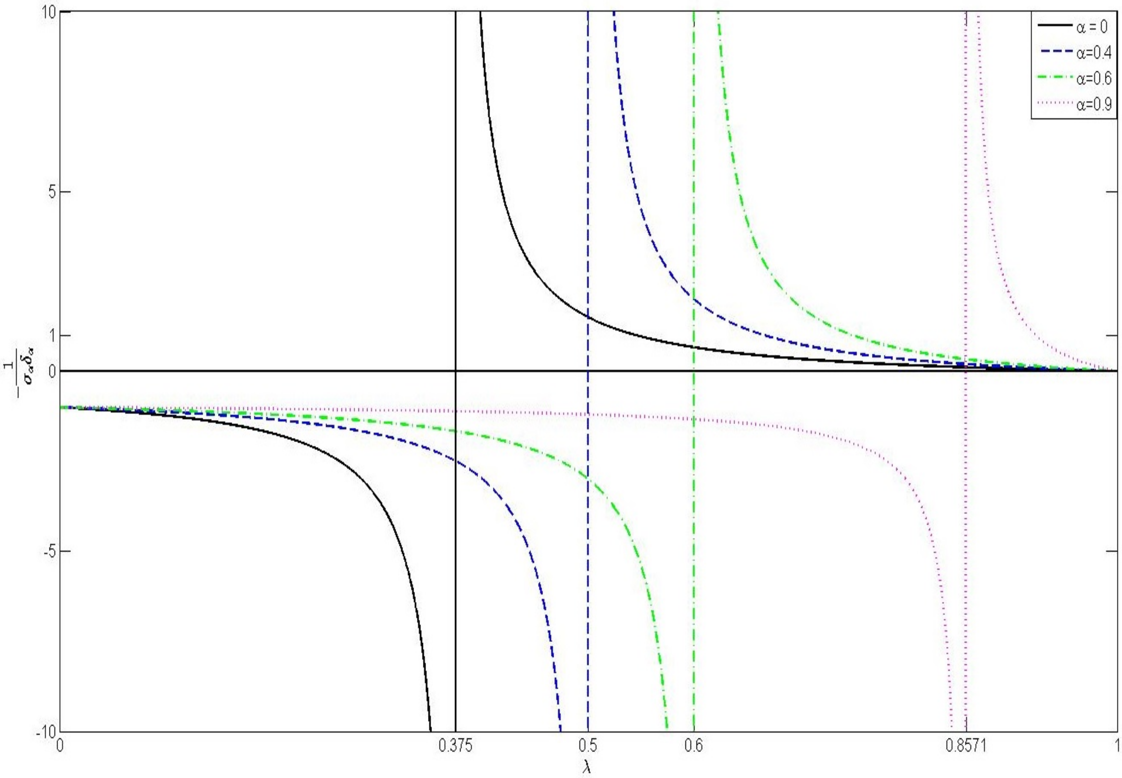

Figure 5: Elasticity of Aggregate Domestic Output with respect to the Domestic Real Interest Rate.
This figure shows the elasticity of aggregate output with respect to the interest rate as a function of the level of financial exclusion λ, and the degree of openness α. The threshold values for the IADL to materialize are depicted by the vertical asymptotes to the elasticity. Monetary policy is most effective in the parameter space around these threshold values.

H.2 Monetary Policy Shock

This section describes the propagation of a monetary policy shock in a small open economy with LAMP, and hence illustrates the micro-level transmission chains discussed in Section 5.2. I suppose that a positive monetary policy shock ε_t hits the expected domestic inflation-based Taylor rule.

Figure 6 shows that the real interest rate rises in response to a positive monetary policy shock. Ricardian households postpone consumption, and want to work more hours. Firms accommodate the fall in demand by cutting their prices, and by reducing their

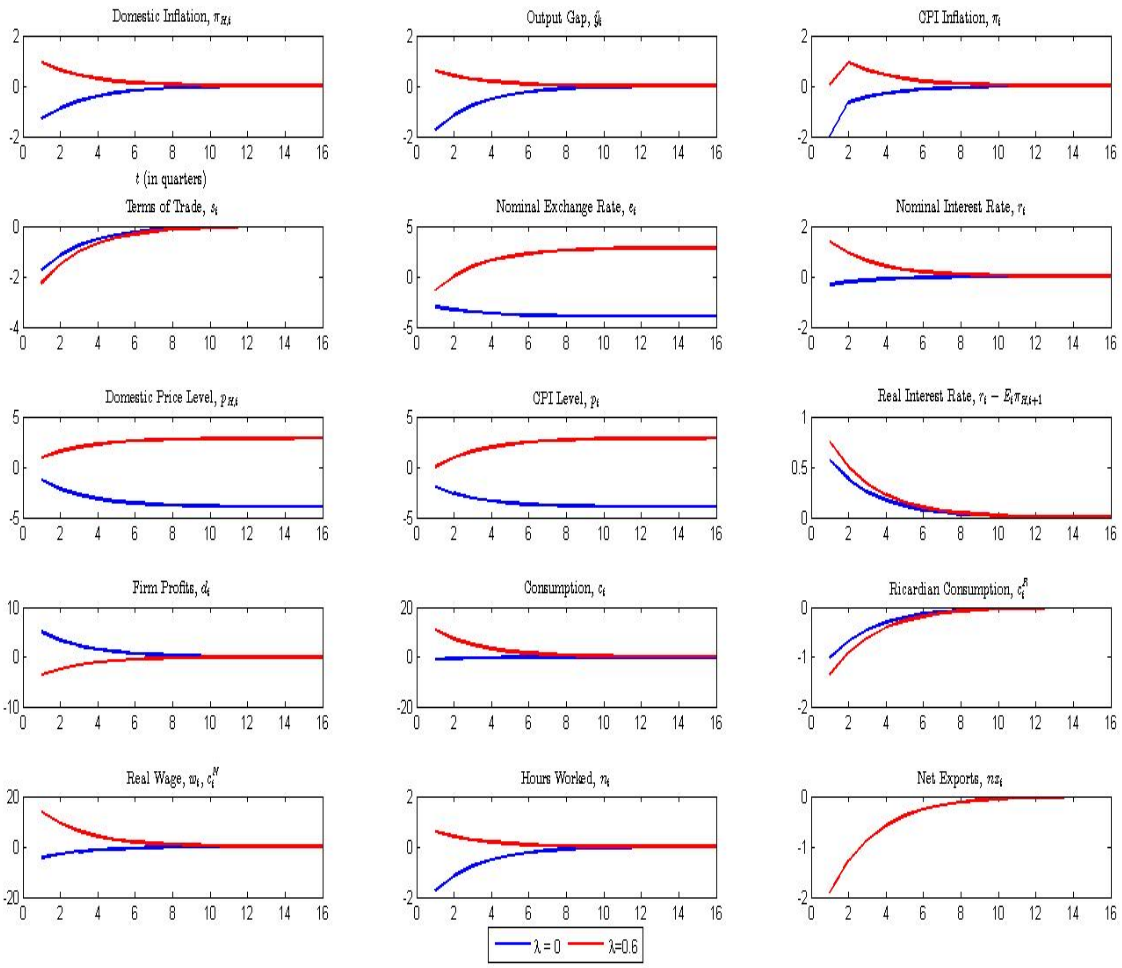

Figure 6: Impulse Responses to a Monetary Policy Shock under an Expected PPI Inflation-Based Taylor Rule. This figure shows the propagation of a one standard deviation monetary policy shock in a small open economy for different levels of financial inclusion. When $\lambda = 0$ (in blue), the standard demand logic applies: an increase in the real interest rate contracts aggregate demand. When $\lambda = 0.6$ (in red), the profit income effect dominates the real wage effect, i.e. the IADL applies. A rise in the real interest rate expands aggregate domestic output.

labor demand. The labor market clears instantaneously at a lower real wage. The decline of the real wage may lead to a further decline in aggregate demand when λ is positive, since non-Ricardian agents consume their wage income each period. The contractionary demand effects of a policy rate increase are thus reinforced by the fall in the real wage.

Real profits of domestic firms increase because the marginal cost reduction exceeds the fall in demand. These profits are distributed as dividends to the Ricardian households. The positive income effect increases Ricardian consumption demand, but does not overturn the initial decline, when firm profits are distributed to a large share of Ricardian agents. In Figure 6, this is shown by the blue lines, which illustrate the propagation of the policy shock when $\lambda = 0$, and $\phi_{\pi_H} = 1.5$. Notice that the nominal interest rate may decline in reaction to a positive nominal interest rate shock due to a fall in domestic inflation expectations.

When the profits income shock is concentrated on a small share of Ricardian agents, the initial fall in Ricardian consumption, and external demand, is overturned. Firms accommodate an increased demand for their products by raising their prices, and by increasing their labor demand. As a result, domestic firms increase production, and the real wage rises. The rise in the real wage increases non-Ricardian consumption, and depresses real firm profits. In general equilibrium, this decline in profits does not invert the aggregate demand increase, but does reduce Ricardian consumption demand. In sum, aggregate output increases following a positive monetary policy variation. In Figure 6, this IADL is depicted by the red lines, illustrating the reaction to the policy shock when $\lambda = \frac{3}{5}$, and $\phi_{\pi_H} = \frac{4}{5}$.

Appendix I Alternative Interest Rate Rules

I.1 Contemporaneous Interest Rate Rule

One may wonder whether the inverted Taylor Principle only applies to forward-looking policy rules, especially in light of the results of Galí et al. (2004). This appendix analyses equilibrium determinacy in a small open economy in which the central bank responds systematically to current domestic inflation. I show that strong, anti-inflationary monetary policy may ensure equilibrium uniqueness when the degree of openness is high, and the degree of financial exclusion relatively moderate. Formally, the monetary authority adopts a domestic inflation-based Taylor rule of form:

$$r_t = \rho + \phi_{\pi_H} \pi_{H,t} + \varepsilon_t \ . \tag{I.1}$$

By combining the IS-curve (19), the Phillips Curve (21), and the interest rate rule (I.1), I obtain the following system of difference equations:

$$\boldsymbol{z}_t = \boldsymbol{A}_{\underline{D}} \mathbb{E}_t \boldsymbol{z}_{t+1} + \boldsymbol{B}_{\underline{D}} (\hat{r}_t - \varepsilon_t) \ ,$$

where $\hat{r}_t \equiv r_t^n - \rho$, and $\boldsymbol{z}_t \equiv (\tilde{y}_t, \pi_{H,t})'$ is a vector of control variables. The coefficient matrix $\boldsymbol{A}_{\underline{D}}$, and the coefficient vector $\boldsymbol{B}_{\underline{D}}$, are given by:

$$\boldsymbol{A}_{\underline{D}} = \frac{1}{\delta_\alpha + \phi_{\pi_H}\kappa_\alpha}\begin{bmatrix} \delta_\alpha & 1-\beta\phi_{\pi_H} \\ \kappa_\alpha\delta_\alpha & \beta\delta_\alpha + \kappa_\alpha \end{bmatrix} \quad \text{and} \quad \boldsymbol{B}_{\underline{D}} = \frac{1}{\delta_\alpha + \phi_{\pi_H}\kappa_\alpha}\begin{bmatrix} 1 \\ \kappa_\alpha \end{bmatrix}.$$

Both the output gap and domestic inflation are nonpredetermined variables, which implies that the dynamic system has a locally unique solution if and only if both eigenvalues of $\boldsymbol{A}_{\underline{D}}$ are inside the unit circle.

Proposition 6. Under interest rate rule (I.1), the necessary and sufficient condition for a rational expectations equilibrium to be locally unique is that:

Case 1 If $\delta_\alpha > 0 : \phi_\pi \in (1, \infty)$;

Case 2 If $\delta_\alpha < 0 : \phi_\pi \in \left[0, \min\left\{1, \delta_\alpha\frac{\beta-1}{\kappa_\alpha}, -1-\frac{2\delta_\alpha(1+\beta)}{\kappa_\alpha}\right\}\right) \cup \left(\max\left\{1, -1-\frac{2\delta_\alpha(1+\beta)}{\kappa_\alpha}\right\}, \infty\right)$

Proof. The dynamic system is rewritten as:

$$\mathbb{E}_t\boldsymbol{z}_{t+1} = \boldsymbol{A}_{\underline{D}}^{-1}\boldsymbol{z}_t - \boldsymbol{A}_{\underline{D}}^{-1}\boldsymbol{B}_{\underline{D}}(\hat{r}_t - \varepsilon_t),$$

where

$$\boldsymbol{A}_{\underline{D}}^{-1} = \begin{bmatrix} 1+\delta_\alpha^{-1}\kappa_\alpha\beta^{-1} & \delta_\alpha^{-1}(\phi_{\pi_H} - \beta^{-1}) \\ -\kappa_\alpha\beta^{-1} & \beta^{-1} \end{bmatrix}.$$

The coefficient matrix $\boldsymbol{A}_{\underline{D}}^{-1}$ is isomorphic to coefficient matrix Γ in the proof of Proposition 7 in Bilbiie (2008). The remainder of the proof follows directly from this observation. ■

Proposition 6, which is illustrated in Figure 7, shows that a contemporaneous Taylor rule may have to be strongly anti-inflationary in order to ensure equilibrium uniqueness when the level of asset market participation is low. The size of parameter ϕ_{π_H} required to ensure equilibrium determinacy may, however, be too large to be of practical relevance. Contrary to Galí et al. (2004), I argue that this result does not (necessarily) suggest that the central bank has to adopt a passive forward-looking interest rate rule. The central bank could alternatively adopt an interest rate peg to ensure a determinate rational expectations equilibrium.

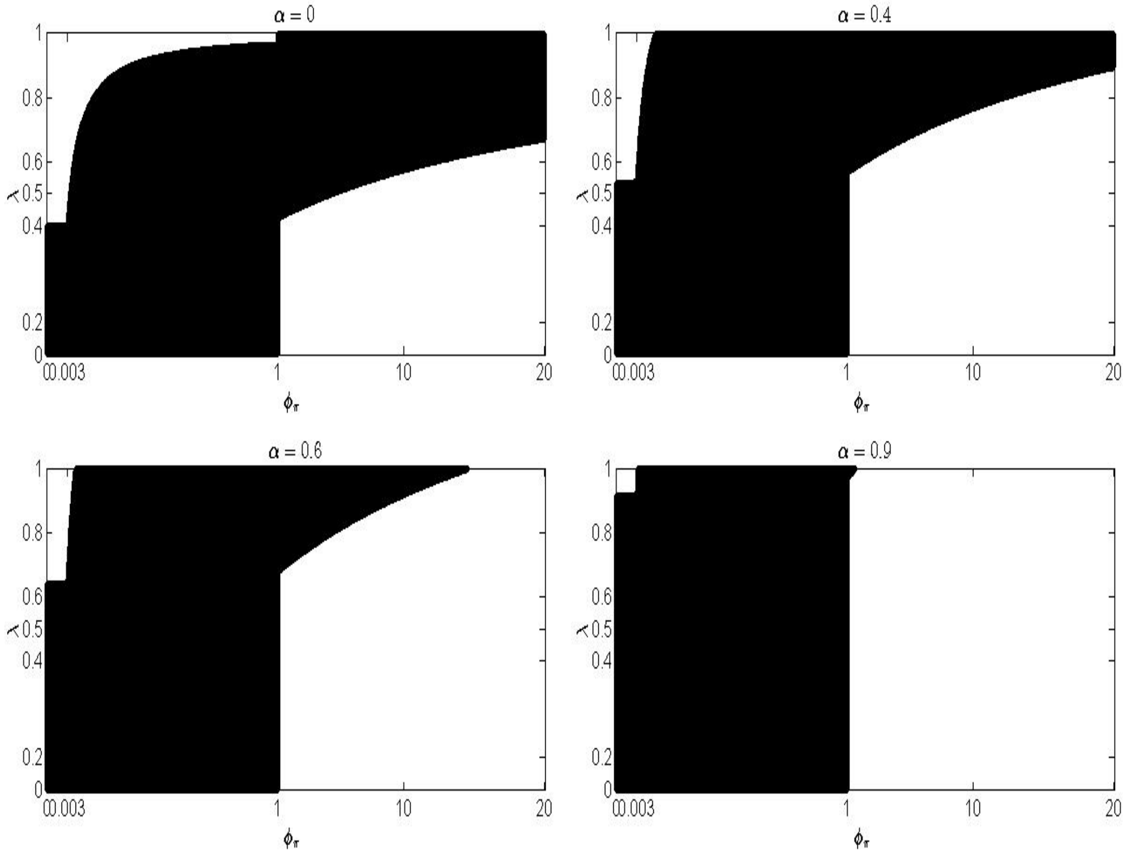

Figure 7: Determinacy under Policy Rule (I.1) as a Function of the Degree of Openness and Financial Exclusion. This figure shows the indeterminacy regions (filled areas) under policy rule (I.1) as a function of the level of financial exclusion λ, ϕ_{π_H}, and α under the baseline parameterization (with $\theta = \frac{2}{3}$). I manipulate the x-axis to ensure the visibility of the determinacy regions. The axis progresses linearly from 0 to .003, from .003 to 1, and from 1 to 20.

I.2 Forward-Looking Taylor Rule

In this appendix, I analyse equilibrium determinacy under a forward-looking Taylor Rule. The forward-looking Taylor Rule systematically reacts to expected domestic inflation, and the expected domestic output gap. Formally, this reaction function is written as

$$r_t = \rho + \phi_{\pi_H}\mathbb{E}_t\pi_{H,t+1} + \phi_{\tilde{y}}\mathbb{E}_t\tilde{y}_{t+1} + \varepsilon_t \; . \tag{I.2}$$

The macroeconomic dynamics under Taylor Rule (I.2) are described by the dynamic two-equation system

$$\boldsymbol{z}_t = \boldsymbol{A}_T\mathbb{E}_t\boldsymbol{z}_{t+1} + \boldsymbol{B}_T(\hat{r}_t - \varepsilon_t) \; .$$

The coefficient matrices $\boldsymbol{A}_T$ and $\boldsymbol{B}_T$ are

$$\boldsymbol{A}_T = \begin{bmatrix} 1-\frac{\phi_{\tilde{y}}}{\delta_\alpha} & \frac{1-\phi_{\pi_H}}{\delta_\alpha} \\ \kappa_\alpha\left(1-\frac{\phi_{\tilde{y}}}{\delta_\alpha}\right) & \beta+\kappa_\alpha\frac{1-\phi_{\pi_H}}{\delta_\alpha} \end{bmatrix} \quad \text{and} \quad \boldsymbol{B}_T = \begin{bmatrix} \frac{1}{\delta_\alpha} \\ \frac{\kappa_\alpha}{\delta_\alpha} \end{bmatrix}.$$

Given that both the output gap and domestic inflation are control variables, the dynamic system has a locally unique solution if and only if both roots of the characteristic polynomial of $\boldsymbol{A}_T$ are unstable.

Proposition 7. Under interest rate rule (I.2), the necessary and sufficient condition for a rational expectations equilibrium to be locally unique is that:

Case 1 When $\delta_\alpha > \frac{\beta}{1+\beta}\phi_{\tilde{y}} : \phi_{\pi_H} \in \left(1-\frac{1-\beta}{\kappa_\alpha}\phi_{\tilde{y}}, 1-\frac{1+\beta}{\kappa_\alpha}\left(\phi_{\tilde{y}}-2\delta_\alpha\right)\right)$;

Case 2
(A) When $\delta_\alpha < -\frac{1}{1-\beta}\phi_{\tilde{y}} : \phi_{\pi_H} \in \left(1-\frac{1+\beta}{\kappa_\alpha}\left(\phi_{\tilde{y}}-2\delta_\alpha\right), 1-\frac{1-\beta}{\kappa_\alpha}\phi_{\tilde{y}}\right) \cap [0,\infty)$;
(B) When $-\frac{1}{1-\beta}\phi_{\tilde{y}} < \delta_\alpha < \frac{\beta}{1+\beta}\phi_{\tilde{y}}$: Equilibrium Indeterminacy $\forall \phi_\pi \in \mathbb{R}_+$.

Case 1 is again the Keynesian case. The equilibrium is unique under policy rules of shape (I.2) when the policy parameters are sufficiently large, yet not too large, to ensure that the real interest rate rises in response to a positive variation in inflation. The Taylor Principle is less likely to apply when $\phi_{\tilde{y}}$ is large. Aggressive responses to changes in output lead to equilibrium indeterminacy. When the level of financial exclusion increases below the inversion threshold, the determinacy region shrinks. When the level of financial exclusion increases above the threshold, the determinacy region expands. In Case 2A, the policy rule has to satisfy a version of the inverted Taylor Principle to ensure equilibrium uniqueness.

Proposition 7 is meaningful from a historical point of view as it limits the ability of this theory to explain the Federal Reserve's passive reaction function in the pre-Volcker era. The policy rule estimated by Clarida et al. (2000) would only have ensured equilibrium determinacy if the level of financial inclusion had been as low as 6.0% in the 1970s. This confirms the result presented in Section 5.4. Proposition 7 is visualized in Figure 8.

Appendix J Non-Tradables and the IADL

This appendix shows that the IADL is more likely to hold when a share of the consumption goods are non-traded goods. I show this by extending the model to incorporate non-traded

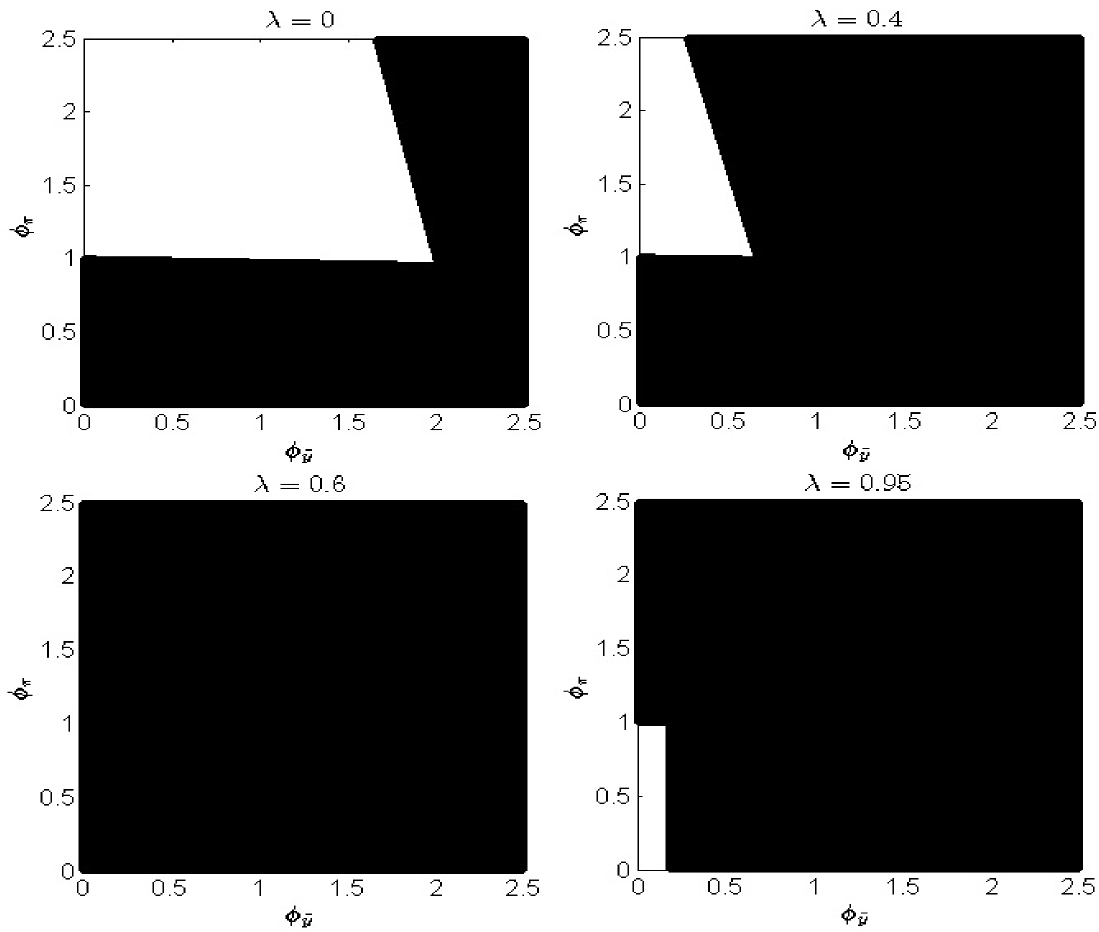

Figure 8: Determinacy under Policy Rule (I.2) as a Function of the Degree of Financial Exclusion.
This figure shows the indeterminacy regions (filled areas) under policy rule (I.2) as a function of $\phi_{\tilde{y}}$, ϕ_{π_H}, and λ under the baseline parameterization (with $\theta = \frac{2}{3}$, and $\alpha = 0.4$).

consumption goods, for the tractable case in which $\eta = \gamma = \xi = 1$. When all consumption goods are non-tradables, the model collapses to the model of Bilbiie (2008).

J.1 Households

J.1.1 Ricardian Households

In this small-country model, each Ricardian agent trades state-contingent claims, holds shares in domestic firms, consumes both traded and non-traded goods, and supplies its labor to intermediate goods producers in the traded and non-traded goods sector. Households maximize utility

$$\ddot{\mathbb{U}} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\ln \ddot{C}_t^R - \vartheta \frac{\ddot{N}_t^{R\,1+\varphi}}{1+\varphi} \right),$$

where $\ddot{N}_t^A \equiv N_t^A + N_{I,t}^A$ measures total hours worked by agent A, the sum of the hours worked in each sector. The wage level is identical across sectors because labor is perfectly mobile.

The composite consumption index for agent A, now denoted by $\ddot{C}_t^A$, is amended to incorporate non-traded goods consumption. Formally,

$$\ddot{C}_t^A \equiv \left[(1-\varrho)^{\frac{1}{\xi}} C_{I,t}^{A\ \frac{\xi-1}{\xi}} + \varrho^{\frac{1}{\xi}} C_t^{A\ \frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}},$$

where ϱ denotes the proportion of traded goods in consumption, and ξ is the elasticity of substitution between the traded and non-traded goods bundle. $C_{I,t}^A \equiv \left(\int_0^1 C_{I,t}^A(l)^{\frac{\varepsilon-1}{\varepsilon}} dl \right)^{\frac{\varepsilon}{\varepsilon-1}}$ is a consumption index of domestically produced immobile goods.

Ricardian households maximize lifetime utility $\ddot{\mathbb{U}}(\cdot)$ subject to the sequence of flow budget constraints

$$\mathbb{E}_t[\Lambda_{t,t+1} Z_{t+1}^R] + \Omega_{t+1}^R \ddot{V}_t + \ddot{P}_t \ddot{C}_t^R \leq Z_t^R + \Omega_t^R (\ddot{V}_t + \ddot{P}_t \ddot{D}_t) + W_t \ddot{N}_t^R \,.$$

The optimality conditions for Ricardian households implied by utility maximization are analogous to the Euler equation and the intratemporal labor condition in the main text. This also holds true for the intratemporal labor condition of non-Ricardian agents.

The consumer price indices derive from expenditure minimization. It is useful to differentiate between the CPI, and the CPI for traded goods given by (B.4). The CPI aggregates the prices of all goods consumed domestically:

$$\ddot{P}_t^A = \left[(1-\varrho) P_{I,t}^{A\ 1-\xi} + \varrho P_t^{A\ 1-\xi} \right]^{\frac{1}{1-\xi}}.$$

A log-linear approximation of the CPI around a steady state satisfying $P_H = P_F = P_I$ gives

$$\ddot{p}_t = (1-\varrho) p_{I,t} + \varrho p_t \,. \tag{J.1}$$

The consumer price index is a weighted average of the prices of non-traded goods and the prices of traded goods.

J.2 Firms

The domestic intermediate goods producer is the main actor on the production side in each sector $S \in [H, I]$.

J.2.1 Optimal Price Setting

In each sector, a fraction $1 - \theta_S$ of the intermediate good producers can adjust its price each period. The others leave their prices unchanged. These assumptions yield

$$\pi_{S,t} = \beta \mathbb{E}_t \pi_{S,t+1} + \Psi_S \underline{mc}_{S,t} \ , \tag{J.2}$$

where $\Psi_S \equiv \frac{(1-\beta\theta_S)(1-\theta_S)}{\theta_S}$, and $\underline{mc}_{S,t} \equiv mc_{S,t} - p_{S,t}$.

J.3 Equilibrium

J.3.1 Aggregate Demand and Output for Traded Goods

In equilibrium, the market for traded goods clears, equating the supply and demand of every traded good variety $k \in [0, 1]$:

$$Y_t(k) = C_{H,t}(k) + \int_0^1 C_{H,t}^i(k) di \ .$$

The optimal allocation of any given expenditure level within each category of goods gives the demand functions. The demand functions are defined analogously for all agents. Using these demand functions, and setting $\eta = \xi$, the clearing condition for good variety k is written as:

$$Y_t(k) = \varrho \left(\frac{P_{H,t}(k)}{P_{H,t}} \right)^{-\varepsilon} \left[(1-\alpha) \left(\frac{P_{H,t}}{\ddot{P}_t} \right)^{-\eta} \ddot{C}_t + \alpha \int_0^1 \left(\frac{P_{H,t}}{P_{F,t}^i} \right)^{-\gamma} \left(\frac{P_{F,t}^i}{\ddot{P}_t{}^i} \right)^{-\eta} \ddot{C}_t{}^i di \right] .$$

By recalling the aggregate domestic production technology for final traded goods (8), and by substituting in the international risk sharing condition ($\ddot{C}_t^R = \ddot{\mathcal{Q}}_{i,t} \ddot{C}_t{}^i$), and the definitions for the bilateral ($\mathcal{S}_{i,t}$) and effective terms of trade in Appendix B.3, the aggregate traded goods market clearing condition is written as

$$Y_t = \varrho \left(\frac{P_{H,t}}{\ddot{P}_t} \right)^{-\eta} \left[(1-\alpha) \ddot{C}_t + \alpha \ddot{C}_t^R \int_0^1 \left(S_{i,t} S_t{}^i \right)^{\gamma-\eta} \ddot{\mathcal{Q}}_{i,t}^{\eta-1} di \right] ,$$

where $\mathcal{S}_t{}^i$ is the effective terms of trade of economy i versus i's rest of the world.

The aggregate traded goods market clearing condition is approximated around the symmetric steady state by:

$$y_t = (1-\alpha)\ddot{c}_t + \alpha\ddot{c}_t^R + \alpha(\gamma-\eta)s_t + \alpha(\eta-1)\ddot{q}_t + \eta(\ddot{p}_t - p_{H,t}) \ .$$

J.3.2 Aggregate Demand and Output for Non-Traded Goods

In equilibrium, the market for non-traded consumption goods clears, equating the supply and demand of non-traded goods:

$$Y_{I,t}(l) = C_{I,t}(l) \quad \forall l \in [0,1] \ .$$

By using the demand functions, and the production technology of non-traded final good firms $Y_{I,t} \equiv \left(\int_0^1 Y_{I,t}(l)^{\frac{\varepsilon-1}{\varepsilon}} dl\right)^{\frac{\varepsilon}{\varepsilon-1}}$, and by setting $\eta = \xi$, the aggregate clearing condition for non-traded goods is written as:

$$Y_{I,t} = (1-\varrho)\left(\frac{P_{I,t}}{\ddot{P}_t}\right)^{-\eta} \ddot{C}_t \ .$$

J.3.3 Aggregate Demand and Output

The domestic production index $\ddot{Y}_t$ is defined by the Cobb-Douglas aggregator

$$\ddot{Y}_t \equiv \frac{Y_t^{\varrho} Y_{I,t}^{1-\varrho}}{\varrho^{\varrho}(1-\varrho)^{1-\varrho}} \ ,$$

The domestic producer price index is thus given by

$$\ddot{P}_{H,t} = P_{H,t}^{\varrho} P_{I,t}^{1-\varrho} \ . \tag{J.3}$$

A log-linear approximation of the domestic production index $\ddot{Y}_t$ yields the aggregate goods market clearing condition

$$\begin{aligned} \ddot{y}_t &= \varrho y_t + (1-\varrho) y_{I,t} \\ &= (1-\alpha\varrho)\ddot{c}_t + \alpha\varrho\ddot{c}_t^R + \alpha\varrho\gamma s_t + \alpha\varrho(\eta-1)\ddot{q}_t \ , \end{aligned} \tag{J.4}$$

where the last equality follows from substituting in the clearing conditions for traded and non-traded goods, (B.4), (J.1), and the effective terms of trade (B.5).

J.4 Aggregate Dynamics

In case $\eta = \gamma = \xi = 1$, the equilibrium conditions of the model can be reduced to a two-equation system that is isomorphic to the dynamic system presented in the main text. In this section, I derive the IS-curve, and the New Keynesian Phillips Curve. The dynamic IS equation shows that the IADL is less likely to materialize when domestic agents consume non-traded goods, i.e. when $\varrho \in [0, 1)$.

J.4.1 IS-Curve

To derive the dynamic IS-curve, I rearrange (E.1), and I substitute in the aggregated goods market clearing condition (J.4), to obtain:

$$\begin{aligned} \ddot{c}_t^R &= \left[1 - (1-\alpha\varrho)\frac{\varphi}{1+\mu}\frac{\lambda}{1-\lambda}\right]\ddot{y}_t + (1-\alpha\varrho)\varphi\frac{\lambda}{1-\lambda}\ddot{a}_t - \alpha\varrho s_t \\ &= \delta_{\alpha,\varrho}\ddot{y}_t + (1+\mu)(1-\delta_{\alpha,\varrho})\ddot{a}_t - \alpha\varrho s_t \ , \end{aligned} \tag{J.5}$$

where $\ddot{a}_t \equiv \varrho a_t + (1-\varrho)a_{I,t}$, and $\delta_{\alpha,\varrho} \equiv 1 - (1-\alpha\varrho)\frac{\varphi}{1+\mu}\frac{\lambda}{1-\lambda}$.

To further develop the dynamic IS-curve for the small open economy with non-traded goods, I substitute (B.4), (B.7), (J.1), (J.3), and (J.5) into the Euler equation for Ricardian consumption (4):

$$\delta_{\alpha,\varrho}\ddot{y}_t = \delta_{\alpha,\varrho}\mathbb{E}_t\ddot{y}_{t+1} + (1+\mu)(1-\delta_{\alpha,\varrho})\mathbb{E}_t\Delta\ddot{a}_{t+1} - (r_t - \mathbb{E}_t\ddot{\pi}_{H,t+1} - \rho) \ .$$

By using the natural level of domestic output (J.7) derived in the next section, I obtain the dynamic IS equation:

$$\tilde{\ddot{y}}_t = \mathbb{E}_t\tilde{\ddot{y}}_{t+1} - \frac{1}{\delta_{\alpha,\varrho}}(r_t - \mathbb{E}_t\ddot{\pi}_{H,t+1} - r_t^n) \ , \tag{J.6}$$

where the natural rate of interest is $r_t^n \equiv \rho - \Big[(1-\delta_{\alpha,\varrho})(1+\mu) + \Gamma_{a,\varrho}\delta_{\alpha,\varrho}\Big](1-\rho_a)\ddot{a}_t$.

J.4.2 New Keynesian Phillips Curve

This section describes the derivation of the New Keynesian Phillips Curve (NKPC). Using (J.2), and (J.3), and setting $\theta_H = \theta_I = \theta$, I write the *New Keynesian inflation equation* in terms of deviations from the variables' natural level as

$$\begin{aligned}
\ddot{\pi}_{H,t} &= \beta \mathbb{E}_t \ddot{\pi}_{H,t+1} + \Psi \left(\varrho \underline{\widetilde{mc}}_{H,t} - (1-\varrho) \underline{\widetilde{mc}}_{I,t} \right) \\
&\equiv \beta \mathbb{E}_t \ddot{\pi}_{H,t+1} + \Psi \underline{\widetilde{\ddot{mc}}}_t \ ,
\end{aligned}$$

where $\underline{\widetilde{mc}}_{S,t} \equiv \underline{mc}_{S,t} - \underline{mc}^n_{S,t}$. To simplify this equation, it is useful to express the domestic real marginal costs of production as:

$$\begin{aligned}
\underline{\ddot{mc}}_t &= -v + \overline{w}_t - \ddot{p}_{H,t} - \ddot{a}_t \\
&= -v + \ddot{c}^R_t + \varphi \ddot{n}^R_t + \alpha \varrho s_t - \ddot{a}_t \ ,
\end{aligned}$$

where, in turn, I substitute in (J.3), (J.1), (B.4), (B.5), and the labor supply condition for Ricardian consumers (3). I simplify this expression by substituting in (J.5), the labor market clearing condition, and the domestic production technology:

$$\underline{\ddot{mc}}_t = -v + \Upsilon_\varrho \ddot{y}_t + \left[(1+\mu)(1-\delta_{\alpha,\varrho}) - \left(1 + \frac{\varphi}{1-\lambda} \right) \right] \ddot{a}_t \ ,$$

where $\Upsilon_\varrho \equiv 1 + \frac{\varphi}{1+\mu} \left[1 + \alpha \varrho \frac{\lambda}{1-\lambda} \right]$. The natural level of domestic production is therefore

$$\ddot{y}^n_t = \Gamma_{0,\varrho} + \Gamma_{a,\varrho} a_t \ , \tag{J.7}$$

where $\Gamma_{0,\varrho} \equiv \frac{v-\mu}{\Upsilon_\varrho}$, and $\Gamma_{a,\varrho} \equiv \frac{1}{\Upsilon_\varrho} \left[\left(1 + \frac{\varphi}{1-\lambda} \right) - (1+\mu)(1-\delta_{\alpha,\varrho}) \right]$. The deviation of the real marginal production costs from its natural level is given by

$$\underline{\widetilde{\ddot{mc}}}_t = \Upsilon_\varrho \tilde{\ddot{y}}_t$$

The New Keynesian inflation equation is now rewritten to obtain the NKPC:

$$\ddot{\pi}_{H,t} = \beta \mathbb{E}_t \ddot{\pi}_{H,t+1} + \kappa_{\alpha,\varrho} \tilde{y}_t \ ,$$

where $\kappa_{\alpha,\varrho} \equiv \Psi \Upsilon_\varrho$.

J.4.3 Dynamics

The IS equation (J.6) shows that the threshold value beyond which the IADL holds also depends on the degree of traded goods in consumption ϱ. Using the IS equation, I derive the threshold value for the IADL to occur

$$\lambda^*_{\alpha,\varrho} = \frac{1}{1 + (1-\alpha\varrho)\frac{\varphi}{1+\mu}} \ . \tag{J.8}$$

Equation (J.8) implies that the IADL is less likely to apply when domestic agents consume non-traded goods. Because non-traded goods reduce the effective openness of the economy ($\alpha\varrho$), the IADL is less likely to hold. In the limit where domestic agents only consume non-traded goods, i.e. in case $\varrho = 0$, the threshold value is identical to the threshold in Bilbiie (2008). A closed economy is an open economy in which all consumption goods are non-tradables.

The intuition for (J.8) is a combination of the intuition underlying the monetary policy transmission channel in a small open economy, and the micro-level drivers in a closed economy. A positive shock to domestic inflation expectations leads to a decline in the real interest rate, and a depreciation of the real exchange rate ($s_t \uparrow$). This leads to an increase in both internal and external demand for domestic traded goods, and an increase in internal demand for non-traded goods. In both sectors, producers that can adjust their price raise their price, while the others increase their demand for labor. The remaining transmission chains are analogous to those discussed in Section 5.2.

Appendix K Change of Model Structure

This appendix discusses the main derivations underlying the results in Section 6.

K.1 Redistributive Dividend Taxes

This section highlights the most important algebraic steps underlying Proposition 4 in Section 6.1. The key expression of Section 6.1 relates Ricardian consumption to aggregate output, productivity, and the effective terms of trade. The derivation of this equation starts by substituting (24) into the budget constraints of Ricardian (2) and non-Ricardian (5) households. This gives:

$$c_t^R = w_t + n_t^R + \frac{1-\tau}{1-\lambda} d_t \quad \text{and} \quad c_t^N = w_t + n_t^N + \frac{\tau}{\lambda} d_t \ .$$

Equating the budget constraints, and substituting in the definition for aggregate consumption, yields:

$$(1-\lambda)c_t^R - (\tau - \lambda)w_t - \tau(1-\lambda)n_t^R = (1-\tau)c_t \ . \tag{K.1}$$

Using the domestic goods market clearing condition (15), this expression is written as:

$$\Big[(1-\alpha)(1-\lambda)+(1-\tau)\alpha\Big]c_t^R-(1-\alpha)(\tau-\lambda)w_t-(1-\alpha)\tau(1-\lambda)n_t^R=(1-\tau)y_t-(1-\tau)\alpha\omega s_t.$$

Substituting in the Ricardian labor supply condition (3), and the labor market clearing condition (17), gives:

$$(1-\tau)y_t-(1-\tau)\alpha\omega s_t=(1-\tau)c_t^R-\Big[(\tau-\lambda)\varphi+\tau(1-\lambda)\Big]\frac{1-\alpha}{1-\lambda}n_t\,.$$

Plugging in the domestic production technology (10), this formula simplifies to:

$$c_t^R=\delta_\tau y_t+(1+\mu)(1-\delta_\tau)a_t-\alpha\omega s_t\ ,\ \text{where}\ \delta_\tau\equiv\frac{1}{1-\tau}\left[1-\tau\frac{\alpha+\mu}{1+\mu}+\varphi\frac{1-\alpha}{1+\mu}\frac{\tau-\lambda}{1-\lambda}\right],$$

which is the expression in Section 6.1.

K.2 Foreign Ownership, and Redistributive Dividend Taxes

This section discusses the algebra behind Proposition 5 in Section 6.2. Again, I derive a relation between Ricardian consumption, aggregate output, the level of domestic productivity, and the terms of trade. To this end, I first substitute the domestic equity market clearing condition (26) into the budget constraint of both the Ricardian agents, and the non-Ricardian agents. This yields

$$c_t^R=w_t+n_t^R+\frac{(1-\varkappa)(1-\tau)}{1-\lambda}d_t\quad\text{and}\quad c_t^N=w_t+n_t^N+\frac{(1-\varkappa)\tau}{\lambda}d_t\,.$$

It is easily verified that the two budget constraints can be combined to obtain (K.1). Following the same steps as above, using the aggregate goods market clearing condition (25), I obtain the expression in Section 6.2:

$$c_t^R=\delta_{\tau,\varkappa}y_t+(1+\mu)(1-\delta_{\tau,\varkappa})a_t-\alpha\omega s_t\ ,\ \text{where}\ \delta_{\tau,\varkappa}\equiv\delta_\tau+\alpha\frac{1}{1-\tau}\frac{\varkappa}{1-\varkappa}\frac{1+\varphi}{1+\mu}\,.$$

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