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FINANCIAL INTEGRATION AND CYCLICALITY OF MONETARY POLICY IN SMALL OPEN ECONOMIES

BY

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Abstract

Should countries follow counter-cyclical or pro-cyclical monetary policies? This paper documents that in contrast to developed economies, developing countries tend to follow pro-cyclical monetary policies. The paper then constructs a New-Keynesian small open economy model with wage rigidity and solves for the optimal monetary policy under different levels of integration in the international financial markets. The model suggests that as economies gain accessibility to the international financial markets the optimal monetary policy shifts from pro-cyclical to counter-cyclical. This result may rationalize the observed difference in monetary policies between developed and developing countries.

1 Introduction

Conventional wisdom recommends that countries follow counter-cyclical monetary policies. This recommendation dates back to at least Wicksell (1907) and has proven to be robust to many developments in monetary theory during the past century.[1] This paper documents that while developed economies typically follow this advice, developing countries do not. Specifically, the paper finds that monetary authorities in developed economies tend to raise their interest rate in times of economic boom and reduce it during slumps, while in developing countries the opposite is true.[2] This finding raises the question whether policymakers in developing countries should adopt policies similar to the ones applied in the developed world, or whether the special conditions under which they operate call for a different policy prescription.

Developing countries have limited access to the international financial markets relative to developed economies. This motivates us to analyze how the level of financial integration affects the optimal monetary policy. To that end we employ a standard New-Keynesian small open economy model with wage rigidity and terms of trade shocks. The model suggests that under full financial integration, i.e. when the economy can freely borrow and lend at the world's interest rate, the optimal policy is counter-cyclical, while under financial autarky, i.e. when the economy is denied access to the international financial markets, the optimal policy is pro-cyclical. The paper also demonstrates that the transition from counter-cyclical to pro-cyclical policies is monotonic in the level of financial integration.[3]

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[1]Counter-cyclical monetary policy was advocated by the "Chicago Plan"; see for example, Mints (1946) and Friedman (1948). The Keynesian IS-LM model, Hicks (1937), also supports counter-cyclical monetary policies. Fischer (1977) and Phelps and Taylor (1977) reestablished the optimality of activist monetary stabilization in a rational expectations framework. Taylor (1993) and much of the New-Keynesian literature that followed also support counter-cyclical monetary policies; see for example, Woodford (2001) and Giannoni and Woodford (2002).

[2]Calvo and Reinhart (2000), Calderón et al. (2003), and Kaminsky et al. (2004) also document this phenomenon.

[3]In the model, the level of financial integration is captured by an adjustment cost to the portfolio of foreign assets. Lower cost implies greater integration.

These results may rationalize the observed difference in monetary policies between developed and developing countries.

The model incorporates two market imperfections: monopolistic competition in the labor market and nominal wage rigidity. The monopolistic competition distorts the steady state equilibrium; hence, in order to motivate monetary policy by cyclical considerations alone, we allow for a constant labor subsidy that restores the first best allocation in steady state.[4] As the terms of trade fluctuate, the role of the monetary policy is therefore to minimize the distortion introduced by wage rigidity. In our framework the monetary authority manipulates the nominal interest rate so as to replicate the flexible wages equilibrium.

Under full financial integration the optimal monetary policy is counter-cyclical. In this case the exchange rate is governed by interest rate differentials. Therefore, in the absence of a policy response, an improvement in the terms of trade has no effect on the exchange rate. A stable exchange rate combined with rigid nominal wages implies that real wages are stable as well. However, if nominal wages were flexible, an improvement in the terms of trade would result in higher real wages as it increases labor demand. Therefore, in order to restore the first best allocation, the monetary policy aims to appreciate the domestic currency so as to increase real wages. This is achieved by increasing the nominal interest rate. That is, when the economy is fully integrated in the world's financial markets, the optimal monetary policy is counter-cyclical.

Under financial autarky the optimal monetary policy is pro-cyclical. In this case households cannot use the international financial markets to smooth consumption and therefore an improvement in the terms of trade increases consumption and reduces the domestic real interest rate. In the absence of a policy response, the fall in the real interest rate comes about through an immediate appreciation of the exchange rate. The appreciation increases real wages and hence endogenously counteracts the expansionary effect of the terms of

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[4]This approach is common in the New-Keynesian literature. See for example, Rotemberg and Woodford (1999), Erceg et al. (2000), and Galí and Monacelli (2005).

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trade. The magnitude of this effect depends on the level of risk aversion; a higher risk aversion implies that marginal utilities are more sensitive to movements in consumption and therefore a greater adjustment to the real interest rate is required in order to restore equilibrium. Hence, when the economy enjoys a positive terms of trade shock, a higher risk aversion implies a greater appreciation of the exchange rate and hence higher real wages. In particular, we show that for a risk aversion coefficient greater than unity (which is the empirically relevant case) the increase in real wages is greater than the one implied by the flexible wages equilibrium. Therefore, the optimal policy is to lower the nominal interest rate so as to depreciate the currency and reduce real wages. That is, under financial autarky the optimal monetary policy is pro-cyclical.

This paper is part of the vast New-Keynesian open-economy literature. Typically, contributions in this literature characterize monetary policies either in terms of an exchange rate regime or by a policy target.[5] Although the cyclical stance of the policy can often be inferred, it is not the focus of attention and is rarely discussed explicitly.

The paper is also related to a smaller body of literature that attempts to understand the motives behind pro-cyclical policies, both monetary and fiscal, in developing countries. Tornell and Lane (1999) and Talvi and Végh (2005), for example, argue that political frictions induce pro-cyclical fiscal policies. Calderón et al. (2003), in an empirical paper, relate the pro-cyclicality of both fiscal and monetary policies to country risk. Calvo and Reinhart (2000) argue that lack of credibility can explain pro-cyclical monetary policies. This paper does not resort directly to such frictions; however, these may at least partially explain the level of integration in the international financial markets, which here is taken exogenously. An important insight from this literature is that pro-cyclical policies are merely a symptom of a deeper problem. Treating the symptom by pushing toward counter-cyclical policies may result in undesirable economic outcomes. Policy recommendations

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[5]See for example, Obstfeld and Rogoff (2000), Svensson (2000), Clarida et al (2001), Devereux and Engel (2003), and Galí and Monacelli (2005).

should therefore treat the underlying problem; once treated, this literature suggests that the economy will endogenously move toward counter-cyclical policies.

The rest of the paper is organized as follows. Section 2 presents evidence of the different cyclical stance of monetary policies in developing versus developed economies. Section 3 presents the model. For simplicity, this section focuses on the two polar cases of financial integration. Section 4 provides closed form solutions to the optimal monetary policies. Section 5 extends the model to include intermediate levels of integration and conducts sensitivity analysis. As an additional robustness check, section 6 introduces demand shocks and demonstrates that the results are largely unaffected by this modification. Section 7 concludes.

2   Cyclicality of Monetary Policy: Stylized Facts

This section documents that developed economies tend to follow counter-cyclical monetary policies while developing countries follow pro-cyclical policies.

Our empirical analysis is mainly influenced by Kaminsky Reinhart and Végh (2004), KRV hereafter. KRV have documented that OECD countries tend to follow counter-cyclical monetary policies while non-OECD countries typically follow pro-cyclical policies. Their dataset consists of a panel of 104 countries in annual frequency. Although informative, we wish to refine their results along two dimensions. First, monetary policy is often evaluated on a monthly basis and therefore it is interesting to reestablish their findings using data of higher frequency. Second, and more importantly for our purpose, KRV's analysis does not discriminate across exchange rate regimes, while our theoretical model suggests that the pro-cyclicality of monetary policy hinges on movements in the exchange rate. This result directs our empirical investigation to focus on countries that let their currency fluctuate. These considerations guide our criteria for sample selection.

2.1 Sample Selection

We use quarterly data for the period 1974-2004 and restrict the sample to include countries with floating or dirty-floating exchange rate regimes with at least 20 consecutive observations. In addition, we remove observations during periods of annual CPI inflation greater than 100 percent.[6]

To determine the type of the exchange rate regimes, we use the classification of Levy-Yeyati and Sturzenegger (2005). Based on actual fluctuations in the exchange rate, its rate of change, and international reserves, their work provides a classification of de-facto exchange rate regimes for IMF-reporting countries. We use data from the International Financial Statistics (IFS) database, and use the IMF's classification of advanced economies and developing countries as reported in the World Economic Outlook.[7] The data appendix provides more details on country-specific sample periods and selection criteria of exchange rate regimes.

Our selection criteria leave us with 15 developed economies and 15 developing countries with varying sample periods. The developed economies are: Australia, Canada, France, Germany, Greece, Israel, Italy, Japan, Korea, Singapore, Spain, Switzerland, United Kingdom, United States, and the Euro Area. The developing countries are: Chile, Colombia, Croatia, Czech Republic, Ecuador, Georgia, Indonesia, Kyrgyz Republic, Mexico, Peru, Philippines, Poland, South Africa, Thailand, and Turkey.

2.2 Methodology and Results

We use the short-term nominal interest rate as the policy instrument. Specifically, we use either the central bank's discount rate or the interbank short-term market rate, depending on data availability. To determine the cyclical stance of the monetary policy we measure the correlation between cyclical movements in the interest rate and output; in addition,

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[6]This criterion is not very restrictive. It only removes the high inflation periods in Peru and Israel and eliminates Belarus from our sample.

[7]"Advanced economies" is the World Economic Outlook's terminology for developed economies.

we estimate interest rate rules and evaluate the sign of the coefficients on output. Positive correlations and positive regression coefficients indicate counter-cyclical monetary policies, while negative values indicate pro-cyclical policies. In what follows we report averages for each country group; country-specific values are presented in the data appendix.

2.2.1   Interest-Output Correlation

We calculate the correlation coefficient in each country between the cyclical components of the interest rate and the natural logarithm of real GDP; these are measured by removing the Hodrick-Prescott (HP hereafter) trend from the series.

Panel A in Table 1 summarizes the results. On average the correlations are positive in developed economies (0.26) and negative in developing countries (-0.18). The distribution of the correlations within each group of countries provides further support to the difference in monetary policies. In developed economies 13 of the 15 correlations are positive, and 7 of them are significantly different from zero while none of the negative correlations is significant.[8] In developing countries 10 of the 15 correlations are negative, with 5 significantly different from zero and none of the positive correlations is significant. Figure 1 illustrates these findings graphically.

2.2.2   Interest Rate Rules

We estimate an interest rate rule for each country. Our specification takes the form:

$$\widetilde{R}_t = \beta_\pi \widetilde{\pi}_t + \beta_y \widetilde{Y}_t + \beta_\sigma \Delta \widetilde{\sigma}_t + \varepsilon_t \tag{1}$$

where $\widetilde{R}_t$, $\widetilde{\pi}_t$, $\widetilde{Y}_t$, and $\Delta\widetilde{\sigma}_t$ are the cyclical components (measured using HP filter) of the nominal interest rate, CPI inflation in the past 4 quarters, the logarithm of real GDP, and the rate of change in the nominal exchange rate,[9] respectively. For $\beta_\sigma = 0$, this specification is similar to the one in Taylor (1993). The difference is that Taylor assumes constant

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[8]Unless otherwise stated, we use a 5 percent significance level.

[9]We use effective exchange rates whenever available, otherwise we use the exchange rate against the US dollar. See the data appendix for details.

long-run levels for the interest rate and inflation and a linear trend in log output, while here we allow for time varying non-linear trends. In an environment of stable inflation and balanced growth there would be no difference between the two specifications; however, in our sample many countries have experienced disinflationary process[10] and therefore movements in interest rate and inflation capture changes in trend in addition to cyclical fluctuations. To control for this problem we use HP trends.

Some authors argue that in open economies the monetary authority should react to the exchange rate in addition to inflation and output.[11] For that reason we include it in (1). It should be noted, however, that others argue against the inclusion of the exchange rate in the policy rule. Taylor (2001), for example, argues that policy rules like (1) do not work much better, and sometimes even worse, than rules that impose $\beta_\sigma = 0$. The reason is that fluctuations in the exchange rate affect both inflation and output; as a result, the interest rate reacts indirectly to exchange rate fluctuations even when it is not included explicitly in the policy rule. A direct reaction to the exchange rate brings only minor improvement, if any.[12]

We first impose $\beta_\sigma = 0$ and estimate (1) by OLS for each country separately. We also use a GLS panel regression where we restrict output coefficients to be equal for all countries within each group.[13] Panel B in Table 1 summarizes the results. Similarly to the indication of the correlation coefficients, on average β_y is positive for developed economies (0.22) and negative for developing countries (-0.33). In developed economies 11 of the 15 coefficients are positive, and 7 of them are significantly different from zero. In developing countries 12 of the 15 coefficients are negative, and 5 of them are significant. The panel regression also produces a positive coefficient for developed economies (0.18) and a negative coefficient for

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[10]Chile, Colombia, Indonesia, Mexico, and Spain, to name a few.

[11]See Ball (1999) and Benigno and Benigno (2001).

[12]Clarida et al. (2001) and Leitemo and Söderström (2005) make similar arguments.

[13]The estimation allows for country-specific inflation coefficients and variances. We do not use fixed effects since all intercepts are zero by construction. Also, endogeneity problems are probably minor when $\beta_\sigma = 0$ since typically the transmission mechanism from monetary policy to output and prices works with lags.

developing countries (-0.11), with both significantly different from zero.

Next, we add the exchange rate to the regression. We estimate (1) by TSLS and use the lagged interest rate, $\widetilde{R}_{t-1}$, and the lagged change in the exchange rate, $\Delta\widetilde{\sigma}_{t-1}$, as instruments for $\Delta\widetilde{\sigma}_t$. Panel C summarizes the results. As before, output coefficients are positive, on average, in developed economies (0.13) and negative in developing countries (-0.14); however, significance levels deteriorate in these estimations. The panel regression seems to result in more accurate estimates as it pools more observations for the output coefficients. For developed economies β_y is positive (0.27) and significant, and for developing countries the coefficient is negative (-0.17) and significant at an 8 percent significance level.

In sum, our analysis supports KRV's findings. That is, we also find that developed economies tend to follow counter-cyclical monetary policies while developing countries typically follow pro-cyclical policies.

3 The Model: Two Polar Cases of Financial Integration

This section lays down the model. Here, we start by analyzing only the two polar cases of financial integration since these can be easily solved with closed form solutions (after taking log-linear approximation). Later, in Section 5, we extend the model to include intermediate levels of integration.

3.1 The environment

Consider a small open economy that is perfectly integrated in the world's goods markets. Agents in the economy produce an exportable good and consume an importable good. The relative price of these goods, the terms of trade, is determined in the world's markets and therefore is exogenous to the economy. Fluctuations in the terms of trade are the only source of aggregate uncertainty in the model. For now we consider two structures of international financial markets: complete markets and financial autarky.

The economy consists of households, employment agencies, firms, insurance companies, and a government. The households consume the importable good and are endowed with differentiated labor skills. They act as monopolists in the labor market as each household sets the nominal wage of its labor skill. Nominal wages are sticky à la Calvo (1983); that is, households can adjust their nominal wage only when they receive a random-idiosyncratic-signal that allows them to do so. The insurance companies provide households with insurance against these shocks. The employment agencies rent labor services from the households. They aggregate differentiated labor skills into labor inputs which, in turn, are supplied to the firms. The firms use labor inputs to produce the exportable good. The government sets the monetary policy by controlling the nominal interest rate. Following Woodford (2003), money, or more precisely - cash, serves only as a unit of account. We find this approach especially appropriate to the question of this paper since it allows abstracting from considerations that motivate the Friedman rule as optimal; as a result, we are able to set the steady state nominal interest rate at any arbitrary level and focus the analysis only on the cyclical properties of the monetary policy.[14]

3.1.1 Prices

Let P_t^* denote date t terms of trade, i.e. the price of the exportable good in terms of importables. Let P_t denote the domestic currency price of the importable good, and S_t the nominal exchange rate (the price of one unit of foreign currency in terms of the domestic currency). Normalizing the foreign currency price of the importable good to 1 and assuming

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[14]An earlier version of this paper used money in the utility function. When solving for the optimal monetary policy, the international finance literature that uses this modeling strategy often assumes that the utility from liquidity services is arbitrarily small. See, for example, Obstfeld and Rogoff (1995, 1998, 2000), Devereux and Engel (2003), and Corsetti and Pesenti (2005). This assumption allows abstracting from considerations that motivate the Friedman rule. Here we adopt a cashless economy model as in Woodford (2003). The two modeling strategies result in an *identical* system of equations, except, of course, for money demand. The cashless economy, however, avoids the need to resort to conflicting assumptions between motives for holding money and policy considerations.

that the law of one price holds, we get:

$$P_t = S_t$$

From now on we will use the exchange rate in place of the price level.

3.1.2 Shocks

The terms of trade, P_t^*, is the only source of aggregate uncertainty. We assume that it follows a stationary $AR(1)$ process in logs:

$$\log\left(P_t^*\right) = (1 - \rho_{P*})\mu_{P*} + \rho_{P*}\log\left(P_{t-1}^*\right) + \varepsilon_t^{P*} \qquad 0 < \rho_{P*} < 1 \qquad (2)$$

where:

$$\varepsilon_t^{P*} \overset{iid}{\sim} N\left(0, \sigma_{\varepsilon^{P*}}^2\right)$$

We assume that there is a continuum of households on the unit interval. We index households by h, $h \in [0,1]$. Households receive binary idiosyncratic shocks, $I_t(h)$, that either get the value 0 or 1. Whenever $I_t(h) = 1$ household h is allowed to freely adjust its nominal wage for period t, otherwise $I_t(h) = 0$ and the nominal wage is set at a predetermined level. The shocks are iid over time and across households, and they are independent of the aggregate shock P_t^*. Specifically we assume that the idiosyncratic shocks follow a Bernoulli distribution:

$$I_t(h) \sim B\left(1 - \xi_w\right)$$

Where $1 - \xi_w$ is the probability of a household to receive a signal that allows it to change its wage.

We denote by s_t the realization of aggregate events in date t. s^t denotes the history of aggregate events from date zero to date t, that is $s^t = (s_0, s_1, \ldots, s_t)$. We assume that the economy starts from steady state and therefore there is no uncertainty with respect to s_0.

3.1.3 Financial Assets

A full set of contingent financial assets, denoted by $B_t^* \left(s^t, s_{t+1} \right)$, is available. Each unit of $B_t^* \left(s^t, s_{t+1} \right)$ pays one unit of the foreign currency if $\left(s^t, s_{t+1} \right)$ realizes, and is traded in date t after history s^t. Each unit of $B_t^* \left(s^t, s_{t+1} \right)$ costs $Q_t^* \left(s^t, s_{t+1} \right)$ units of the foreign currency. The stochastic discount factor in terms of domestic currency, $Q_t \left(s^t, s_{t+1} \right)$, is determined by the no arbitrage condition:

$$Q_t \left(s^t, s_{t+1} \right) \equiv \frac{S_t \left(s^t \right)}{S_{t+1} \left(s^t, s_{t+1} \right)} Q_t^* \left(s^t, s_{t+1} \right)$$

The risk-free foreign interest factor, R_t^*, and its domestic counterpart, R_t, are given by:

$$\frac{1}{R_t^*} = \int_{s_{t+1}} Q_t^* \left(s^t, s_{t+1} \right) ds_{t+1}$$

$$\frac{1}{R_t} = \int_{s_{t+1}} Q_t \left(s^t, s_{t+1} \right) ds_{t+1}$$

Under full financial integration, asset prices, $Q_t^* \left(s^t, s_{t+1} \right)$, are taken exogenously; we assume, however, that these are actuarially fair, that is:

$$\frac{Q_t^* \left(s^t, \widehat{s}_{t+1} \right)}{Q_t^* \left(s^t, \widetilde{s}_{t+1} \right)} = \frac{\Pr \left(s^t, \widehat{s}_{t+1} / s^t \right)}{\Pr \left(s^t, \widetilde{s}_{t+1} / s^t \right)} \qquad \forall \widehat{s}_{t+1}, \widetilde{s}_{t+1}$$

where $\Pr \left(s^t, s_{t+1} / s^t \right)$ is the probability of event s_{t+1} conditional on history s^t. This implies:

$$\frac{1}{R_t^*} = \frac{Q_t^* \left(s^t, s_{t+1} \right)}{\Pr \left(s^t, s_{t+1} / s^t \right)} \qquad \forall \left(s^t, s_{t+1} \right)$$

We assume that in the international financial markets R_t^* is constant, such that:

$$R_t^* = \beta^{-1} \qquad \forall t$$

where β is the subjective discount factor of the households. When the economy is in financial autarky foreign assets are restricted to zero and R_t^* becomes endogenous and hence no longer equal β^{-1}.[15]

Finally, there are also domestic government bonds, denoted by B_t, that yield a safe return of R_t.

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[15]In that case $Q_t^* \left(s^t, s_{t+1} \right)$ is endogenous. Its equilibrium level brings the holdings of B^* to zero. Note that although households are faced with idiosyncratic shocks, the existence of insurance companies (discussed in section 3.2.1) guarantees that all households choose the same portfolio of B^*.

3.2 Agents

3.2.1 Insurance Companies

Every period households and insurance companies meet to sign state-contingent insurance contracts against next period's idiosyncratic shocks. These contracts provide insurance against the inability to control nominal wages in the next period. Under each contract it is agreed that if $I_{t+1}\left(s^t, s_{t+1}, h\right) = 1$ then household h pays the insurance company one unit of the domestic currency, while if $I_{t+1}\left(s^t, s_{t+1}, h\right) = 0$ the household receives q units. We denote by $b_t\left(s^t, s_{t+1}, h\right)$ the quantity of such contracts. Notice that any possible future aggregate state, s_{t+1}, characterizes a type of insurance contract. Zero profits for every type of contract requires:

$$\int_0^1 I_{t+1}\left(s^t, s_{t+1}, h\right) b_t\left(s^t, s_{t+1}, h\right) dh = q \int_0^1 \left[1 - I_{t+1}\left(s^t, s_{t+1}, h\right)\right] b_t\left(s^t, s_{t+1}, h\right) dh$$

Taking expectations conditional on date t information gives:

$$q = \frac{1 - \xi_w}{\xi_w} \tag{3}$$

which reflects actuarially fair pricing in the insurance market.

Finally, it should be noted that the reason for introducing insurance companies to the model is technical. The existence of insurance contracts removes much of the heterogeneity across household. As we show later, these contracts equate the marginal utilities of consumption across households which, in turn, significantly simplifies the analysis.

3.2.2 Employment Agencies

Employment agencies are price takers. They construct labor inputs, L_t, by aggregating differentiated labor skills, $l_t\left(h\right)$ $h \in [0, 1]$, in a Dixit-Stiglitz aggregator:

$$L_t = \left[\int_0^1 l_t\left(h\right)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}} \qquad \theta > 1$$

L_t is then supplied to the domestic producers of the exportable good. Competition among employment agencies generates the following labor demand for $l_t(h)$:

$$l_t(h) = \left(\frac{w_t(h)}{W_t}\right)^{-\theta} L_t \tag{4}$$

where $w_t(h)$ is the nominal wage of labor skill type h, and W_t is the aggregate wage index (the price of L_t), which is given by:

$$W_t = \left[\int_0^1 w_t(h)^{1-\theta} \, dh\right]^{\frac{1}{1-\theta}} \tag{5}$$

3.2.3 Firms

There is a large number of identical competitive firms. The firms produce the exportable good. They use a Cobb-Douglas technology with labor as the only factor of production. Output, Y_t, is given by:

$$Y_t = P_t^* L_t^\alpha \qquad 0 < \alpha < 1 \tag{6}$$

Notice that by measuring output in terms of the importable good, fluctuations in P_t^* can also be interpreted as productivity shocks.

Given W_t, S_t, and P_t^*, firms choose labor to maximize profits. This results in the following labor demand:

$$\frac{W_t}{S_t} = \alpha P_t^* L_t^{\alpha-1} \tag{7}$$

3.2.4 Government

The government issues nominal domestic risk-free bonds, B_t, and provides lump sum transfers, T_t, to the households. It also subsidizes labor at rate τ_w in order to offset the distortionary effect of the monopolistic competition in the labor market. The government budget constraint is given by:

$$B_t = R_{t-1}B_{t-1} + T_t + \tau_w \int_0^1 w_t(h) \, l_t(h) \, dh$$

The monetary policy is carried out by controlling R_t.

3.2.5 Households

Households consume the importable good and trade in financial assets. They also set their wage, $w_t(h)$, whenever they receive a signal that allows them to do so, i.e. when $I_t(h) = 1$. If the household does not receive a signal, then the nominal wage is automatically updated by the steady state inflation rate, π_{ss}, as in Erceg et al. (2000), that is: $w_t(h) = (1 + \pi_{ss}) w_{t-1}(h)$. Given the nominal wage, households supply any level of labor so as to satisfy labor demand (4).

It proves convenient to formulate the households' problem recursively:

$$V_1\left[s^t, I_t(h) = 1, B_{t-1}(h), B_{t-1}^*\left(s^t, h\right), b_{t-1}\left(s^t, h\right)\right] =$$

$$\underset{c_t(h),B_t(h),w_t(h),B_t^*(s^{t+1},h),b_t(s^{t+1},h)}{Max} \quad U\left[c_t(h)\right] - V\left[l_t(h)\right]$$

$$+ (1 - \xi_w)\beta E\left\{V_1(\cdot)/s^t, I_{t+1}(h) = 1\right\}$$

$$+ \xi_w \beta E\left\{V_0(\cdot)/s^t, I_{t+1}(h) = 0\right\}$$

$$s.t. \qquad l_t(h) = \left[\frac{w_t(h)}{W_t}\right]^{-\theta} L_t$$

$$\overline{w}_{t+1}(h) = (1 + \pi_{ss}) w_t(h)$$

$$\int_{s_{t+1}} Q_t^*\left(s^t, s_{t+1}\right) B_t^*\left(s^t, s_{t+1}, h\right) ds_{t+1} = (1 + \tau_w)\frac{w_t(h)}{S_t} l_t(h) + B_{t-1}^*\left(s^t, h\right) - \frac{B_t(h)}{S_t}$$

$$+ \frac{R_{t-1}B_{t-1}(h) + \Pi_t + T_t - b_{t-1}\left(s^t, h\right)}{S_t} - c_t(h)$$

and:

$$V_0\left[s^t, I_t(h) = 0, B_{t-1}(h), B_{t-1}^*\left(s^t, h\right), b_{t-1}\left(s^t, h\right), \overline{w}_t(h)\right] =$$

$$\underset{c_t(h),B_t(h),B_t^*(s^{t+1},h),b_t(s^{t+1},h)}{Max} \quad U\left[c_t(h)\right] - V\left[l_t(h)\right]$$

$$+ (1 - \xi_w)\beta E\left\{V_1(\cdot)/s^t, I_{t+1}(h) = 1\right\}$$

$$+ \xi_w \beta E\left\{V_0(\cdot)/s^t, I_{t+1}(h) = 0\right\}$$

$$s.t. \qquad l_t(h) = \left[\frac{\overline{w}_t(h)}{W_t}\right]^{-\theta} L_t$$

$$\overline{w}_{t+1}(h) = (1+\pi_{ss})\overline{w}_t(h)$$

$$\int_{s_{t+1}} Q_t^*\left(s^t, s_{t+1}\right) B_t^*\left(s^t, s_{t+1}, h\right) ds_{t+1} = (1+\tau_w)\frac{\overline{w}_t(h)}{S_t}l_t(h) + B_{t-1}^*\left(s^t, h\right) - \frac{B_t(h)}{S_t}$$

$$+\frac{R_{t-1}B_{t-1}(h) + \Pi_t + T_t + qb_{t-1}\left(s^t, h\right)}{S_t} - c_t(h)$$

where $U(\cdot)$ and $V(\cdot)$ are the periodical utility functions of consumption and labor, respectively. They are twice continuously differentiable and strictly monotonically increasing in their arguments. $U(\cdot)$ is concave and $V(\cdot)$ is convex. Π_t is profits, and $\overline{w}_t(h)$ is the wage whenever $I_t(h) = 0$. Notice that the difference between V_1 and V_0 is that under former the wage rate is a choice variable, while under the latter it is taken as given and it is part of the state variables. In addition, the budget constraints differ in the payment to/from the insurance companies.

Optimality Conditions Optimal choice of wage insurance contracts together with their equilibrium price (3) gives:

$$U_{c_t}\left(s^t, I_t(h) = 1\right) = U_{c_t}\left(s^t, I_t(h) = 0\right)$$

Therefore, consumption is perfectly smoothed across the idiosyncratic states.

Access to the world financial markets allows for consumption smoothing over time and across aggregate states of nature:

$$U_{c_t(h)} = \begin{cases} U_{c_{t+1}(h)} & \text{under full financial integration} \\ \beta\frac{\Pr\left(s^{t+1}/s^t\right)}{Q_t^*\left(s_t, s^{t+1}\right)}U_{c_{t+1}(h)} & \text{under financial autarky} \end{cases} \qquad (8)$$

Note that under financial autarky $Q_t^*\left(s_t, s^{t+1}\right)$ is endogenous, as assets are traded domestically with zero net supply.

Households optimality condition with respect to domestic bonds gives:

$$\frac{U_{c_t(h)}}{S_t} = \beta R_t E_t\left\{\frac{U_{c_{t+1}(h)}}{S_{t+1}}\right\} \qquad (9)$$

We assume symmetry across households. Specifically, endowment of assets in period zero is such that initially all households choose the same level of consumption. This assumption together with the optimality conditions above imply that consumption is equated across households at all dates and states, that is:

$$C_t\left(s^t,\widehat{h}\right) = C_t\left(s^t,\widetilde{h}\right) \qquad \forall s^t, \widetilde{h}, \widehat{h}$$

Therefore, from this point on we will drop the index h from C_t.

Optimality of wage setting gives:

$$w_t\left(h\right) = \frac{1}{1+\tau_w}\frac{\theta}{\theta-1}\sum_{s=0}^{\infty} E_{t,0}\left\{\lambda_{t+s}\frac{S_{t+s}}{\left(1+\pi_{ss}\right)^s}\frac{V_{l_{t+s}}\left[w_t\left(h\right)\right]}{U_{c_{t+s}}}\right\} \qquad (10)$$

$$\text{where:} \qquad \lambda_{t+s} \equiv \frac{\xi_w^s\beta^s\left(1+\pi_{ss}\right)^{(1-\theta)s}\frac{U_{c_{t+s}}}{S_{t+s}}W_{t+s}^\theta L_{t+s}}{\sum_{s=0}^{\infty}\xi_w^s\beta^s\left(1+\pi_{ss}\right)^{(1-\theta)s}E_t\left\{\frac{U_{c_{t+s}}}{S_{t+s}}W_{t+s}^\theta L_{t+s}\right\}}$$

where $E_{t,0}$ denotes the mathematical expectation conditional on history s^t, $I_t\left(h\right) = 1$, and $I_{t+s}\left(h\right) = 0$ for all $s > 0$. This equation implicitly characterizes $w_t\left(h\right)$ as a function of aggregate quantities (L_{t+s}, C_{t+s}, W_{t+s}, and S_{t+s}). We can therefore conclude that all households that can adjust their wage in period t choose the same wage rate. Using labor demand (4), we can also conclude that they have the same labor level as well. That is:

$$w_t\left(\widehat{h}\right) = w_t\left(\widetilde{h}\right) \qquad \forall \widehat{h}, \widetilde{h} \in [0,1] \quad s.t. \ I_t\left(\widehat{h}\right) = I_t\left(\widetilde{h}\right) = 1$$

$$l_t\left(\widehat{h}\right) = l_t\left(\widetilde{h}\right) \qquad \forall \widehat{h}, \widetilde{h} \in [0,1] \quad s.t. \ I_t\left(\widehat{h}\right) = I_t\left(\widetilde{h}\right) = 1$$

Notice that households $\widehat{h}$ and $\widetilde{h}$ will continue having the same wage and labor levels as long as both cannot readjust their wage. This result leads us to characterize households by cohorts rather than their index h.

Notation 1 *Let w_t^t denote newly set wages; that is, wages of households with $I_t\left(h\right) = 1$.*

To gain intuition for the optimal wage setting condition, equation (10), notice that with no subsidy ($\tau_w = 0$) and assuming flexible wages ($\xi_w = 0$) it becomes:

$$\frac{w_t^t}{S_t} = \frac{\theta}{\theta-1}\frac{V_{l_t}}{U_{c_t}}$$

which simply suggests that households charge a constant markup, $\frac{\theta}{\theta-1}$, over the labor supply function; where supply is given by the marginal rate of substitution between consumption and labor, $\frac{V_l}{U_c}$. Under sticky wages, i.e. $\xi_w > 0$, the markup is over a weighted average of future marginal rates of substitution for histories in which the household would not be able to readjust its wage. The weights are given by λ_{t+s}.

3.3 Economy's Resource Constraint

Combine the households' budget constraint with the government budget constraint, firms' profits, and the zero profit condition in the insurance sector to get the resource constraint of the economy:

$$\frac{1}{R^*} E_t \left[B_t^* \left(s^t, s_{t+1} \right) \right] = B_{t-1}^* \left(s^t \right) + Y_t - C_t \tag{11}$$

Under financial autarky we will impose $B_t^* = 0$ for all t.

3.4 Model's Solution

We solve the model by taking a first order approximation around the deterministic steady state. This results in a simple linear system that allows us to derive closed form solutions.

Before approximating the system we must impose stationarity on the nominal variables; to that end, we deflate them by the steady state inflation rate and define:

$$\Omega_t \equiv \frac{W_t}{\left(1 + \pi_{ss}\right)^t}$$

$$\omega_t^{t-s} \equiv \frac{w_t^{t-s}}{\left(1 + \pi_{ss}\right)^t}$$

$$\sigma_t \equiv \frac{S_t}{\left(1 + \pi_{ss}\right)^t}$$

3.4.1 System of Equations

Under full financial integration the steady state level of foreign assets is exogenous; therefore, for consistency with the case of financial autarky, we assume $B_{ss}^* = 0$. We log-linearize

equations (2), and (5) through (11), and get:

$$\widetilde{P}_t^* = \rho_{P^*}\widetilde{P}_{t-1}^* + \varepsilon_t^{P^*} \tag{12}$$

$$\widetilde{\Omega}_t \cong (1 - \xi_w)\widetilde{\omega}_t^t + \xi_w\widetilde{\Omega}_{t-1} \tag{13}$$

$$\widetilde{Y}_t \cong \widetilde{P}_t^* + \alpha\widetilde{L}_t \tag{14}$$

$$\widetilde{\Omega}_t - \widetilde{\sigma}_t \cong \widetilde{P}_t^* - (1 - \alpha)\widetilde{L}_t \tag{15}$$

$$\widetilde{C}_t \cong \begin{cases} \widetilde{C}_{t+1} & \text{under full financial integration} \\ \frac{1}{\gamma_C}\widetilde{R}_t^* + E_t\left(\widetilde{C}_{t+1}\right) & \text{under financial autarky} \end{cases} \tag{16}$$

$$\widetilde{R}_t \cong -\widetilde{\sigma}_t + E_t\left(\widetilde{\sigma}_{t+1}\right) + \gamma_C\widetilde{C}_t - \gamma_C E_t\left(\widetilde{C}_{t+1}\right) \tag{17}$$

$$\widetilde{\omega}_t^t \cong (1 - \xi_w\beta)\frac{\widetilde{\sigma}_t - \gamma_C\widetilde{C}_t + \gamma_L\widetilde{L}_t + \gamma_L\theta\widetilde{\Omega}_t}{1 + \gamma_L\theta} + \xi_w\beta E_t\left(\widetilde{\omega}_{t+1}^{t+1}\right) \tag{18}$$

$$E_t\left(B_t^*\right) \cong \frac{1}{\beta}B_{t-1}^* + \frac{C_{ss}}{\beta}\left(\widetilde{Y}_t - \widetilde{C}_t\right) \quad \text{where } B_t^* = 0 \text{ under financial autarky.} \tag{19}$$

where tilde variables denote log deviations from steady state, that is $\widetilde{x}_t \equiv \log(x_t) - \log(x_{ss})$, also:

$$\gamma_L \equiv \frac{V_{ll_{ss}}}{V_{l_{ss}}}L_{ss} > 0 \quad , \quad \gamma_C \equiv \frac{U_{cc_{ss}}}{U_{c_{ss}}}C_{ss} < 0$$

This system gives us 8 equations in 9 variables. Under full financial integration the variables are: $\widetilde{L}_t$, $\widetilde{Y}_t$, $\widetilde{\Omega}_t$, $\widetilde{\omega}_t^t$, $\widetilde{\sigma}_t$, $\widetilde{C}_t$, B_t^*, $\widetilde{R}_t$, and $\widetilde{P}_t^*$, while under financial autarky $\widetilde{R}_t^*$ replaces B_t^*. The model is closed by letting the monetary authority choose $\widetilde{R}_t$.

4 Optimal Monetary Policy

In this section we solve for the first best allocation and then find a monetary policy that recovers it as an equilibrium outcome. Clearly, if such a policy exists, it is optimal. We conduct this exercise for both structures of financial markets, and then analyze the cyclical properties of the optimal policies and provide intuition. It should be noted that for simplicity we discuss only non-sunspot equilibria. Appendix 1 shows how the policy rules presented in this section can be modified in order to establish uniqueness without affecting any of our results.

4.1 Full Financial Integration

Under full financial integration the first best allocation is found by solving:

$$\underset{C_t,L_t,B_t^*(s^{t+1})}{Max} \qquad \sum_{t=0}^{\infty} \beta^t E_0 \left[U\left(C_t\right) - V\left(L_t\right)\right]$$

$$s.t. \qquad \int_{s_{t+1}} Q_t^*\left(s^t, s_{t+1}\right) B_t^*\left(s^t, s_{t+1}\right) ds_{t+1} = B_{t-1}^*\left(s^t\right) + P_t^* L_t^\alpha - C_t$$

For simplicity, this formulation already imposes a symmetric allocation across households and therefore we only need to find the aggregate quantities.[16] The first best allocation is characterized by:

$$C_t = C_{t+1} \tag{20}$$

$$\frac{V_{L_t}}{U_{C_t}} = \alpha P_t^* L_t^{\alpha-1} \tag{21}$$

$$\frac{1}{R^*} E_t \left[B_t^*\left(s^t, s_{t+1}\right)\right] = B_{t-1}^*\left(s^t\right) + P_t^* L_t^\alpha - C_t \tag{22}$$

Notice that by (7), (8), (10), and (11), the economy with staggered wages has the same steady state as the first best allocation provided that:

$$\tau_w = \frac{1}{\theta - 1}$$

That is, the optimal labor subsidy exactly offsets the distortion of the monopolistic competition in the labor market. As in Rotemberg and Woodford (1999), the fiscal policy in the model is focused on restoring the optimal *level* of economic activity and is independent of the monetary policy. The role of the monetary policy is therefore to restore optimal *fluctuations*.

4.1.1 Optimal Monetary Policy

The first best allocation clearly differs from the staggered wages equilibrium in its labor market condition.[17] Recall, however, that in characterizing the equilibrium we had one

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[16]Symmetry follows by concavity of preferences and equal welfare weights across households.

[17]Under flexible wages, i.e. $\xi_w = 0$, the economy achieves the first best regardless of the monetary policy (assuming $\tau_w = \frac{1}{\theta-1}$).

degree of freedom left as we derived 8 equations in 9 unknowns. We can therefore impose efficiency in the labor market as suggested by (21), and then solve for the implied monetary policy.

After complementing the equilibrium conditions by the log linearized version of (21), the implied interest rate rule is given by:[18]

$$\widetilde{R}_t \cong \frac{\gamma_L}{\gamma_L + 1 - \alpha}\left(1 - \rho_{P^*}\right)\widetilde{P}_t^* \tag{23}$$

and in terms of output:

$$\widetilde{R}_t \cong \frac{\gamma_L}{\gamma_L + 1}\left(1 - \rho_{P^*}\right)\widetilde{Y}_t \tag{24}$$

Which suggests that the optimal monetary policy is counter-cyclical since the interest rate increases with output.

Interestingly, we find that under the optimal policy nominal wages always take their steady state value, that is:

$$\widetilde{\Omega}_t \cong 0$$

Therefore, the optimal monetary policy targets wage inflation. The reason is that this policy exactly offsets the distortion that sticky wages introduce. The monetary authority manipulates the interest rate in a way that households which can adjust their wage choose to change it by exactly the steady state inflation rate. As a result, the relative price of any two labor skills is constant at unity, and *all* households enjoy the optimal wage level that would have prevailed if wages were flexible.

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[18]As discussed in chapter 4 of Woodford (2003), an interest rate rule that depends only on exogenous shocks may lead to sunspots equilibria, and therefore may result in undesirable outcomes. Woodford (2003) also shows that by modifying the interest rate rule to react to endogenous variables uniqueness may be achieved. Appendix 1 finds optimal rules that react to both the terms of trade and the exchange rate such that the equilibrium is unique and all results discussed in the text remain.

4.2   Financial Autarky

Under financial autarky the first best allocation is found by solving:

$$\underset{C_t,L_t}{Max} \qquad \sum_{t=0}^{\infty} \beta^t E_0 \left[U\left(C_t\right) - V\left(L_t\right)\right]$$

$$s.t. \qquad C_t = P_t^* L_t^{\alpha}$$

The first best allocation is now characterized by:

$$\frac{V_{L_t}}{U_{C_t}} = \alpha P_t^* L_t^{\alpha-1} \tag{25}$$

$$C_t = P_t^* L_t^{\alpha} \tag{26}$$

Again, in steady state, this allocation coincides with the staggered wages equilibrium provided that:

$$\tau_w = \frac{1}{\theta - 1}$$

4.2.1   Optimal Monetary Policy

As in the case of full integration, the first best allocation differs from the staggered wages economy only in its labor market condition. Taking the same approach as before, we complement the equilibrium conditions of the staggered wages economy by imposing efficiency in the labor market and then find the implied interest rate rule.

The solution for the optimal rule in this case is given by:[19]

$$\widetilde{R}_t \cong \frac{\gamma_L\left(1 + \gamma_C\right)}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\left(1 - \rho_{P^*}\right)\widetilde{P}_t^* \tag{27}$$

and in terms of output:

$$\widetilde{R}_t \cong \frac{\gamma_L}{\gamma_L + 1}\left(1 + \gamma_C\right)\left(1 - \rho_{P^*}\right)\widetilde{Y}_t \tag{28}$$

This suggests that the cyclicality of the optimal monetary policy is determined by the value of γ_C.[20] If $|\gamma_C| < 1$ then the policy is counter-cyclical, if $|\gamma_C| = 1$ it is acyclical, and for $|\gamma_C| > 1$, which is the empirically relevant case, the optimal policy is pro-cyclical.

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[19]The comment in the previous footnote applies to equation (27) as well.

[20]Recall that $\gamma_C < 0$, and its absolute value is the relative risk aversion coefficient evaluated at steady state.

Also, as in the case of full integration we have:

$$\widetilde{\Omega}_t = 0$$

That is, the monetary authority completely offsets the distortion that sticky wages introduce.

4.3   Intuition and Discussion

We have just shown the main result of the paper: if the economy is fully integrated in the world's financial markets then the optimal monetary policy is counter-cyclical, while under financial autarky the optimal policy is pro-cyclical (provided that the relative risk aversion coefficient is greater than 1).

The key to understanding this result is the behavior of the exchange rate and its effect on real wages. In order to gain some intuition, we analyze the response of the economy to an improvement in the terms of trade.

For simplicity we make two assumptions. First, assume that ξ_w is arbitrarily close to 1, hence the nominal wage index remains unchanged throughout the analysis.[21] Second, assume that the monetary policy is exogenous and that it follows a stationary $AR(1)$ process:

$$\widetilde{R}_t = \rho_R \widetilde{R}_{t-1} + \varepsilon_t^R$$

where:

$$\varepsilon_t^R \overset{iid}{\sim} N\left(0, \sigma_R^2\right)$$

Notice that in both cases, full integration and financial autarky, the optimal policy rule follows such a process with $\rho_R = \rho_{P^*}$, and where the random shocks, ε_t^R and $\varepsilon_t^{P^*}$, are

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[21]Notice that this assumption implies $\widetilde{\Omega}_t = 0$, which is also implied by the optimal policy. However, the two cases are fundamentally different. The optimal monetary policy eliminates the distortionary effect of the sticky wages as households *choose* to keep their wage at the level of the economy average. In contrast, by assuming $\xi_w \to 1$, wage rigidity is distortionary. The wage index in this case is constant because households cannot adjust their wage. A household that is allowed to change its wage would change it to a level different from the economy average.

proportional to each other.[22] Therefore, the optimal policy can be viewed as a special case of this exogenous process. These assumptions greatly simplify the analysis as they allow us to find a closed form solution to the model for a fairly arbitrary monetary policy.

We proceed by analyzing the reaction of the economy to an increase in $\widetilde{P}_t^*$. We will first hold the interest rate constant and then ask in what direction it should move in order to restore the flexible wages equilibrium.

Full Financial Integration   As $\widetilde{P}_t^*$ increases, labor demand shifts outward. When the economy has access to a complete set of financial assets consumption is perfectly smoothed, that is $\widetilde{C}_t = 0$ for all t, and therefore labor supply remains unchanged. This is illustrated in Panel A of Figure 2.

Also, notice that the Euler equation (17) coincides in this case with the interest parity condition:

$$\widetilde{R}_t = -\widetilde{\sigma}_t + E_t\left(\widetilde{\sigma}_{t+1}\right)$$

and therefore the exchange rate does not react to fluctuations in the terms of trade. Given the process for $\widetilde{R}_t$, the exchange rate (in a non-sunspot equilibrium) is given by:

$$\widetilde{\sigma}_t = -\frac{1}{1-\rho_R}\widetilde{R}_t \tag{29}$$

If the interest rate is unchanged the economy moves from point A to point B in the figure.[23] Recall that the first best allocation is achieved by the flexible wages equilibrium, represented by point C. It is now clear that the optimal policy in this case aims to appreciate the domestic currency so as to increase the real wage and move the economy to point C. This is achieved by an increase in the interest rate, and therefore the optimal monetary policy is counter-cyclical.

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[22]The coefficients of proportionality are determined by the coefficient of $\widetilde{P}_t^*$ in the optimal monetary policies (23) and (27).

[23]Here we make use of the assumption that the wage index is unchanged; without it the economy would move to a point along the new demand curve that is higher than point B but lower than C as a fraction $1 - \xi_w$ of the households readjusts nominal wages.

Financial Autarky As before, an improvement in the terms of trade shifts labor demand outward. However, under financial autarky households cannot smooth consumption and therefore consumption increases, which in turn, reduces labor supply. This is demonstrated in Panel B of Figure 2.

The economic expansion is expected to die out over time; therefore, the increase in consumption reduces the real interest rate. This can be seen from the Euler equation (17). Since we hold the nominal interest rate fixed, a fall in the real interest rate can come about only through an appreciation of the exchange rate. This can also be seen from the solution for $\widetilde{\sigma}_t$ (under the assumption that $\xi_w \to 1$), we now have:

$$\widetilde{\sigma}_t \cong -\frac{1-\alpha}{1-\alpha\,(1+\gamma_C)} \cdot \frac{1}{1-\rho_R}\widetilde{R}_t + \frac{\gamma_C}{1-\alpha\,(1+\gamma_C)}\widetilde{P}_t^* \tag{30}$$

Since $\gamma_C < 0$, an increase in $\widetilde{P}_t^*$ appreciates the domestic currency. Holding nominal wages fixed ($\widetilde{\Omega}_t = 0$), this appreciation leads to an increase in real wages.

We know that the optimal policy attempts to manipulate the exchange rate in a way that brings the economy to point C (see Panel B of Figure 2). Therefore, in order to evaluate the direction in which the monetary authority should change the interest rate, we need to determine the magnitude of the increase in real wages that is generated by the appreciation of the exchange rate. If this appreciation leads the economy to a point below point C (a point like B_1 in the figure), then the optimal response is to increase the interest rate; while if the economy reaches a point above C (such as B_2) then the optimal response is to reduce the interest rate. We therefore turn to calculating the real wage in point C; that is, the real wage under the flexible wages equilibrium.

Using labor supply, $\widetilde{\Omega}_t - \widetilde{\sigma}_t = \gamma_L\widetilde{L}_t - \gamma_C\widetilde{C}_t$, equilibrium in the goods market, $\widetilde{C}_t = \widetilde{P}_t^* + \alpha\widetilde{L}_t$, and labor demand, $\widetilde{\Omega}_t - \widetilde{\sigma}_t \cong \widetilde{P}_t^* - (1-\alpha)\,\widetilde{L}_t$, we find that the real wage at point C is given by:

$$\widetilde{\Omega}_t - \widetilde{\sigma}_t\Big|_{\text{point } C} = \frac{\gamma_L - \gamma_C}{\gamma_L + 1 - \alpha\,(1+\gamma_C)}\widetilde{P}_t^*$$

By (30), the real wage in points B_1 and B_2 is given by:

$$\left.\widetilde{\Omega}_t - \widetilde{\sigma}_t\right|_{\text{point } B_{1,2}} = -\frac{\gamma_C}{1 - \alpha\left(1 + \gamma_C\right)}\widetilde{P}_t^*$$

It is now easy to check that if $|\gamma_C| < 1$, the economy reaches a point like B_1 and the optimal policy is to increase the interest rate, that is to follow a counter-cyclical monetary policy. However, if $|\gamma_C| > 1$, which is the empirically relevant case, then the economy reaches a point like B_2 and the optimal policy is to reduce the interest rate, and hence follow a pro-cyclical policy.

The reason that γ_C plays a dominant role can be seen from the Euler equation (17). Higher risk aversion implies that marginal utilities are more sensitive to fluctuations in consumption; as a result, a greater movement in the real interest rate is required in order to restore equilibrium. Holding the nominal interest rate fixed implies that a greater appreciation rate is required, and therefore real wages become more responsive as well.

It is not unusual for developing countries to react with monetary expansion to an appreciation of their currency. In an environment with sticky prices this policy is often motivated by an attempt to manipulate the terms of trade.[24] Here we clearly abstract from such channels since the terms of trade is taken as an exogenous process. Instead, the analysis above directs attention to the labor market as the monetary policy attempts to manipulate real wages. In this sense the mechanism at work is the same as the one of standard closed economy Keynesian models where monetary expansion stimulates the economy through a depreciation of real wages.

5 Different Levels of Financial Integration

The analysis so far has focused on two polar cases: full financial integration and financial autarky. This section allows for intermediate levels of integration and demonstrates that

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[24]Several contributions point out that manipulating the terms of trade in favor of the domestic economy may be supported as an optimal policy. See discussion in Corsetti and Pesenti (2001, 2005), Benigno and Benigno (2003), and Galí and Monacelli (2005).

the optimal monetary policy shifts monotonically from pro-cyclical to counter-cyclical as the economy becomes more integrated in the international financial markets.

5.1 Model's Alteration

Now assume that domestic residents can only trade risk-free bonds in the international markets. Let B_t^* denote the number of foreign bonds bought in date t. Each unit of B_t^* pays R_t^* units of the foreign currency in $t+1$ with certainty.

Financial integration is modeled by introducing a convex adjustment cost to the portfolio of foreign assets, $\kappa\left(B_t^*\right)$, where the function $\kappa\left(\cdot\right)$ satisfies $\kappa\left(B_{ss}^*\right) = 0$, $\kappa'\left(B_{ss}^*\right) = 0$, and $\kappa''\left(\cdot\right) \geq 0$. This cost represents various barriers that prevent domestic residents from trading freely in the international financial markets; such barriers may include taxes, transaction costs, costs that arise from exchanging currencies, country risk, and any form of capital controls. Clearly, lower cost implies greater financial integration.

Note that since the model is linearized, and due to our assumptions regarding the cost function, only its second derivative evaluated at steady state, $\kappa''\left(B_{ss}^*\right)$, matters for the dynamics of the model. Therefore, all functions that satisfy the assumptions above are equivalent for our purpose; for simplicity of exposition we will employ a quadratic cost function:

$$\kappa\left(B_t^*\right) = \frac{\kappa}{2}\left(B_t^* - B_{ss}^*\right)^2 \qquad \kappa \geq 0$$

Varying κ allows us to study the effect of financial integration. When $\kappa = 0$ the economy can borrow and lend freely at the world's interest rate and therefore this case represents a developed economy.[25] In addition, and as demonstrated below, when κ is negligibly small the dynamics of the model are very similar to those of the complete markets case analyzed

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[25]It is well known that linearized small open economy models with risk-free bonds and no frictions in the financial markets induce unit-root dynamics in consumption and foreign assets. The introduction of a portfolio adjustment cost restores stationarity. Therefore, for the case of full integration we will use an arbitrarily small κ rather than zero. This approach is standard in the literature. See, for example, Schmitt-Grohé and Uribe (2003) and Neumeyer and Perri (2005).

earlier.[26] As κ increases the country faces greater barriers to adjusting its foreign portfolio, and as $\kappa \to \infty$ the country is in financial autarky. We can therefore move continuously from full financial integration to financial autarky by varying κ.

This modification to the model only alters the Euler equation for foreign assets and the resource constraint of the economy. The Euler equation is now given by:

$$U_{C_t} \left[1 + \kappa \left(B_t^* - B_{ss}^*\right)\right] = \beta R_t^* E_t \left(U_{C_{t+1}}\right) \tag{31}$$

where again $R_t^* = \beta^{-1}$, and the resource constraint takes the form:

$$B_t^* + \frac{\kappa}{2} \left(B_t^* - B_{ss}^*\right)^2 = R_{t-1}^* B_{t-1}^* + Y_t - C_t \tag{32}$$

The linearized versions of (31) and (32) replace equations (16) and (19) respectively. As before, the optimal monetary policy is found by imposing efficiency in the labor market.

The log-linearized system of equations is solved numerically using the method of Sims (2002). The model is then simulated in order to study the cyclical properties of the monetary policy for different values of κ. The choice of parameter values is described below.

5.2 Calibration

Parameters values are mainly adopted from other studies in the literature. Table 2 reports the baseline parameterization.

A period in the model corresponds to one quarter. The discount factor, β, is set to 0.99, which suggests a world real interest rate of 4 percent. Labor income share, α, is set to 0.7.

Following van Winccop (1999) the relative risk aversion coefficient, $|\gamma_C|$, takes the value 3. This value represents an average of estimates in the literature. However, since the analysis of the case of financial autarky suggests that the cyclical pattern of the monetary

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[26]This result is in-line with other papers in the literature. Schmitt-Grohé and Uribe (2003) show that small open economy models with risk-free bonds behave almost identically to their complete markets counterparts. Baxter and Crucini (1995) and Heathcote and Perri (2002) find similar results in a two-country model.

policy may crucially depend on this parameter, we will experiment with other values as well.

The Frisch elasticity of labor supply is given by γ_L^{-1}. In Mendoza (1991) the implied elasticity is 2.2 and in Numeyer and Perri (2005) it is 1.67. We choose a value of 2, that is $\gamma_L = 0.5$.

The elasticity of substitution between differentiated labor skills, θ, takes a value of 6. This implies a markup of 20 percent ($\frac{\theta}{\theta-1}$) in the labor market. For comparison, Erceg Henderson and Levin (2000) take $\theta = 4$ (a markup of 33 percent), Chari Kehoe and McGrattan (2002) use $\theta = 7.67$ (a markup of 15 percent), Huang and Liu (2002) use values of $\theta = 2, 4, 6$ (markups of 100, 33, and 20 percent, respectively).

The probability to receive a wage adjustment signal, $1 - \xi_w$, is set to 0.25. This corresponds to an average wage duration of 4 quarters ($\frac{1}{1-\xi_w}$). This value is consistent with Erceg Henderson and Levin (2000), Chari Kehoe and McGrattan (2002), and Huang and Liu (2002).

The autocorrelation coefficient of the terms of trade, ρ_{P^*}, is set to 0.8. This value is based on autocorrelations in our sample. With the exception of Singapore, which displays an extremely low autocorrelation, the coefficient for developed economies varies from 0.84 to 0.99 with an average of 0.91. For developing counties the autocorrelation varies from 0.51 to 0.94, with an average of 0.70.[27]

The standard deviation of the innovation to the terms of trade, $\sigma_{\varepsilon^{P^*}}$, is set to 0.03. The average standard deviation in developed economies (excluding Singapore) is 0.025, and in developing countries it is 0.044. Naturally, this parameter affects the volatility of the economic aggregates; however, since the model is linearized and is driven by only one shock, the volatility of the error term has no effect on correlations, and specifically it has no effect on the correlation between output and the nominal interest rate which is the object

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[27]Due to limitation of data availability these statistics are based on 12 developed economies and 6 developing countries. See the data appendix for details.

of interest.

Finally, the parameter κ allows us to move from the case of full integration, represented by an arbitrarily small κ, to financial autarky, $\kappa \to \infty$. We will therefore experiment with a wide range of values.

5.3   Results

We use the baseline parameterization to simulate the model under different levels of κ. However, before evaluating the effect of financial integration on the cyclical pattern of monetary policy, we wish to compare the dynamics of the model with risk-free bonds to those of complete markets and financial autarky. Specifically, we verify our conjecture that the bond economy with an arbitrarily small κ approximates the complete markets case, and that a large enough κ approximates the financial autarky scenario.

Figure 3 presents the impulse response functions of the four models: complete markets, financial autarky, bond economy with $\kappa = 10^{-5}$, and bond economy with $\kappa = 100$. Clearly, the dynamics under complete markets are very similar to those of the bond economy with small κ, and the dynamics of the model with $\kappa = 100$ are practically identical to the case of financial autarky. These results validate our earlier conjecture.

Figure 4 presents the correlation between the nominal interest rate, $\widetilde{R}$, and output, $\widetilde{Y}$, as a function of κ using the baseline parameterization. Each data point in the figure is the average correlation over $1,000$ simulations each 100 periods long. As expected, the correlation falls as the economy becomes less integrated in the international financial markets, i.e. as κ increases. That is, as the economy looses access to the world's financial markets the optimal monetary policy shifts from counter-cyclical to pro-cyclical.

5.4   Sensitivity Analysis

The choice of parameter values is largely based on studies that focused on developed economies. We therefore wish to reevaluate the implications for the cyclical pattern of

monetary policy using other values as well.

The closed form solution for the case of financial autarky, equation (28), indicates that the results crucially depend on the value of the relative risk aversion coefficient. Specifically, if $|\gamma_C| < 1$ then the optimal policy is counter-cyclical even when the economy is cutoff from the international financial markets. We therefore experiment with other values of relative risk aversion. Panel A of Figure 5 depicts the correlation between output, $\widetilde{Y}$, and the nominal interest rate, $\widetilde{R}$, for different values of $|\gamma_C|$. The figure reveals, as one may have expected, that when $|\gamma_C| > 1$ the correlation falls monotonically as the economy becomes less integrated in the international financial markets. On the other hand, when $|\gamma_C| < 1$ the model displays high correlations for any level of financial integration. This is hardly surprising since equations (24) and (28) indicate that in both polar cases the model generates a perfect correlation between output and the nominal interest rate.

The rest of the panels in Figure 5 study the effect of other parameters on the cyclical stance of the monetary policy. With the exception of the autocorrelation of the terms of trade, none of the parameters seems to have any important quantitative effect on the results. As for the autocorrelation coefficient, ρ_{P*}, Panel F suggests that greater persistence is associated with policies that are more pro-cyclical. Nevertheless, the figure still confirms our main result: lower financial integration, i.e. higher κ, pushes the monetary authority toward pursuing pro-cyclical policies.

6   Demand Shocks

Typically, counter-cyclical monetary policy is recommended under the premise that the business cycle is driven by demand shocks. In contrast, the business cycle in the model is driven by supply shocks. We therefore wish to reevaluate our results after introducing demand shocks to the model.

We alter the model only by adding a stochastic preference parameter. The periodical

utility function is now given by:

$$\eta_t U\left(C_t\right) - V\left(L_t\right)$$

where:

$$\log\left(\eta_t\right) \;=\; \left(1 - \rho_\eta\right)\mu_\eta + \rho_\eta \log\left(\eta_{t-1}\right) + \varepsilon_t^\eta \qquad 0 < \rho_\eta < 1$$

$$\varepsilon_t^\eta \overset{iid}{\sim} N\left(0, \sigma_\eta^2\right)$$

We also assume that demand and supply shocks are uncorrelated, that is:

$$COV\left(\varepsilon_t^\eta, \varepsilon_t^{P^*}\right) = 0$$

Other than that, the model is identical to the one presented earlier. The introduction of preference shocks only affects equations that involve the marginal utility of consumption, these are the Euler equation for foreign assets (8), the Euler equation for domestic bonds (9), and the optimal wage setting (10). The only difference is that all marginal utilities, U_{c_t}, are now multiplied by η_t.

As before, the optimal monetary policy seeks to restore efficiency in the labor market.

6.1   Complete Markets

Under complete financial markets the optimal interest rate policy is given by:

$$\widetilde{R}_t \cong \frac{\gamma_L}{\gamma_L + 1 - \alpha}\left(1 - \rho_{P^*}\right)\widetilde{P}_t^* \cong \frac{\gamma_L}{\gamma_L + 1}\left(1 - \rho_{P^*}\right)\widetilde{Y}_t$$

Clearly, the optimal policy is counter-cyclical. Notice, however, that this policy does not react to the demand shocks, and in fact it is identical to the case where the business cycle was driven by supply shocks alone - see equations (23) and (24).

To gain intuition for this result, we focus on the labor market. Recall that labor supply is determined by the marginal rate of substitution between labor and consumption, which now is given by $\gamma_L \widetilde{L}_t - \gamma_C \widetilde{C}_t - \widetilde{\eta}_t$. Under complete markets the marginal utility of consumption

is smoothed, i.e. $\widetilde{\eta}_t + \gamma_C \widetilde{C}_t = 0$, which suggests that demand shocks are completely offset by movement in consumption and therefore have no effect on labor supply. That is, under full financial integration fluctuations in the preference parameter have no effect on the labor market and therefore call for no reaction from the monetary authority.

6.2   Financial Autaky

Under financial autarky the optimal policy is given by:

$$\widetilde{R}_t \cong \frac{\gamma_L}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\left(1 - \rho_\eta\right)\widetilde{\eta}_t + \frac{\gamma_L\left(1 + \gamma_C\right)}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\left(1 - \rho_{P^*}\right)\widetilde{P}_t^*$$

This equation is in-line with conventional wisdom in the sense that a positive demand shock calls for an increase of the interest rate which, in turn, pushes the policy toward counter-cyclicality.

Output in this case is given by:

$$\widetilde{Y}_t \cong \frac{\alpha}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\widetilde{\eta}_t + \frac{\gamma_L + 1}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\widetilde{P}_t^*$$

That is, output increases with both shocks, demand and supply.

Given these results, the only way the optimal policy can be pro-cyclical is for the relative risk aversion coefficient to be large enough. In the model with no demand shocks the cutoff value was unity; however, in this case risk aversion must be even greater. For the exact condition we calculate the covariance between output and the nominal interest rate:

$$COV\left(\widetilde{Y}_t, \widetilde{R}_t\right) = \left[\frac{1}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)}\right]^2 \gamma_L \left\{\alpha\frac{\sigma_{\varepsilon\eta}^2}{1 + \rho_\eta} + \left(\gamma_L + 1\right)\left(1 + \gamma_C\right)\frac{\sigma_{\varepsilon p^*}^2}{1 + \rho_{P^*}}\right\}$$

The optimal monetary policy is pro-cyclical if the covariance is negative, that is:

$$|\gamma_C| > 1 + \frac{\alpha}{1 + \gamma_L}\frac{1 + \rho_{P^*}}{1 + \rho_\eta}\frac{\sigma_{\varepsilon\eta}^2}{\sigma_{\varepsilon p^*}^2} \tag{33}$$

Clearly the cutoff value is greater than one; however, its exact value depends on the relative volatility and relative persistence of demand and supply shocks. Unfortunately, the literature provides little guidance in this direction. Parkin (1988) concludes that fluctuations

in preference shocks are tiny, while Hall (1997) finds that they play a dominant role in driving the business cycle and specifically are more volatile than productivity shocks. Baxter and King (1991) find that both shocks display similar persistence while the variance of preference shocks is about 36 percent greater than that of productivity shocks. Stockman and Tesar (1995) report difficulties in estimating a stochastic process for preference shocks. Depending on the procedure they employ, their estimates of the variance of the preference parameter varies from 0.01 to 2.5 times the variance of productivity.

Nevertheless, in order to get some sense of magnitude for the cutoff value implied by (33), note that if both shocks follow similar stochastic processes then under our baseline parameterization the cutoff value is around 1.5. If one assumes that the variance of the preference shocks is twice as large as the variance of supply shocks then the cutoff value increases to 2. This is still at the lower end of conventional estimates of relative risk aversion; hence, pro-cyclical policies can be supported as optimal even in the presence of substantial demand shocks.

6.3   Intermediate Levels of Integration

We now turn to simulating the bond economy with both demand and supply shocks. Our objective in these simulations is twofold. First, we wish to confirm that the effect of financial integration on the cyclical stance of the monetary policy is monotonic; and second, in absence of reliable estimates for the volatility of demand shocks, we evaluate the robustness of the results by experimenting with a wide range of values.

Throughout the simulations we hold the autocorrelation of the demand shocks, ρ_η, fixed at 0.8, which is the same as the autocorrelation of the supply shocks, ρ_{P*}. We let the ratio $\sigma^2_{\varepsilon\eta}/\sigma^2_{\varepsilon p*}$ take the values 0, 1, 2, 3, and 5. We do that by fixing $\sigma^2_{\varepsilon P*}$ at its level in the baseline simulations and letting $\sigma^2_{\varepsilon\eta}$ vary, although it should be stressed that the absolute value of the variances have no effect on the interest-output correlation, only their ratio matters.

Figure 6 depicts the optimal interest-output correlation as a function of κ in the different simulations. In all cases the correlation increases as κ falls; that is, greater financial integration implies that the monetary authority should pursue counter-cyclical policies more aggressively. The figure also demonstrates that the model can support pro-cyclical policies even when demand shocks are overwhelmingly more volatile than supply shocks. In order to rule out pro-cyclical policies altogether the model requires $\sigma^2_{\varepsilon^\eta}$ to be more than three times greater than $\sigma^2_{\varepsilon^{p*}}$.

7   Conclusion

This paper has documented that, in contrast to developed economies, developing countries tend to follow pro-cyclical monetary policies. The paper then showed that a fairly standard New-Keynesian model can explain the observed difference through the level of integration in the international financial markets. Specifically, the model suggests that under full financial integration the optimal monetary policy is counter-cyclical, while if the economy is excluded from the international financial markets then the optimal policy is pro-cyclical. The model also suggests that the transition from counter-cyclical to pro-cyclical policies is monotonic in the level of integration. That is, greater integration pushes the optimal monetary policy toward counter-cyclicality. These results are robust to the introduction of demand shocks.

Finally, an important insight from the paper is that the cyclical pattern alone may not serve as an indicator for evaluating policies. It may, however, serve as an indicator for the economic conditions under which policymakers operate. In terms of the model, a pro-cyclical monetary policy might be a symptom of the inability to access the international financial markets. Therefore, advising countries to follow counter-cyclical policies merely treats the symptom and may result in undesirable economic outcomes. Instead, attention should be focused on measures for promoting integration in the international financial markets. Once integrated, policies would endogenously display greater counter-cyclicality.

8 Appendix 1: Determinacy of Equilibria

The results in the text ignore determinacy issues since they were derived by assuming non-sunspot equilibria. This appendix shows that the monetary policy can achieve uniqueness by including the exchange rate in the interest rate rule with an arbitrary positive coefficient. We also show that such modification does not affect any of the results discussed in the text.

8.1 Full Financial Integration

8.1.1 Determinacy of the Exchange Rate

Under full integration $\widetilde{C}_t = 0$. Therefore, the interest rate rule (23) and the Euler equation (17) give:

$$\frac{\gamma_L}{\gamma_L + 1 - \alpha} \left(1 - \rho_{P^*}\right) \widetilde{P}_t^* \cong -\widetilde{\sigma}_t + E_t \left(\widetilde{\sigma}_{t+1}\right)$$

which characterizes the solution for the exchange rate. Under the *non-sunspot* equilibrium we have:

$$\widetilde{\sigma}_t = -\frac{\gamma_L}{\gamma_L + 1 - \alpha} \widetilde{P}_t^* \tag{34}$$

However, the Euler equation clearly has a unit root which opens the possibility for multiple solutions. Specifically:

$$\widetilde{\sigma}_t = -\frac{\gamma_L}{\gamma_L + 1 - \alpha} \widetilde{P}_t^* + \chi_t$$

where χ_t is some non-fundamental noise such that $E_t \left(\chi_{t+1}\right) = \chi_t$, is also a solution. Following Woodford (2003) we now show that by including the exchange rate (with a positive coefficient) in the interest rate rule, the monetary policy can support a unique equilibrium. Consider the following rule:

$$\widetilde{R}_t = A\widetilde{P}_t^* + B\widetilde{\sigma}_t \qquad B > 0 \tag{35}$$

Substituting $\widetilde{R}_t$ into (17), and imposing $\widetilde{C}_t = 0$, gives:

$$E_t \left(\widetilde{\sigma}_{t+1}\right) \cong A\widetilde{P}_t^* + (1 + B)\widetilde{\sigma}_t$$

Since the exchange rate is a non-predetermined endogenous variable, and since $B > 0$ this equation has a unique solution. One can easily check that this solution is given by:

$$\widetilde{\sigma}_t = -\frac{A}{B + 1 - \rho_{P*}} \widetilde{P}_t^*$$

In order to recover the non-sunspot solution as given by equation (34), we must impose:

$$A = \frac{\gamma_L}{\gamma_L + 1 - \alpha}(B + 1 - \rho_{P*}) \qquad B > 0$$

Therefore, any policy rule that satisfies this condition is able to determine the exchange rate at the level of the non-sunspot equilibrium. Furthermore, after substituting the exchange rate into the policy rule (35) and using the restrictions on A and B we recover the expression for the interest rate, equation (23), as a reduced form solution. This suggests that if the rest of the system is determined at the level of the non-sunspot equilibrium, then all the results discussed in the text still hold. We therefore turn to show that given (34) the rest of the system is uniquely determined.

8.1.2 The Rest of the System

By using (34) to substitute for $\widetilde{\sigma}_t$, and by manipulating equations (13), (15), and (18), we get:

$$\begin{bmatrix} E_t\left(\widetilde{\Omega}_{t+1}\right) \\ \widetilde{\Omega}_t \end{bmatrix} = \Gamma \begin{bmatrix} \widetilde{\Omega}_t \\ \widetilde{\Omega}_{t-1} \end{bmatrix}$$

$$\text{where} \qquad \Gamma \equiv \begin{bmatrix} \frac{1+\beta}{\beta} + \frac{(1-\xi_w)(1-\xi_w\beta)}{\xi_w\beta}\frac{\gamma_L+1-\alpha}{(1+\gamma_L\theta)(1-\alpha)} & -\frac{1}{\beta} \\ 1 & 0 \end{bmatrix}$$

This system has a unique solution if and only if Γ has one eigenvalue inside the unit circle and the other outside the unit circle.[28] It is sufficient to show that:

$$\det(\Gamma) = \lambda_1 \lambda_2 > 1$$

$$\det(\Gamma) - TR(\Gamma) + 1 = (\lambda_1 - 1)(\lambda_2 - 1) < 0$$

where λ_1 and λ_2 are the eigenvalues of Γ. Notice that:

$$\det(\Gamma) = \frac{1}{\beta} > 1$$

and therefore both eigenvalues have the same sign, and at least one of them lies outside the unit circle. Also:

$$\det(\Gamma) - TR(\Gamma) + 1 = -\frac{(1 - \xi_w)(1 - \xi_w \beta)}{\xi_w \beta} \frac{\gamma_L + 1 - \alpha}{(1 + \gamma_L \theta)(1 - \alpha)} < 0$$

This rules out the possibility that both eigenvalues lie outside the unit circle since we have already established that they both have the same sign. We can therefore conclude that the solution is unique.

Clearly, $\widetilde{\Omega}_t = 0$ solves the difference equation, and using (13), we also get $\widetilde{\omega}_t^t = 0$, which indicates that the policy recovers the flexible wages equilibrium. Finally, using the static equations (14) and (15) we solve uniquely for $\widetilde{L}_t$ and $\widetilde{Y}_t$.

We have therefore shown that the monetary authority can support the non-sunspot equilibrium as a unique outcome of its policy.

8.2 Financial Autarky

We now show that under financial autarky any interest rate rule of the form of (35) imposes determinacy on the economic system. By substituting equations (13), (14), (15), (19), and

---

[28]If we define $X_{t+1} \equiv \widetilde{\Omega}_t$, then we can write the system as:

$$\begin{bmatrix} E_t\left(\widetilde{\Omega}_{t+1}\right) \\ X_{t+1} \end{bmatrix} = \Gamma \begin{bmatrix} \widetilde{\Omega}_t \\ X_t \end{bmatrix}$$

which makes clear that it involves one predetermined variable and one non-predetermined.

(35) into (17) and (18) the system becomes:

$$
\begin{bmatrix} E_t\left(\widetilde{\Omega}_{t+1}\right) \\ E_t\left(\widetilde{\sigma}_{t+1}\right) \\ \widetilde{\Omega}_t \end{bmatrix} = \Gamma_1 \begin{bmatrix} \widetilde{\Omega}_t \\ \widetilde{\sigma}_t \\ \widetilde{\Omega}_{t-1} \end{bmatrix} + \Gamma_2 \widetilde{P}_t^*
$$

where:

$$
\Gamma_1 = \begin{bmatrix} 1 + \frac{1}{\beta} + \Xi & -\Xi & -\frac{1}{\beta} \\ -\frac{\alpha\gamma_C}{1-\alpha(1+\gamma_C)}\left(\frac{1}{\beta} + \Xi\right) & \Xi\frac{\alpha\gamma_C}{[1-\alpha(1+\gamma_C)]} + \frac{1-\alpha}{1-\alpha(1+\gamma_C)}B + 1 & \frac{1}{\beta}\frac{\alpha\gamma_C}{1-\alpha(1+\gamma_C)} \\ 1 & 0 & 0 \end{bmatrix}
$$

$$
\Gamma_2 = \begin{bmatrix} -\Xi\frac{\gamma_L-\gamma_C}{1+\gamma_L-\alpha(1+\gamma_C)} \\ \Xi\frac{\gamma_L-\gamma_C}{1+\gamma_L-\alpha(1+\gamma_C)}\frac{\alpha\gamma_C}{1-\alpha(1+\gamma_C)} + \frac{1-\alpha}{1-\alpha(1+\gamma_C)}\left[A - \frac{\gamma_C}{1-\alpha}(1-\rho)\right] \\ 0 \end{bmatrix}
$$

$$
\Xi \equiv \frac{(1-\xi_w)(1-\xi_w\beta)}{\xi_w\beta}\frac{1+\gamma_L-\alpha(1+\gamma_C)}{(1+\gamma_L\theta)(1-\alpha)} > 0
$$

This system has a unique solution if and only if Γ_1 has one eigenvalue inside the unit circle and two outside.[29] The characteristic polynomial of Γ_1 is given by:

$$
P(\lambda) = \lambda^3 + A_2\lambda^2 + A_1\lambda + A_0
$$

where:
$$
A_0 = -\frac{1}{\beta}\left[\frac{1-\alpha}{1-\alpha(1+\gamma_C)}B + 1\right]
$$
$$
A_1 = \frac{1}{\beta} + \Xi\frac{\alpha\gamma_C}{1-\alpha(1+\gamma_C)} + \left[\frac{1-\alpha}{1-\alpha(1+\gamma_C)}B + 1\right]\left[\frac{1+\beta}{\beta} + \Xi\right]
$$
$$
A_2 = -\Xi\frac{\alpha\gamma_C}{1-\alpha(1+\gamma_C)} - \left[\frac{1-\alpha}{1-\alpha(1+\gamma_C)}B + 1\right] - \left[\frac{1+\beta}{\beta} + \Xi\right]
$$

---

[29]If we define $X_{t+1} \equiv \widetilde{\Omega}_t$, then we can write the system as:

$$
\begin{bmatrix} E_t\left(\widetilde{\Omega}_{t+1}\right) \\ E_t\left(\widetilde{\sigma}_{t+1}\right) \\ X_{t+1} \end{bmatrix} = \Gamma_1 \begin{bmatrix} \widetilde{\Omega}_t \\ \widetilde{\sigma}_t \\ X_t \end{bmatrix} + \Gamma_2\widetilde{P}_t^*
$$

which makes clear that it involves one predetermined variable and two non-predetermined.

For uniqueness it is *sufficient* to show that:[30]

$$1 + A_2 + A_1 + A_0 > 0$$
$$-1 + A_2 - A_1 + A_0 < 0$$
$$|A_2| > 3$$

Given the parameters above one can easily show that:

$$1 + A_2 + A_1 + A_0 = \frac{1-\alpha}{1-\alpha(1+\gamma_C)} B\Xi > 0$$

$$-1 + A_2 - A_1 + A_0 = -\frac{1-\alpha}{1-\alpha(1+\gamma_C)}\left(2\Xi + 2\frac{1+\beta}{\beta}B + B\Xi\right) - 4\frac{1+\beta}{\beta} < 0$$

and:

$$A_2 = -\frac{1-\alpha}{1-\alpha(1+\gamma_C)}(\Xi + B) - 1 - \frac{1+\beta}{\beta}$$
$$< -1 - \frac{1+\beta}{\beta}$$
$$< -3$$

Hence, all conditions for uniqueness are satisfied.

One can check that for an arbitrary positive B and:

$$A = B\frac{\gamma_L - \gamma_C}{\gamma_L + 1 - \alpha(1+\gamma_C)} + \frac{\gamma_L(1+\gamma_C)}{\gamma_L + 1 - \alpha(1+\gamma_C)}(1 - \rho_{P*}) \qquad B > 0 \qquad (36)$$

The unique solution of the system is given by:

$$\widetilde{\sigma}_t = -\frac{\gamma_L - \gamma_C}{\gamma_L + 1 - \alpha(1+\gamma_C)}\widetilde{P}_t^*$$
$$\widetilde{\Omega}_t = 0$$

Given this result the variables $\widetilde{\omega}_t^t$, $\widetilde{L}_t$, $\widetilde{C}_t$, and $\widetilde{Y}_t$ are recovered from a system of static

---

[30]See appendix C in Woodford (2003).

linearly independent equations and therefore have a unique solution as well:

$$
\begin{aligned}
\widetilde{\omega}_t^t &= 0 \\
\widetilde{Y}_t &= \widetilde{C}_t = \frac{1 + \gamma_L}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)} \widetilde{P}_t^* \\
\widetilde{L}_t &= \frac{1 + \gamma_C}{\gamma_L + 1 - \alpha\left(1 + \gamma_C\right)} \widetilde{P}_t^*
\end{aligned}
$$

One can check that this solution together with the restrictions on the parameters A and B and the interest rate rule (35) satisfy the remaining equilibrium condition, equation (17).

Finally, after substituting the solution for the exchange rate into the policy rule (35) and using the restrictions on A and B as given by (36), we recover the expression for the interest rate, equation (27), as a reduced form solution. Therefore, the monetary authority is able to recover the non-sunspot allocation as a unique equilibrium.

9   Appendix 2: Data

The data source for all series in the empirical section of the paper is the IFS. The paper uses quarterly data for the period 1974.1-2004.4 on short-term nominal interest rate, real GDP, CPI, the nominal exchange rate, and the terms of trade.

For nominal interest rate we use either the central bank rate, line 60, or the interbank market rate, line 60B, depending on data availability (see Table 3). For quarterly data we average monthly observations in each quarter.

For real GDP we use volume indices, line 99BVR (seasonally adjusted) or 99BVP (not seasonally adjusted), depending on data availability. For countries with no seasonal correction we adjust the series using X12 multiplicative method.

Inflation is measured using CPI, line 64. For quarterly data we average monthly observations. We then calculate inflation by the CPI growth rate during the last four quarters.

For the nominal exchange rates we use the nominal effective exchange rate, line NEC or NEU. For countries with no data on the effective rates we use the nominal exchange rate

against the US Dollar, line AH. See Table 4 for the choice of series for each country. For the estimation of equation (1), the rate of change in the exchange rate was calculated by log difference.

For terms of trade series we divide export unit value, line 74, by import unit value, line 75. These were used for evaluating the time series properties of the terms of trade.

For the cyclical components we remove HP trends from the interest rate, log GDP, inflation, the exchange rate, and its rate of change. We use a smoothing parameter of 1600 in all cases.

We restrict our sample to include countries with floating or dirty-floating exchange rate regimes with at least 20 consecutive observations. In addition, we remove observations in periods of annual CPI inflation of more than 100 percent.

The classification of exchange rate regimes is based on Levy-Yeyati and Sturzenegger (2005). They assign a five-way index to each country-year observation. The value 1 indicates an inconclusive regime, 2 is float, 3 is dirty float, 4 is either dirty float or a crawling peg, and 5 indicates a fixed exchange rate regime. We include observations that take the values 2 or 3; however, we also include observations that take the value 1 or 4 if they follow directly after periods of floating or dirty-floating (i.e. indexed by 2 or 3) and return to these regimes immediately afterwards. In other words, observations indexed by 1 or 4 are allowed to the extent that they do not open or close the sample period.

Table 3 reports the resulting sample periods for each country. The table also complements Table 1 by reporting country specific interest-output correlations and output coefficients from the estimation of the interest rate rules. Table 4 reports the exchange rate series used for each country and the estimated coefficients of the $AR(1)$ process of the terms of trade.

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**Figure 1: Country Correlations Between
Cyclical Components of GDP and Short-Term Interest Rate**
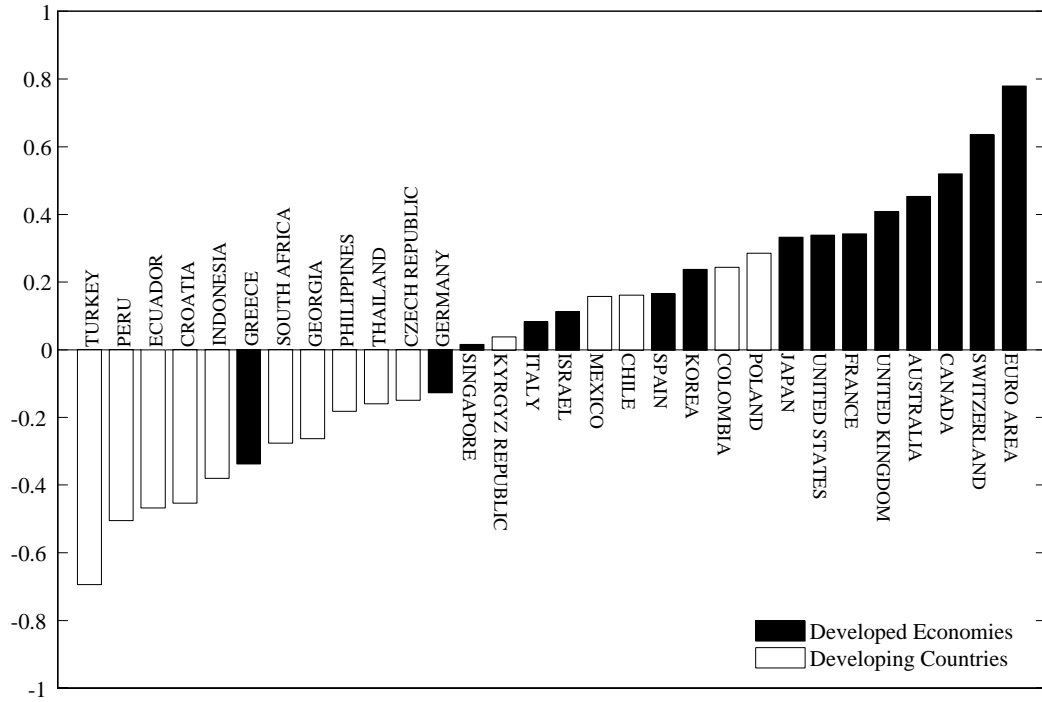
Figure 2: The Labor Market – An Improvement in the Terms of Trade

Panel A: Full Financial Integration   Panel B: Financial Autarky
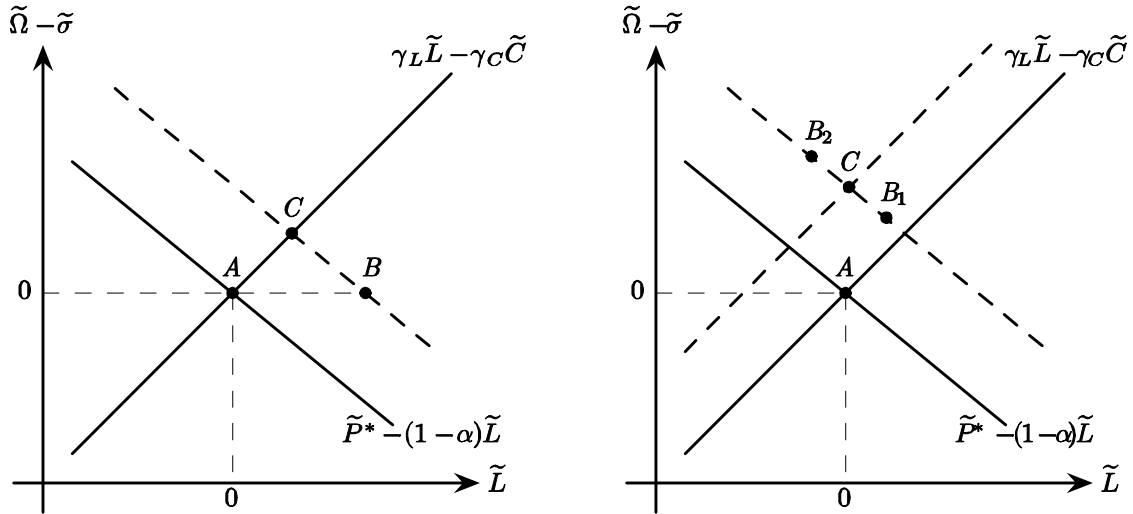
Figure 3: Impulse Response Functions
1 Percent Increase in the Terms of Trade

(A) Terms of Trade, $\widetilde{P}^*$

(B) Consumption, $\widetilde{C}$

(C) Labor, $\widetilde{L}$

(D) Output, $\widetilde{Y}$

(E) Exchange Rate, $\widetilde{S}$

(F) Nominal Interest Rate, $\widetilde{R}$
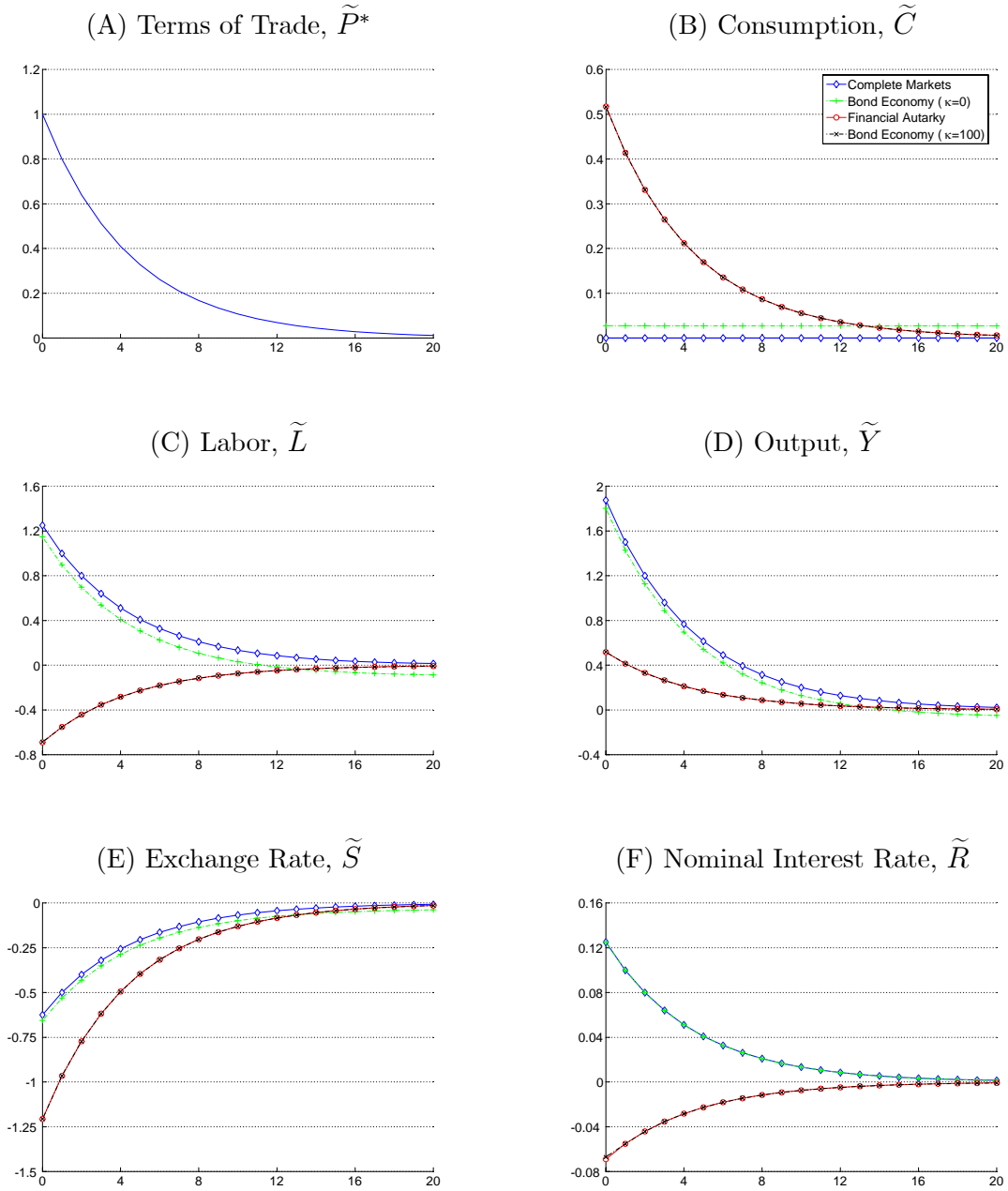
Figure 4: Interest-Output Correlation As a Function of κ, Baseline Parameterization*
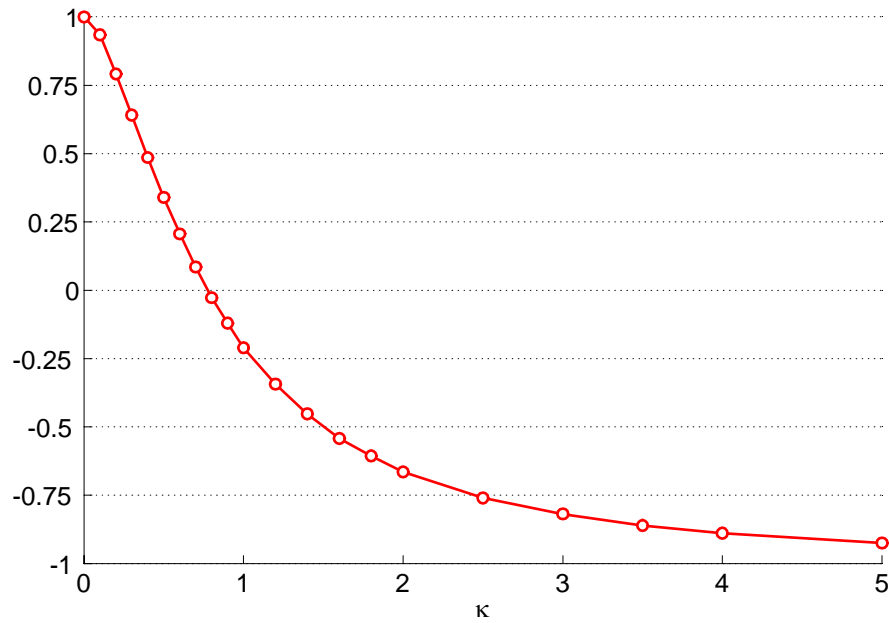
* Each data point is the average correlation over 1,000 simulations, each 100 periods long.

Figure 5: Interest-Output Correlation As a Function of κ, Sensitivity Analysis*
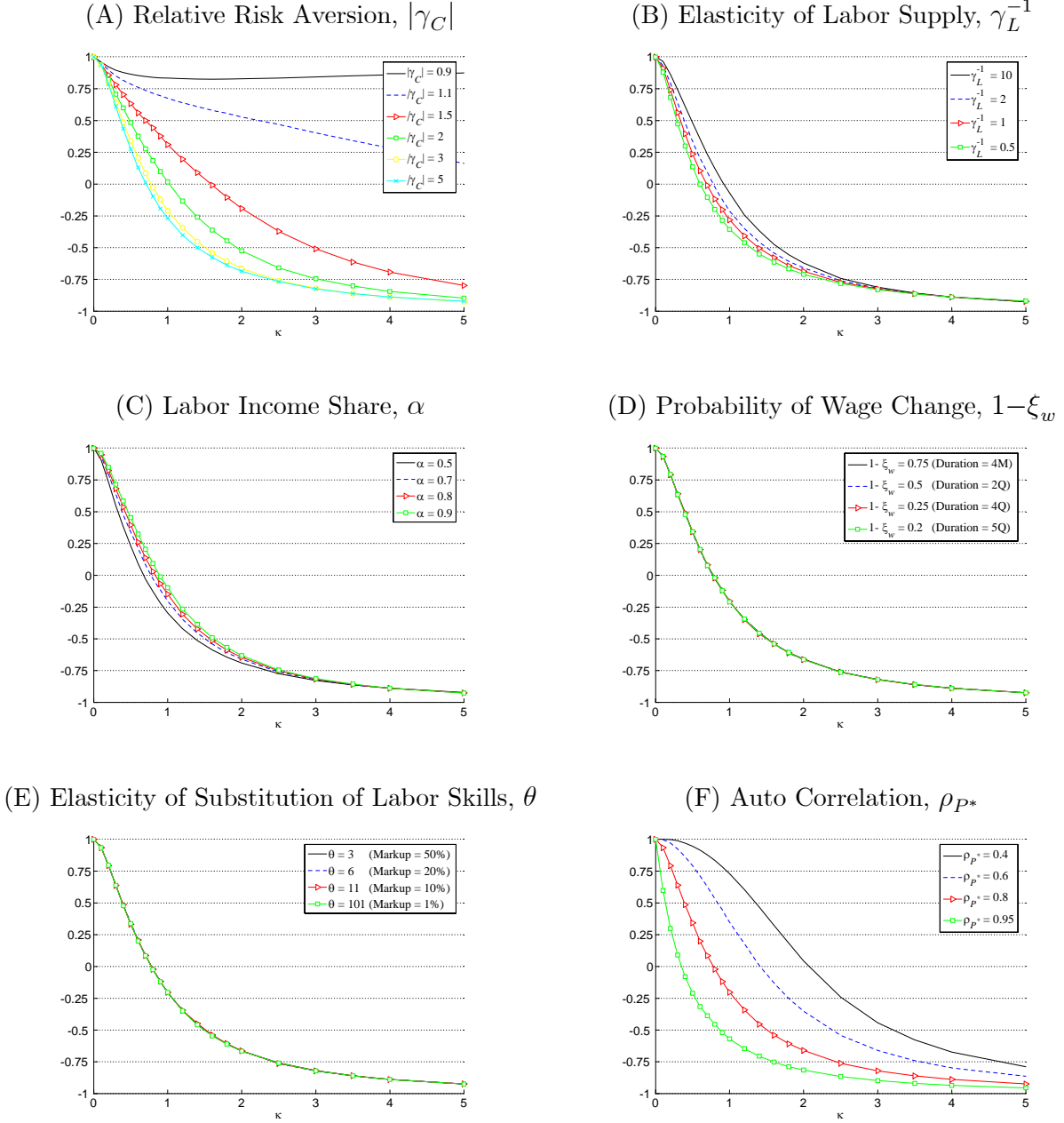
(A) Relative Risk Aversion, $|\gamma_C|$

(B) Elasticity of Labor Supply, γ_L^{-1}

(C) Labor Income Share, α

(D) Probability of Wage Change, $1-\xi_w$

(E) Elasticity of Substitution of Labor Skills, θ

(F) Auto Correlation, ρ_{P*}

* Each data point is the average correlation over 1,000 simulations, each 100 periods long.

**Figure 6: Interest-Output Correlation As a Function of κ,
A Model with Demand Shocks ($\rho_\eta = 0.8$)***
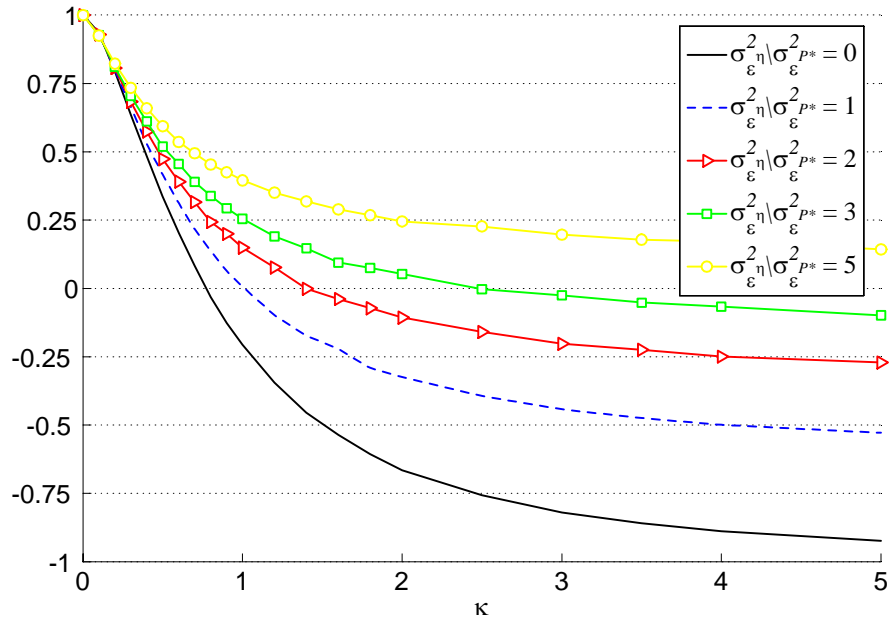
* Each data point is the average correlation over 1,000 simulations, each 100 periods long.

Table 1: Cyclicality of Short-Term Interest Rate by Country Group*

Panel A: Interest-Output Correlation

	Average	Positive	Negative	Sig. Positive**	Sig. Negative**
Developed Economies	0.26	13	2	7	0
Developing Countries	-0.18	5	10	0	5

Panel B: Output Coefficient in Interest Rule Estimation, $\beta_\sigma = 0$, OLS

	Average	Positive	Negative	Sig. Positive**	Sig. Negative**	β_y	Panel Regression P-value
Developed Economies	0.22	11	4	7	2	0.18	0.000
Developing Countries	-0.33	3	12	0	5	-0.11	0.000

Panel C: Output Coefficient in Interest Rule Estimation, $\beta_\sigma \neq 0$, TSLS

	Average	Positive	Negative	Sig. Positive**	Sig. Negative**	β_y	Panel Regression P-value
Developed Economies	0.13	8	7	3	1	0.27	0.002
Developing Countries	-0.14	4	11	0	3	-0.17	0.080

* Output refers to real GDP and interest rates are either the central bank's rate or the interbank market rate, depending on data availability. All statistics are calculated using the cyclical components of the variables; these are measured by the deviation of the variables from HP trend.
** 5 percent significance level.

Table 2: Baseline Parameter Values

Preferences:	Discount factor, β	0.99
	Relative risk aversion, $\lvert\gamma_C\rvert$	3
	Elasticity of labor supply, γ_L^{-1}	2
Labor Market:	Elasticity of substitution, θ	6
	Wage rigidity, ξ_w	0.75
Technology:	Labor income share, α	0.7
Terms of Trade:	Autocorrelation, ρ_{P*}	0.8
	Std. of innovations, $\sigma_{\varepsilon^{P*}}$	0.03
Portfolio adjustment cost:	Second derivative at SS, κ	varies
	SS assets, B_{ss}^*	0

Table 3: Complementary Table, Interest and Output

	$\rho_{\widetilde{R},\widetilde{Y}}$	P-val.	OLS β_y	P-val.	TSLS β_y	P-val.	Interest Series*	Sample	OBS.
Developed Economies									
Australia	0.45	0.000	0.46	0.001	0.81	0.734	60B	1984.1-2004.4	84
Canada	0.52	0.000	0.51	0.000	0.48	0.001	60	1976.1-2004.4	116
France	0.34	0.139	0.41	0.005	0.85	0.181	60	1974.1-1978.4	20
Germany**	-0.13	0.485	-0.06	0.720	-0.45	0.203	60	1991.1-1998.4	32
Greece	-0.34	0.055	-0.08	0.025	-0.20	0.066	60	1983.1-1991.1	33
Israel	0.11	0.339	0.14	0.417	0.12	0.601	60	1986.2-2004.4	75
Italy	0.08	0.542	0.00	0.995	0.32	0.474	60	1980.1-1993.4	56
Japan	0.33	0.000	0.11	0.068	0.31	0.019	60	1974.1-2004.4	124
Korea	0.24	0.263	0.72	0.000	0.71	0.001	60	1980.1-1985.4	24
Singapore	0.02	0.947	-0.22	0.044	-0.32	0.017	60B	1994.1-1998.4	20
Spain	0.17	0.177	0.55	0.159	-0.63	0.643	60	1977.1-1993.4	68
Switzerland	0.63	0.000	0.37	0.000	-0.15	0.621	60	1982.1-2004.4	92
United Kingdom	0.41	0.000	-0.07	0.473	-0.03	0.814	60B	1987.1-2004.4	72
United States	0.34	0.000	0.09	0.045	0.24	0.401	60	1974.1-2004.4	124
Euro Area	0.78	0.000	0.42	0.000	-0.12	0.830	60	1999.1-2004.4	24
Developing Countries									
Chile	0.16	0.280	0.21	0.249	0.33	0.181	60	1993.2-2004.4	47
Colombia	0.24	0.110	-0.13	0.699	1.33	0.691	60	1994.1-2004.4	44
Croatia	-0.45	0.009	-0.15	0.006	-0.28	0.014	60	1997.1-2004.4	32
Czech Republic	-0.15	0.476	-0.26	0.129	-0.21	0.468	60	1995.4-2001.4	25
Ecuador	-0.47	0.004	-1.79	0.006	-0.15	0.933	60	1991.1-1999.4	36
Georgia	-0.26	0.263	-0.62	0.312	-1.06	0.128	60B	2000.1-2004.4	20
Indonesia	-0.38	0.046	-0.42	0.312	-0.45	0.648	60	1998.1-2004.4	28
Kyrgyz Republic	0.04	0.875	-0.03	0.913	-0.26	0.585	60B	2000.1-2004.4	20
Mexico	0.16	0.332	0.39	0.276	0.81	0.203	60B	1995.1-2004.4	40
Peru	-0.50	0.001	-0.87	0.015	-0.41	0.539	60	1992.2-2002.4	43
Philippines	-0.18	0.353	-0.02	0.955	-0.09	0.797	60	1997.1-2003.4	28
Poland	0.29	0.074	0.32	0.073	0.33	0.337	60	1995.1-2004.4	40
South Africa	-0.28	0.104	-1.08	0.000	-1.31	0.001	60	1996.1-2004.4	36
Thailand	-0.16	0.279	-0.04	0.279	-0.01	0.894	60	1993.1-2004.4	48
Turkey	-0.69	0.000	-0.46	0.002	-0.62	0.001	60	1999.1-2004.4	24

* Line 60 is the central bank discount rate, line 60B is the interbank market rate.

** For Germany the sample starts in 1991.1, however the calculation of annual inflation takes 4 observations and therefore the estimation of the interest rate rules starts in 1992.1.

Table 4: Complementary Table, Exchange Rates and Terms of Trade

| | Terms of Trade* | | Exchange Rate |
	ρ_{P*}	$\sigma_{\varepsilon P*}$	Series**
Developed Economies			
Australia	0.97	0.021	NEC
Canada	0.88	0.022	NEU
France	NA	NA	NEU
Germany	0.88	0.010	NEU
Greece	0.90	0.037	NEU
Israel	0.85	0.026	NEC
Italy	0.99	0.022	NEU
Japan	0.95	0.037	NEU
Korea	0.85	0.020	AH
Singapore	0.13	0.008	NEC
Spain	0.97	0.049	NEU
Switzerland	NA	NA	NEU
United Kingdom	0.84	0.010	NEU
United States	0.89	0.017	NEU
Euro Area	NA	NA	NEU
Developing Countries			
Chile	NA	NA	NEC
Colombia	0.57	0.046	NEC
Croatia	NA	NA	NEC
Czech Republic	NA	NA	NEC
Ecuador	NA	NA	NEC
Georgia	NA	NA	AH
Indonesia	NA	NA	AH
Kyrgyz Republic	NA	NA	AH
Mexico	NA	NA	AH
Peru	NA	NA	AH
Philippines	0.53	0.073	NEC
Poland	0.51	0.027	NEC
South Africa	0.91	0.080	NEC
Thailand	0.94	0.026	AH
Turkey	0.72	0.013	AH

* Statistics are the result of estimating an AR(1) process to $\log(P^*)$.

** Lines NEC and NEU are nominal effective rates. Line AH is the nominal rate against the US Dollar.