Globalization and Monetary Control*

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Abstract

It has recently become popular to argue that globalization has had or will soon have dramatic consequences for the nature of the monetary transmission mechanism, and it is sometimes suggested that this could threaten the ability of national central banks to control inflation within their borders, at least in the absence of coordination of policy with other central banks. In this paper, I consider three possible mechanisms through which it might be feared that globalization can undermine the ability of monetary policy to control inflation: by making liquidity premia a function of "global liquidity" rather than the supply of liquidity by a national central bank alone; by making real interest rates dependent on the global balance between saving and investment rather than the balance in one country alone; or by making inflationary pressure a function of "global slack" rather than a domestic output gap alone. These three fears relate to potential changes in the form of the three structural equations of a basic model of the monetary transmission mechanism: the LM equation, the IS equation, and the AS equation respectively. I review the consequences of global integration of financial markets, final goods markets, and factor markets for the form of each of these parts of the monetary transmission mechanism, and find that globalization, even of a much more thorough sort than has yet occurred, is unlikely to weaken the ability of national central banks to control the dynamics of inflation.

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Concern has recently been expressed in a variety of quarters that the problems facing central banks may be substantially complicated by the increasing globalization of goods markets, factor markets, and financial markets in recent years. Some of the more alarmist views suggest that the very ability of national central banks to materially influence the dynamics of inflation in their countries through monetary policy actions may be undermined by globalization. According to such accounts, the recently observed low and stable inflation in many parts of the world should be attributed mainly to favorable (and likely transient) global developments rather than to the sound policies of central banks in those parts of the world; and rather than congratulating themselves on how skilled they have become at the conduct of monetary stabilization policy, central bankers should instead live in dread of the day when the implacable global market forces instead turn against them, making a return of inflation all but inevitable.

In this paper I consider a variety of reasons why globalization might be expected to weaken the control of national central banks over inflation within their borders. These correspond to three distinct aspects of the transmission mechanism for monetary policy: the link between central-bank actions and overnight nominal interest rates (in a conventional 3-equation model, the extent to which it is possible for central-bank policy to shift the "LM curve"); the link between real interest rates and the balance between saving and investment in the economy (described by the "IS curve"); and the link between variations in domestic real activity and inflation (described by the "AS curve").

On the one hand, it might be thought that in a globalized world, it is "global liquidity" that should determine world interest rates rather than the supply of liquidity by a single central bank (especially a small one); thus one might fear that a small central bank will no longer have any instrument with which to shift the LM curve. Alternatively, it might be thought that changes in the balance between investment and saving in one country should matter little for the common world level of real interest rates, so that the "IS curve" should become perfectly horizontal even if the LM curve could be shifted. It might then be feared that loss of control over domestic real interest rates would eliminate any leverage of domestic monetary policy over domestic spending or inflation. Or as still another possibility, it might be thought that inflation should cease to depend on economic slack in one country alone (especially a small one), but rather upon "global slack"; in this case the AS curve would become horizontal, implying that even if domestic monetary policy can be effectively used to control domestic aggregate demand, this might not allow any control over domestic inflation.

I take up each of these possibilities, by discussing the effects of openness (of goods markets, of factor markets, and of financial markets) on each of these three parts of a "new Keynesian" model of the monetary transmission mechanism. I first consider each argument in the context of a canonical open-economy monetary model (following the exposition by Clarida, Gali and Gertler, 2002), and show that openness need not have any of the kinds of effects that I have just proposed. In each case, I also consider possible variants of the standard model in which the effects of globalization might be more extreme. These cases are not always intended to be regarded as especially realistic, but are taken up in an effort to determine if there are conditions under which the fear of globalization would be justified. Yet I find it difficult to construct scenarios under which globalization would interfere in any substantial way with the ability of domestic monetary policy to maintain control over the dynamics of domestic inflation.

It is true that, in a globalized economy, foreign developments will be among the sources of economic disturbances to which it will be appropriate for a central bank to respond, in order for it to achieve its stabilization goals. But there is little reason to fear that the capacity of national central banks to stabilize domestic inflation, without having to rely upon coordinated action with other central banks, will be weakened by increasing openness of national economies. Thus it will continue to be appropriate to hold national central banks responsible for domestic inflation outcomes, and confidence regarding the future outlook for inflation remains justified in the case of national central banks that have demonstrated vigilance in controlling inflation thus far.

1 International Financial Integration and the Scope for National Monetary Policies

I shall first consider the implications of the international integration of financial markets for the monetary transmission mechanism. I consider this issue first because there can be little doubt that financial markets are already, to an important extent, global markets. The volume of cross-border financial claims of all sorts has grown explosively over the past quarter century, and real interest rates in different countries have been observed to be more strongly correlated as well (Kose *et al.*, 2006).

It is sometimes argued that increased integration of international financial markets should imply that interest rates in each country will come to be determined largely by world conditions rather than domestic conditions. It is then feared that as a result, domestic monetary policy will come to have little leverage over domestic interest rates. Rogoff (2006, pp. 272-273) suggests that this is already occurring, and argues that even large central banks like the Fed are able to affect financial markets as much as they are only thanks to the fact that many other central banks tend to *follow* their policy decisions. That is, Rogoff argues that even though "individual central banks' monetary policies matter less in a globalized world," this "does not imply that central banks have less influence over real interest rates *collectively*." To the extent that this is true, it would seem to imply a substantial reduction in the ability of national central banks to use domestic monetary policy as an instrument of stabilization policy. It might be thought to present a strong argument for explicit agreements among central banks for the coordination of policy, and perhaps even for global monetary union. One might expect that especially in the case of a small country, that can have only a correspondingly small effect on the global balance between investment and savings, domestic monetary policy should cease to be useful for controlling aggregate domestic expenditure or domestic inflation.

In this section of the paper, I consider whether such inferences are valid, by analyzing the connection between real interest rates and aggregate demand in a two-country model with fully integrated international financial markets. Here I focus solely on the way in which equilibrium real interest rates must be consistent with the relation that exists between the economy's time path of output on the one hand and the private sector's preferences over alternative time paths of consumption on the other — the structural relations that correspond to the "IS curve" of a canonical closed-economy model. I defer until the following section the question of how globalization might affect the central bank's ability to influence domestic interest rates owing to changes in the demand for central-bank liabilities. For the moment, I shall take it for granted that a central bank is able to shift the "LM curve," and ask how that affects the aggregate demand curve, *i.e.*, the equilibrium relation between domestic inflation and real expenditure.

1.1 Interest-Rate Policy and Aggregate Demand in a Two-Country Model

I first consider the "aggregate demand block" of a canonical two-country new Keynesian model, as expounded for example in Clarida, Gali and Gertler (2002) [hereafter CGG].[1] I consider first the case of complete international financial integration, so that there is even complete international risk sharing. Moreover, following CGG, I suppose that households in both countries consume the same basket of internationally traded goods. This extreme case has the implication that there is clearly a single real interest rate that is relevant to the intertemporal substitution decisions of households in both countries — the intertemporal relative price of the composite consumption good that is consumed in both countries. This allows me to consider the implications of the equalization of real interest rates across borders in the case where the strongest possible result of this kind obtains.

Let us assume that each of two countries are made up of infinite-lived households, and that each household (in either country) has identical preferences over intertemporal consumption streams. Specifically, following CGG, let us assume that each household ranks consumption streams according to a utility function of the form[2]

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t), \tag{1.1}$$

where $0 < \beta < 1$ is a discount factor,

$$u(C) = \frac{C^{1-\sigma^{-1}}}{1-\sigma^{-1}} \tag{1.2}$$

is the period utility flow from consumption, where $\sigma > 0$ is the constant intertemporal elasticity of substitution of consumer expenditure, and C_t is an index of the household's consumption of both domestically-produced and foreign-produced goods.

[1] Models with a similar structure have been extensively used in the recent literature on the analysis of monetary policy for open economies; see, *e.g.*, Svensson (2000), Benigno and Benigno (2001, 2005, 2006), or Gali and Monacelli (2005).

[2] Here I specify only the way in which utility depends on consumption expenditure. The disutility of working and the liquidity services provided by money balances are assumed to contribute terms to the utility function that are additively separable from the terms included in (1.1); these extensions are discussed in sections 2 and 3.

CGG assume in particular that

$$C_t = C_{Ht}^{1-\gamma} C_{Ft}^{\gamma}, \tag{1.3}$$

where C_{Ht} represents an index of the household's purchases of goods produced in the "home" country and C_{Ft} an index of purchases of goods produced in the "foreign" country. Thus there is assumed to be a unit elasticity of substitution between the two categories of goods, and $0 < \gamma < 1$ indicates the expenditure share of the foreign country's goods in the consumption basket of households in either country. By considering the determination of aggregate demand in country H in the limit as γ approaches 1, we can consider the consequences of globalization for a country that is small relative to world markets.

It is important to note that here an H subscript refers to purchases of goods produced in country H, by households in either country, and not purchases of goods produced in one's own country; thus a large value of γ means that country H supplies most of the goods consumed worldwide, not that few imported goods are consumed in either country. Regardless of the value of γ, the model describes a world with full integration of goods markets, in the sense that an identical basket of goods (all of which are traded on world markets) is consumed in both countries. I shall use variables without stars to denote the purchases of the representative household in country H, and the corresponding starred variables to denote the purchases of these same goods by the representative household in country F. Because preferences are the same in both countries, one has, for example, the relation $C_t^* = C_{Ht}^{*1-\gamma} C_{Ft}^{*\gamma}$.

Given preferences (1.3), intratemporal optimization implies that households in the home country allocate expenditure across domestic and foreign goods according to the relations

$$P_{Ht} C_{Ht} = (1-\gamma) P_t C_t, \tag{1.4}$$

$$P_{Ft} C_{Ft} = \gamma P_t C_t. \tag{1.5}$$

Here P_{Ht} is an index of the prices charged in country H for domestic goods (specifically, the price of a unit of the composite good the quantity of which is measured by C_{Ht}, in units of currency H), P_{Ft} a corresponding index of the prices charged in country H for foreign goods, and

$$P_t = k^{-1} P_{Ht}^{1-\gamma} P_{Ft}^{\gamma}, \tag{1.6}$$

where $k \equiv (1-\gamma)^{1-\gamma}\gamma^{\gamma}$, is an index of the price of all consumer goods (including imported goods). Corresponding relations (for example, $P^*_{Ft}C^*_{Ft} = \gamma P^*_t C^*_t$) hold for consumer expenditure in the foreign country, where the starred prices indicate price indices for the same baskets of goods in country F (and in terms of the foreign currency).

The existence of complete financial markets implies the existence of a uniquely defined stochastic discount factor $Q_{t,T}$ that defines the present value in period t (in units of the domestic currency) of random income in period $T > t$ (also in units of the domestic currency). Optimal allocation of consumption expenditure over time and across states then implies that

$$\beta \left(\frac{C_T}{C_t} \right)^{-\sigma^{-1}} = Q_{t,T} \frac{P_T}{P_t} \tag{1.7}$$

for each possible state of the world at date T. Let i_t be the one-period riskless nominal interest rate in terms of the domestic currency; given (1.7), consistency of this rate with the stochastic discount factor (*i.e.*, the absence of financial arbitrage opportunities) requires that

$$(1+i_t)^{-1} = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma^{-1}} \frac{P_t}{P_{t+1}} \right]. \tag{1.8}$$

This is the key equilibrium relation between the short-term nominal interest rate i_t controlled by the central bank of country H[3] and aggregate expenditure in that country. The riskless one-period real rate of return r_t in country H must satisfy a corresponding relation

$$(1+r_t)^{-1} = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma^{-1}} \right]. \tag{1.9}$$

Finally, relations of exactly the same form relate the intertemporal consumption allocation in the foreign country to asset prices there; equations corresponding to (1.7), (1.8), and (1.9) each hold with each variable replaced by a corresponding starred variable.

The relations stated thus far would hold equally in the case of two closed-economy models, one for each country. (In that case, of course, one would have to assume that

[3]The means by which it is possible for the central bank to control this rate are discussed in the following section.

both H goods and F goods are produced in each country.) CGG further assume that each good is sold in a world market, and that the law of one price holds. Hence one must have

$$P_{Ht} = \mathcal{E}_t P_{Ht}^*,$$

$$P_{Ft} = \mathcal{E}_t P_{Ft}^*,$$

and as a consequence

$$P_t = \mathcal{E}_t P_t^* \tag{1.10}$$

as well, where $\mathcal{E}_t$ is the nominal exchange rate in period t. (Note that (1.10) depends not only on the validity of the law of one price, but also on the existence of identical consumption baskets in the two countries.) Similarly, complete international financial integration (frictionless cross-border trade in all financial assets) implies the relation

$$Q_{t,T} = \frac{\mathcal{E}_t}{\mathcal{E}_T} Q_{t,T}^* \tag{1.11}$$

between the stochastic discount factors (and hence asset prices) in the two countries.

Conditions (1.10) and (1.11) together imply that

$$Q_{t,T} \frac{P_T}{P_t} = Q_{t,T}^* \frac{P_T^*}{P_t^*}, \tag{1.12}$$

i.e., that the stochastic discount factors for *real* income streams must be identical in the two countries, and hence that

$$r_t = r_t^*. \tag{1.13}$$

Thus real interest rates must be equalized in the two countries. In (1.13) the equality of short-term real rates is stated, but in fact, since the real stochastic discount factors are identical, the entire real term structure must be identical in the two countries. This is true regardless of the monetary policies pursued by the two national central banks.

However, this result does *not* depend on the hypothesis of complete international financial integration. In fact, under the preference specification assumed by CGG, an identical result would hold under the hypothesis of complete financial autarchy. Let us suppose that there is a mass $1 - \gamma$ of households in country H and a mass γ in country F, so that income per household is the same in both countries (when expressed in units of the same currency). Under the assumption of financial autarchy, trade must be balanced each period, so that

$$(1-\gamma)P_{Ft}C_{Ft} = \gamma\mathcal{E}_t P^*_{Ht}C^*_{Ht}.$$

Because expenditure is allocated to the two classes of goods in the shares indicated by (1.4)–(1.5), and the corresponding relations for households in country F, this implies that

$$P_t C_t = \mathcal{E}_t P^*_t C^*_t.$$

It would then follow from (1.10) that $C_t = C^*_t$ each period. This in turn implies (given (1.7) and the corresponding relation for country F) that (1.12) must hold, and hence that the term structure of real interest rates must be the same in each country.

Thus we find that the same allocation of resources and system of asset prices represents an equilibrium under either the assumption of costless cross-border trade in financial assets or the assumption of no trade at all.[4] Since these prices and quantities achieve asset-price equalization with zero exchange of financial assets, it follows that they would also represent an equilibrium under *any* assumption about costs of asset trade or incompleteness of international financial markets.[5] Hence in this model, increased financial openness *has no consequences whatsoever* for asset-price determination or aggregate demand under any monetary policies. Of course this irrelevance result is a fairly special one; in particular, it is not exactly true except in the case of preferences of the precise form (1.3), *i.e.,* a unit elasticity of substitution between domestic and foreign goods, and identical preferences in the two countries. But the fact that complete irrelevance is possible (and does not even require an "extreme" preference specification) indicates that the effects of financial globalization need not be large.

It is also important to note that real interest-rate equalization does not imply that domestic monetary policy has no effect on domestic aggregate demand, even in the case of a country that is small relative to global markets (country H in the case in which γ is near 1). Let us derive the "aggregate demand block" of our two-country model (a generalization of the "AD curve" of a static, single-country textbook model),

[4] This equivalence in a model with a unit elasticity of substitution between home and foreign goods was first pointed out by Cole and Obstfeld (1991).

[5] Here I assume that we start from an initial condition with zero net cross-border financial claims, as would necessarily be true in the case of financial autarchy.

by combining the equilibrium relations between interest rates, real activity and prices implied by intertemporal optimization and goods market clearing (corresponding to the "IS curve" of the textbook model) with those implied by the monetary policies of the two central banks (corresponding to the "LM curve").

First, note that world demand for the composite world consumption good

$$C_t^w \equiv (1-\gamma)C_t + \gamma C_t^* \tag{1.14}$$

must equal the supply of the composite world good, so that

$$C_t^w = k\, Y_t^{1-\gamma} Y_t^{*\gamma}, \tag{1.15}$$

where Y_t and Y_t^* are per capita aggregate production of the domestic and foreign composite goods respectively. Next, note that (1.12) together with (1.7) implies that the consumption growth factor C_T/C_t (for any state at any date $T > t$) is the same for households in both countries. Hence world demand for the composite world good must grow at that same rate as well, so that one must also have

$$\beta \left(\frac{C_T^w}{C_t^w} \right)^{-\sigma^{-1}} = Q_{t,T} \frac{P_T}{P_t} = Q_{t,T}^* \frac{P_T^*}{P_t^*}.$$

Substituting (1.15), we then have

$$Q_{t,T} \frac{P_T}{P_t} = Q_{t,T}^* \frac{P_T^*}{P_t^*} = \beta \left(\frac{Y_t}{Y_T} \right)^{\sigma^{-1}(1-\gamma)} \left(\frac{Y_t^*}{Y_T^*} \right)^{\sigma^{-1}\gamma}. \tag{1.16}$$

Given these stochastic discount factors, the two nominal interest rates must satisfy

$$(1+i_t)^{-1} = \beta E_t \left[\left(\frac{Y_t}{Y_{t+1}} \right)^{\sigma^{-1}(1-\gamma)} \left(\frac{Y_t^*}{Y_{t+1}^*} \right)^{\sigma^{-1}\gamma} \frac{P_t}{P_{t+1}} \right] \tag{1.17}$$

and

$$(1+i_t^*)^{-1} = \beta E_t \left[\left(\frac{Y_t}{Y_{t+1}} \right)^{\sigma^{-1}(1-\gamma)} \left(\frac{Y_t^*}{Y_{t+1}^*} \right)^{\sigma^{-1}\gamma} \frac{P_t^*}{P_{t+1}^*} \right]. \tag{1.18}$$

Relations (1.17)–(1.18) are a pair of "IS equations" relating interest rates to output (real aggregate demand for each of the two countries' products) and to expected inflation, generalizing the "intertemporal IS relation"[6] of a closed-economy new Keynesian model.

[6] See, *e.g.*, equation (1.1) of Woodford (2003, chap. 4).

To complete the "aggregate demand block" of the model, we must adjoin to these equations a pair of equations representing the monetary policies of the two central banks. For example, monetary policy might be specified by a pair of "Taylor rules,"

$$1 + i_t = \bar{I}_t \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} Y_t^{\phi_y}, \tag{1.19}$$

$$1 + i_t^* = \bar{I}_t^* \left(\frac{P_t^*}{P_{t-1}^*} \right)^{\phi_\pi^*} Y_t^{*\phi_y^*}, \tag{1.20}$$

where $\bar{I}_t$ and $\bar{I}_t^*$ are two state-dependent factors that may represent time-variation in the inflation target, a desire to respond to departures of output from a time-varying measure of potential, a time-varying conception of the "neutral" rate of interest, or a random control error in the implementation of the central bank's interest-rate target, among other possibilities. (For purposes of our analysis it matters only that the processes $\{\bar{I}_t, \bar{I}_t^*\}$ be exogenously specified, rather than depending on the evolution of any endogenous variables.) Then (1.17)–(1.20) represent a system of four equations per period to determine the evolution of the four nominal variables $\{P_t, P_t^*, i_t, i_t^*\}$ given the evolution of the real quantities $\{Y_t, Y_t^*\}$. They thus represent a two-country (and dynamic) version of the "AD equation" of a textbook macro model. Together with a model of aggregate supply (discussed in section 3), they allow one to understand the endogenous determination of both output and inflation in the two countries.

The question that we wish to address is, to what extent are the monetary policies of the two countries — here represented in particular by the evolution over time of the intercept terms $\bar{I}_t$ and $\bar{I}_t^*$ — able to exert independent influence over aggregate demand (and hence the general level of prices) in each country? To examine the way in which the various endogenous variables are jointly determined, it is as usual convenient to log-linearize the system of equilibrium relations, around some steady-state equilibrium values of the variables. The steady state that we shall consider is one in which there is a common steady-state level of output in each country, $Y_t = Y_t^* = \bar{Y} > 0$, and zero inflation in each country; it follows that in each country the steady-state nominal interest rate is equal to $i_t = i_t^* = \beta^{-1} - 1 > 0$. The monetary policy specification is consistent with this if in the steady state, $\bar{I} = \beta^{-1}\bar{Y}^{-\phi_y}$ and $\bar{I}^* = \beta^{-1}\bar{Y}^{-\phi_y^*}$. The log-linear approximations to the two "IS equations" (1.17)–(1.18) are given by

$$(1-\gamma)\hat{Y}_t + \gamma\hat{Y}_t^* = E_t[(1-\gamma)\hat{Y}_{t+1} + \gamma\hat{Y}_{t+1}^*] - \sigma(\hat{\imath}_t - E_t\pi_{t+1}), \tag{1.21}$$

$$(1-\gamma)\hat{Y}_t + \gamma\hat{Y}^*_t = E_t[(1-\gamma)\hat{Y}_{t+1} + \gamma\hat{Y}^*_{t+1}] - \sigma(\hat{\imath}^*_t - E_t\pi^*_{t+1}), \qquad (1.22)$$

while the log-linear approximations to the two monetary policy rules (which here replace the "LM equations" that would be appropriate if, as in many textbook expositions, we were to specify monetary policy by a fixed money supply[7]) are given by

$$\hat{\imath}_t = \bar{\imath}_t + \phi_\pi \pi_t + \phi_y \hat{Y}_t, \qquad (1.23)$$

$$\hat{\imath}^*_t = \bar{\imath}^*_t + \phi^*_\pi \pi^*_t + \phi^*_y \hat{Y}^*_t. \qquad (1.24)$$

Here I use the notation $\hat{Y}_t \equiv \log(Y_t/\bar{Y})$, $\pi_t \equiv \log(P_t/P_{t-1})$, $\hat{\imath}_t \equiv \log(1+i_t/1+\bar{\imath})$, $\bar{\imath}_t \equiv \log(\bar{I}_t/\bar{I})$, and correspondingly for the starred variables.

The system of equations (1.21)–(1.24) can be simplified by using (1.23)–(1.24) to substitute for $\hat{\imath}_t$ and $\hat{\imath}^*_t$ in the other two equations. Under the assumption that $\phi_\pi, \phi^*_\pi > 0$, the resulting system can be written in the form

$$\begin{bmatrix} \pi_t \\ \pi^*_t \end{bmatrix} = A \begin{bmatrix} E_t\pi_{t+1} \\ E_t\pi^*_{t+1} \end{bmatrix} - B_0 \begin{bmatrix} \hat{Y}_t \\ \hat{Y}^*_t \end{bmatrix} + B_1 \begin{bmatrix} E_t\hat{Y}_{t+1} \\ E_t\hat{Y}^*_{t+1} \end{bmatrix} - A \begin{bmatrix} \bar{\imath}_t \\ \bar{\imath}^*_t \end{bmatrix}. \qquad (1.25)$$

Here

$$A \equiv \begin{bmatrix} \phi_\pi^{-1} & 0 \\ 0 & \phi_\pi^{*-1} \end{bmatrix},$$

and B_0, B_1 are two matrices of coefficients, all of which are positive in the case that $\phi_y, \phi^*_y \geq 0$. In the case that $\phi_\pi, \phi^*_\pi > 1$ (as recommended by Taylor, 1999), we observe that

$$\lim_{n\to\infty} A^n = 0,$$

and the system (1.25) can be "solved forward" to yield a unique bounded solution for the two inflation rates in the case of any bounded processes $\{\hat{Y}_t, \hat{Y}^*_t, \bar{\imath}_t, \bar{\imath}^*_t\}$, given by

$$\begin{bmatrix} \pi_t \\ \pi^*_t \end{bmatrix} = -B_0 \begin{bmatrix} \hat{Y}_t \\ \hat{Y}^*_t \end{bmatrix} + \sum_{j=0}^{\infty} A^j (B_1 - AB_0) \begin{bmatrix} E_t\hat{Y}_{t+j+1} \\ E_t\hat{Y}^*_{t+j+1} \end{bmatrix} - \sum_{j=0}^{\infty} A^{j+1} \begin{bmatrix} E_t\bar{\imath}_{t+j} \\ E_t\bar{\imath}^*_{t+j} \end{bmatrix}. \qquad (1.26)$$

[7] The addition of "LM equations" of this conventional sort to the model is discussed in section 2.

This generalizes the result obtained for a closed-economy model in the case of a Taylor rule with $\phi_\pi > 1$.[8]

The solution obtained for home-country inflation can be written in the form

$$\pi_t = \sum_{j=0}^{\infty}[\psi_{1,j}E_t\hat{Y}_{t+j} + \psi_{2,j}E_t\hat{Y}^*_{t+j} + \psi_{3,j}E_t\bar{\imath}_{t+j} + \psi_{4,j}E_t\bar{\imath}^*_{t+j}]. \tag{1.27}$$

The coefficients $\{\psi_{i,j}\}$ for successive horizons j are plotted (for each of the values $i = 1, 2, 3, 4$) in the four panels of Figure 1. In these numerical illustrations, I assume coefficients $\phi_\pi = 2, \phi_y = 1$ for the Taylor rule in each country,[9] a value $\sigma = 6.37$ for the intertemporal elasticity of substitution,[10] and a period length of one quarter. The coefficients of the solution are plotted for each of three possible values of γ: $\gamma = 0$, the closed-economy limit; $\gamma = 0.5$, the case of two countries of equal size; and $\gamma = 1$, the small-open-economy limit.

The solution (1.26) can be viewed as describing a pair of dynamic "AD relations" for the two open economies, in each of which there is a downward-sloping static relation between the inflation rate and output, or aggregate real expenditure on that country's products. (The observation about the slope follows from the fact that the elements of B_0 are positive. In the numerical examples, it is illustrated by the negative values for $\psi_{1,0}$ shown in the upper left panel of Figure 1.) Here we are especially interested in the question of how changes in each country's monetary policy affect the location of the AD curve in that country, and hence the inflation rate that would result in the case of a given level of real activity.

Let us first consider the effect of the anticipated time path of the intercept $\{\bar{\imath}_t\}$ on inflation in the home country, taking as given the magnitude of the response

[8] See, *e.g.,* equation (2.7) of Woodford (2003, chap. 2). The discussion there is of inflation determination in a flexible-price model where $\{\hat{Y}_t\}$ is exogenously given, but the same calculation can be viewed as deriving a dynamic "AD relation" for a sticky-price model.

[9] In the notation of the paper, where π_t is a one-period inflation rate and $\hat{\imath}_t$ a one-period interest rate, then the values used are actually $\phi_\pi = 2, \phi_y = 0.25$. The values quoted in the text are the equivalent coefficients of a Taylor rule written in terms of an annualized interest rate and an annualized inflation rate, as in Taylor (1999), where a rule with these coefficients is argued to be relatively similar to Fed policy under Alan Greenspan.

[10] This is the value estimated for the US economy by Rotemberg and Woodford (1997). Here and elsewhere, the parameter values used in the numerical illustrations are such that in the case of a closed economy (the $\gamma = 0$ case in Figure 1), the model coincides with the baseline parameter values used in the numerical analysis of the basic new Keynesian model in Woodford (2003, chap. 4).

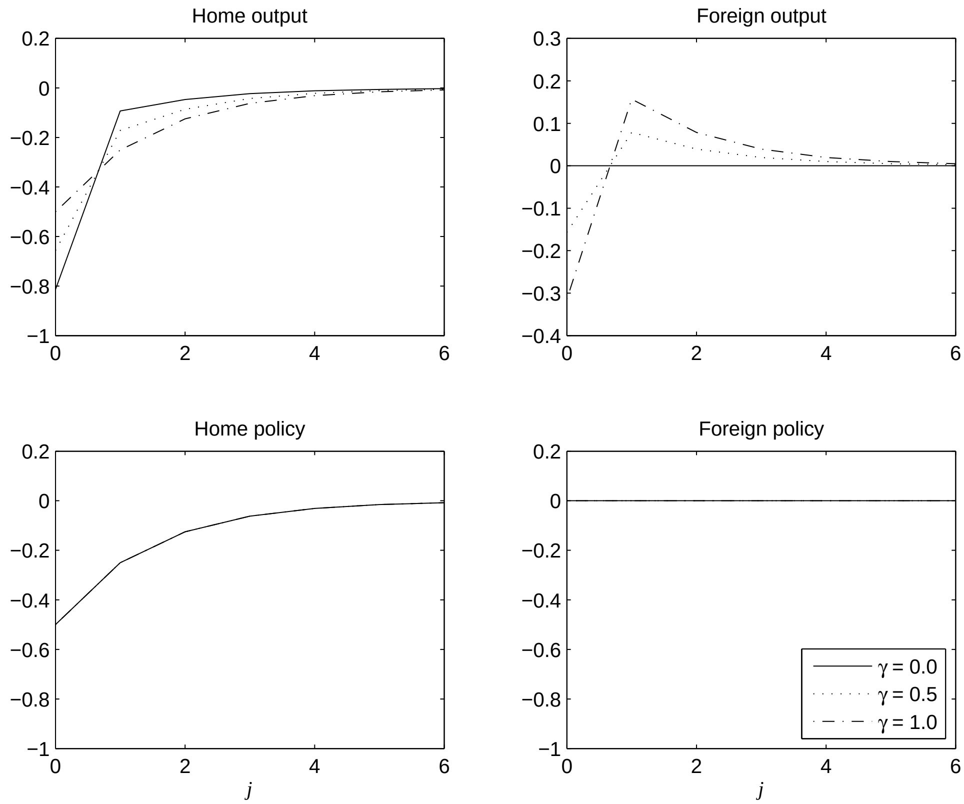

Figure 1: Coefficients of the dynamic AD relation (1.27), for alternative degrees of openness.

coefficients ϕ_π, ϕ_y, and also leaving fixed the specification of monetary policy in the other country. These effects are indicated by the coefficients $\{\psi_{3,j}\}$ plotted in the lower left panel of Figure 1. A first important observation is that it is *possible* to shift the central-bank reaction function arbitrarily in one country, without violating any requirement for the existence of equilibrium — thus no market forces prevent a central bank from having an independent monetary policy, even in the case of complete financial integration. (We see this from the fact that we have been able to solve the system (1.25) under an arbitrary perturbation of the path $\{\bar{\imath}_t\}$.)

Moreover, tightening policy in the home country (increasing $\bar{\imath}_t$, or being expected to increase it in a later period) shifts the AD relation for that country, so as to imply a lower inflation rate π_t for any expected paths of real activity in the two countries. (This is indicated by the negative coefficients in the lower left panel of the figure.) Thus it continues to be possible to use monetary policy to control nominal expenditure and inflation, even in a fully globalized economy. Indeed, the coefficients indicating the effect of current or expected future tightenings of policy on current inflation are *identical* to those that would apply in the case of a closed economy, and are independent of the size of the home economy relative to the world economy (*i.e.*, are independent of the value of γ). Thus even in the case of a very small open economy, monetary policy does not cease to be effective for domestic inflation control as a result of globalization.

The solution (1.26) can also be used to examine the degree to which there are monetary policy "spillovers" as a result of openness, at least to the extent that these are thought to operate through effects of foreign monetary policy on aggregate demand. While the system solution (1.26) might make it appear that inflation in each country depends on the monetary policies of both, this is not true (for given paths of output in the two countries). Because the matrix A is diagonal, the solution for π_t is independent of the expected path of $\{\bar{\imath}^*_{t+j}\}$, and π^*_t is similarly independent of the expected path of $\{\bar{\imath}_{t+j}\}$. (This is shown by the zero coefficients at all horizons in the lower right panel of Figure 1.) One can similarly show that the values of the coefficients ϕ^*_π, ϕ^*_y affect only the solution for π^*_t, and not the solution for π_t.

The implication is that foreign monetary policy cannot affect inflation determination in the home country, except to the extent that this occurs through effects of foreign monetary policy on foreign output. (In the case of completely flexible wages and prices, so that monetary policy would have little effect on real activity, there would be no possibility of "spillovers" from expansionary foreign monetary policy to domestic inflation, assuming the home central bank follows a Taylor rule of the form (1.19).) And even the cross-border effects that are possible when monetary policy affects real activity are not necessarily of the kind often assumed in popular discussions of the implications of "excess global liquidity". To the extent that expansionary monetary policy in the rest of the world makes foreign output temporarily high, the equilibrium real rate of return consistent with a given path of output in the home country is *lowered* (as indicated by (1.21)). This makes a given Taylor rule for the home central bank *more contractionary*, as shown by the negative coefficient $\psi_{2,0}$ in the upper right panel of Figure 2: if one is to avoid disinflation and/or reduced aggregate demand, it is necessary to lower $\bar{\imath}_t$ in accordance with the reduction in the equilibrium real rate of return associated with trend output.[11]

It might seem surprising that an independent domestic monetary policy can exert the same effect on domestic inflation as in a closed economy, despite the fact that (at least in the case of a sufficiently small open economy) there is no possibility of a non-negligible affect of domestic monetary policy on the common world real interest rate. But this should not really be a surprise. It is commonly understood in the case of closed-economy monetary models that even in the case of fully flexible wages and prices — so that neither output nor equilibrium real interest rates can be affected by monetary policy — it remains possible for monetary policy to determine the general level of prices. This means that monetary policy can shift the AD relation even when it cannot change the equilibrium real rate of interest.[12] And the classic Mundell-Fleming analysis concludes that monetary policy should be *more* effective, rather than less, in the case of international capital mobility, even though this is assumed to imply the existence of a common world interest rate; the fact that a monetary expansion cannot lower interest rates simply ensures that all of the adjustment that results in a larger quantity of money being voluntarily held must involve increases in output or prices rather than lower interest rates. A similar conclusion obtains if the change in monetary policy is modeled as a shift in an interest-rate reaction function rather than a change in the money supply: both are simply reasons for the LM curve to shift.

1.2 Exchange-Rate Determination

One way to understand how monetary policy continues to be effective even in the globalized economy is by considering the consequences of domestic monetary policy for the exchange rate, and the implications of exchange rate changes for inflation. A log-linear approximation to (1.11) implies that any equilibrium (in which departures from the steady state are sufficiently small) must satisfy the uncovered interest-rate

[11] These remarks apply to the case in which expansionary foreign monetary policy makes foreign output *currently* high relative to its expected future level. The anticipation of a foreign monetary expansion in the *future* would instead be currently *inflationary* in the home country; for this would imply that foreign output should be higher in the future than it is now, making the equilibrium real rate of return higher rather than lower.

[12] For an analysis of inflation determination in such a model when monetary policy is specified by a Taylor rule, see Woodford (2003, chap. 2).

parity condition,

$$\hat{\imath}_t - \hat{\imath}_t^* = E_t[e_{t+1} - e_t], \tag{1.28}$$

where $e_t \equiv \log \mathcal{E}_t$. The implications of this relation for the equilibrium exchange rate are most easily derived in the case that we assume common reaction-function coefficients for the two central banks ($\phi_\pi^* = \phi_\pi, \phi_y^* = \phi_y$), while allowing the intercepts $\bar{\imath}_t, \bar{\imath}_t^*$ to follow different paths. In this case the monetary policy specifications (1.19)–(1.20) imply that

$$\hat{\imath}_t - \hat{\imath}_t^* = (\bar{\imath}_t - \bar{\imath}_t^*) + \phi_\pi(z_t - z_{t-1}) + \phi_y(\hat{Y}_t - \hat{Y}_t^*), \tag{1.29}$$

introducing the notation $z_t \equiv \log(P_t/P_t^*)$ for the differential in the absolute level of prices between the two countries. Then using the fact that (1.10) implies that $z_t = e_t$ to substitute for z_t in (1.29), and using this relation to substitute for the interest-rate differential in (1.28), we obtain a difference equation of the form

$$E_t \Delta e_{t+1} = (\bar{\imath}_t - \bar{\imath}_t^*) + \phi_\pi \Delta e_t + \phi_y(\hat{Y}_t - \hat{Y}_t^*) \tag{1.30}$$

for the rate of exchange-rate depreciation.

Under the assumption that $\phi_\pi > 1$, this has a unique bounded solution for the depreciation rate,

$$\Delta e_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} [E_t(\bar{\imath}_{t+j}^* - \bar{\imath}_{t+j}) + \phi_y E_t(\hat{Y}_{t+j}^* - \hat{Y}_{t+j})]. \tag{1.31}$$

This shows how the exchange rate must depreciate as a result either of an increase in the relative tightness of foreign monetary policy or of an increase in relative foreign output. The law of one price implies that changes in the exchange rate must correspond directly to differences in the inflation rates of the two countries, so that[13]

$$\pi_t - \pi_t^* = \Delta z_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} [E_t(\bar{\imath}_{t+j}^* - \bar{\imath}_{t+j}) + \phi_y E_t(\hat{Y}_{t+j}^* - \hat{Y}_{t+j})]. \tag{1.32}$$

Equation (1.32) shows how a change in the monetary policy of one central bank, not perfectly matched by a corresponding change in the policy of the other central

[13]This solution is consistent, of course, with (1.26), derived earlier under more general assumptions; in fact, it is simply the difference between the first and second lines of (1.26). The alternative derivation is intended simply to provide additional insight into the economic mechanisms reflected by this solution.

bank, must create a difference in the inflation rates of the two countries. The result here only identifies the equilibrium inflation differential for a *given* output differential, but in the case that $\phi_y = 0$, the output differential is irrelevant, and the equation directly tells us what the inflation differential must be. Moreover, the coefficients in this relation do not involve γ. It follows that even the central bank of a very small country must be able to substantially affect domestic inflation by changing its policy; for it can change the inflation differential, and (at least in the case of a very small country) this must not be because it changes the inflation rate in the rest of world but not at home.

The argument just given implies not only that the central bank must be able to shift the aggregate demand curve, but more specifically that it must be able to *control the inflation rate*, regardless of the nature of aggregate supply (for example, no matter how sticky prices or wages may be). It is the flexibility of the prices of imports in terms of the domestic currency in this model (implied by the assumption of producer-currency pricing) that allows for such a strong conclusion. Indeed, Svensson (2000) argues that achievement of a central bank's CPI inflation target is possible over a shorter horizon in the case that the economy is substantially open, under the assumption (as in the CGG model) that there is relatively immediate pass-through of exchange-rate changes to the prices of imported goods.[14]

1.3 Determination of the Domestic Price Index

In the above discussion, I have assumed that the central bank is interested in controlling the evolution of a broad consumer price index, including the prices of imported consumer goods, and so have derived an "aggregate demand" relation that relates this price index to the volume of real activity in an open economy. This assumption is consistent with the kind of official inflation target that inflation-targeting central banks in small open economies typically aim at. However, one might also be interested in the ability of monetary policy to control the rate of growth of a *domestic price index*, in which one considers only the prices of goods produced in that country. This is certainly of analytical interest, in isolating the various channels through which monetary policy can affect inflation, even if one's stabilization objective is assumed

[14]Svensson calls this "the direct exchange-rate channel" for the transmission of monetary policy.

to involve only CPI inflation.[15]

But it is also arguable that a central bank should concern itself with stabilization of domestic prices rather than a consumer price index. Suppose, for example, that one takes the goal of monetary policy to be to eliminate the distortions resulting from nominal rigidities, by bringing about the allocation of resources that would occur in the case of fully-flexible wages and prices. In a model of the kind considered by CGG (with flexible wages and producer-currency pricing), this will be achieved if the monetary policies of the two central banks bring about an equilibrium in which the domestic price index is completely stabilized in each country. Import prices will instead vary in response to (asymmetric) shocks to real "fundamentals", in such an equilibrium, since the relative prices of the goods produced in the two countries would vary in the case of flexible wages and prices. Hence it might be deemed reasonable to hold each central bank responsible for stabilizing the domestic price index in its country, while allowing import prices to vary.

Here I consider the effects of monetary policy on domestic inflation in a globalized economy, in order to clarify that the effects on inflation discussed in the previous section do not result purely from what Svensson calls the "direct exchange-rate channel." I show that one can also derive an aggregate-demand equation that relates the *domestic* price index to domestic output, and indeed it might seem more reasonable to call this "the aggregate demand curve", since it is the product of these two quantities that represents aggregate expenditure on domestic products.

Under the preferences assumed above, consumer optimization implies a simple connection between the equilibrium terms of trade and the composition of world output. The law of one price implies that the relative price of home and foreign goods is the same in both countries, and consequently (1.4)–(1.5) imply that households choose the same ratio of foreign goods to home goods in both countries. Market-clearing requires that this common ratio equal the relative supplies of the two types of goods; hence the equilibrium terms of trade must satisfy[16]

$$S_t \equiv \frac{P_{Ft}}{P_{Ht}} = \frac{Y_t}{Y_t^*}. \tag{1.33}$$

[15]See, for example, the discussion in Svensson (2000).

[16]Note that Y_t is output *per capita* in the home country, and similarly with Y_t^*; hence the relative supply of the two composite goods is equal to $(1-\gamma)Y_t/\gamma Y_t^*$.

The definition of the consumption price index P_t then implies that

$$\frac{P_{Ht}}{P_t} = kS_t^{-\gamma} = kY_t^{-\gamma}Y_t^{*\gamma}, \tag{1.34}$$

$$\frac{P_{Ft}}{P_t} = kS_t^{1-\gamma} = kY_t^{1-\gamma}Y_t^{*\gamma-1}. \tag{1.35}$$

We now have a solution for equilibrium relative prices, given output in the two countries. Combining this with our previous solution for consumer price inflation given output, we can obtain a solution for domestic price inflation in each country, given the two countries' levels of output. If we define the domestic inflation rates in each country as $\pi_{Ht} \equiv \Delta \log P_{Ht}$, $\pi^*_{Ft} \equiv \Delta \log P^*_{Ft}$,[17] then relations (1.34)–(1.35) imply that

$$\pi_{Ht} = \pi_t + \gamma(\Delta\hat{Y}_t^* - \Delta\hat{Y}_t), \tag{1.36}$$

$$\pi^*_{Ft} = \pi^*_t + (1-\gamma)(\Delta\hat{Y}_t - \Delta\hat{Y}_t^*). \tag{1.37}$$

If we then substitute the above solution (1.26) for the consumer price inflation rates in these expressions, we obtain solutions for π_{Ht} and π^*_{Ft} as functions of the paths of output in the two countries, and the two monetary policies, under the assumption that monetary policy is described by two rules of the form (1.19)–(1.20). Our conclusions about the magnitude of the effect on home country inflation of a change in home country monetary policy remain exactly the same as before, since (as long as we are controlling for the paths of output in the two countries) there is no additional effect on the terms of trade.

If, however, the central bank is concerned with stabilization of domestic inflation rather than consumer price inflation, it may be of more interest to consider the consequences of monetary policy rules that respond to domestic inflation rather than to CPI inflation as assumed in (1.19)–(1.20). Suppose, then, that we replace (1.19) by a policy of the form

$$1 + i_t = \bar{I}_t \left(\frac{P_{Ht}}{P_{Ht-1}}\right)^{\phi_\pi} Y_t^{\phi_y}, \tag{1.38}$$

and similarly for the foreign central bank. In this case, we can no longer simply use the solution (1.26) for the CPI inflation rates, but must instead repeat the derivation using the alternative monetary policy rules.

[17] CGG simply call the domestic inflation rates π_t and π^*_t respectively; thus their notation encourages an emphasis on domestic inflation stabilization.

Rewriting (1.21)–(1.22) in terms of domestic inflation rates, by using (1.36)–(1.37) to substitute for the CPI inflation rates, we obtain

$$(1+\theta)\hat{Y}_t - \theta\hat{Y}_t^* = E_t[(1+\theta)\hat{Y}_{t+1} - \theta\hat{Y}_{t+1}^*] - \sigma(\hat{\imath}_t - E_t\pi_{Ht+1}), \tag{1.39}$$

$$(1+\theta^*)\hat{Y}_t^* - \theta^*\hat{Y}_t = E_t[(1+\theta^*)\hat{Y}_{t+1}^* - \theta^*\hat{Y}_{t+1}] - \sigma(\hat{\imath}_t^* - E_t\pi_{Ft+1}^*), \tag{1.40}$$

where

$$\theta \equiv \gamma(\sigma - 1), \qquad \theta^* \equiv (1-\gamma)(\sigma - 1).$$

Combining these with the log-linearized central-bank reaction functions,

$$\hat{\imath}_t = \bar{\imath}_t + \phi_\pi \pi_{Ht} + \phi_y \hat{Y}_t, \tag{1.41}$$

$$\hat{\imath}_t^* = \bar{\imath}_t^* + \phi_\pi^* \pi_{Ft}^* + \phi_y^* \hat{Y}_t^*, \tag{1.42}$$

we then have a system of four equations per period to solve for the paths of $\{\pi_{Ht}, \pi_{Ft}^*, \hat{\imath}_t, \hat{\imath}_t^*\}$, given the paths of $\{\hat{Y}_t, \hat{Y}_t^*, \bar{\imath}_t, \bar{\imath}_t^*\}$. Once one has a solution to these equations, the evolution of the CPI inflation rates in the two countries is then given by equations (1.36)–(1.37).

The system of equations (1.39)–(1.42) can again be reduced to a pair of equations for the two domestic inflation rates, and this system can again be written in the form

$$\begin{bmatrix} \pi_{Ht} \\ \pi_{Ft}^* \end{bmatrix} = A \begin{bmatrix} E_t\pi_{Ht+1} \\ E_t\pi_{Ft+1}^* \end{bmatrix} - \tilde{B}_0 \begin{bmatrix} \hat{Y}_t \\ \hat{Y}_t^* \end{bmatrix} + \tilde{B}_1 \begin{bmatrix} E_t\hat{Y}_{t+1} \\ E_t\hat{Y}_{t+1}^* \end{bmatrix} - A \begin{bmatrix} \bar{\imath}_t \\ \bar{\imath}_t^* \end{bmatrix}, \tag{1.43}$$

where the matrix A is the same as in (1.25), but the matrices $\tilde{B}_0, \tilde{B}_1$ are different. Again the system has a unique bounded solution in the case that $\phi_\pi, \phi_\pi^* > 1$, and again it is of the form (1.26), making the appropriate substitutions. Since the diagonal elements of $\tilde{B}_0$ are again necessarily positive, this solution again defines a downward-sloping AD curve for each country; but now each AD curve relates the price index for that country's products to a corresponding index of the quantity sold of those products. The AD relation for the home country can again be written in the form (1.27), except that this is now an equation for domestic inflation rather than CPI inflation; the numerical values of the coefficients (under the same parameter values as before) are now shown in Figure 2.[18]

[18] Note that while I again assume that $\phi_\pi = 2$, the coefficient has a different meaning, as it now indicates the response to variations in *domestic* inflation only.

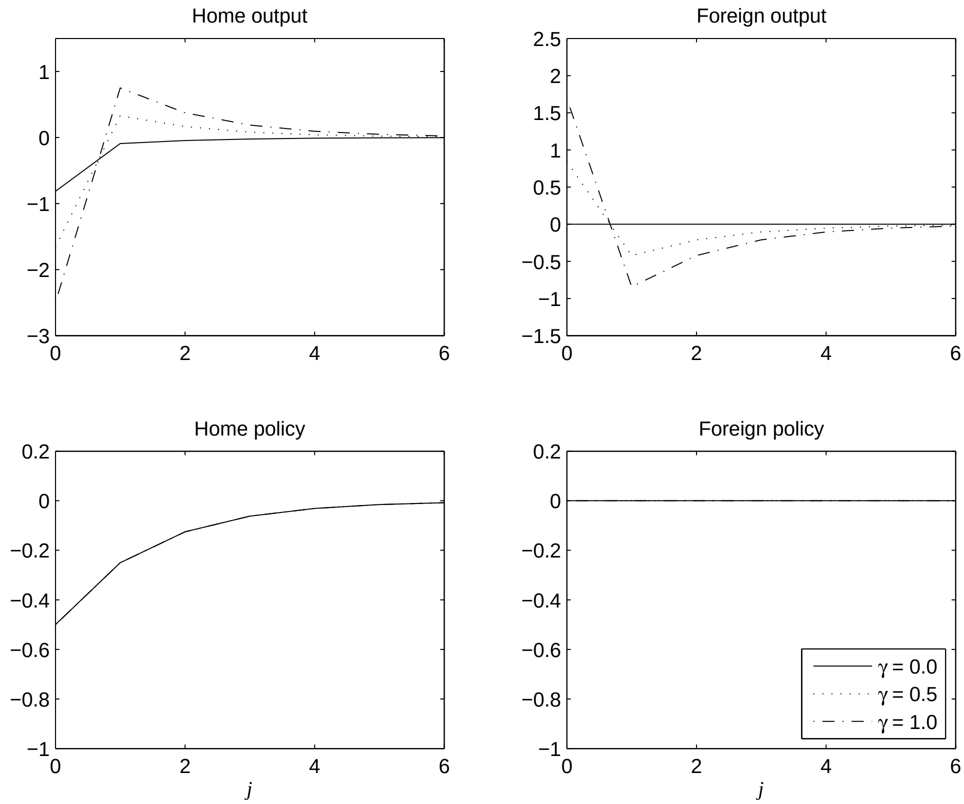

Figure 2: Coefficients of the dynamic AD relation in terms of domestic inflation, for alternative degrees of openness.

We again find that there is scope for independent variation in the monetary policies of the two central banks, and that either central bank can shift the AD curve for its country (and hence the domestic inflation rate associated with given paths of real activity in the two countries) by varying its policy. In fact, because the matrix A is the same as in the previous section, we find exactly the same coefficients as before for the quantitative effects of current or expected future changes in $\bar{\imath}_{t+j}$ on the domestic rate of inflation. And once again, we find that any spillovers from foreign monetary policy on aggregate demand in the home country must be due to the effects of foreign monetary policy on foreign output. However, the sign and likely magnitude of any spillovers are now more ambiguous, as negative terms have been added to the off-diagonal elements of $\tilde{B}_0$ and $\tilde{B}_1$ that tend to reduce the size of these elements, and can even reverse their sign.[19]

When we expressed the AD curve as a relation between P_t and Y_t, the effect of higher foreign output was clearly contractionary, because higher equilibrium consumption of foreign output by domestic households implies a lower marginal utility of income for any given level of domestic output (and hence domestic consumption of domestic output), just as if there had been a reduction in domestic households' impatience to consume. But now we must also take into account the fact that higher foreign output implies an improvement of the home country's terms of trade (for any given level of home output), and hence a higher value of P_{Ht} relative to P_t; this additional effect tends to shift the AD curve in terms of P_{Ht} and Y_t outward, offsetting the other effect. In fact, if $\sigma = 1$ (the case of log utility of consumption), the two effects exactly cancel, and both $\tilde{B}_0$ and $\tilde{B}_1$ are diagonal matrices. In this case, the solution (1.26) implies that the location of the home-country AD curve depends only on home monetary policy and the expected future path of home output (and likewise for the foreign-country AD curve); thus there are *no* international monetary policy spillovers in the AD block of the model.[20]

This last result is a fairly special one. In fact, it is not obvious that $\sigma = 1$ should be regarded as a realistic calibration of the model. While the assumption of log utility of consumption is fairly common in real business-cycle models, it is important to note that this is a specification of the intertemporal elasticity of substitution of *nondurable consumer expenditure* only, in a model in which investment spending is separately modelled (and specified to be much more substitutable over time). In a model in which all private expenditure is modelled as if it were consumer expenditure (*i.e.,* we abstract from any effects of private spending on the evolution of productive capacity), more realistic conclusions are obtained if we specify preferences over the time path of such "consumption" with an intertemporal elasticity of substitution well above 1.[21] In this case, the terms-of-trade effect of higher foreign output is quantitatively more important than the implied reduction of the marginal utility of income (which

[19]For the parameter values used in the numerical example shown in Figure 2, the sign of the effect of foreign monetary stimulus on home inflation is reversed, as shown in the upper right panel.

[20]This result is obtained by CGG, who express the model structural relations entirely in terms of domestic inflation. They find a similar decoupling of the structural equations for the two countries in the aggregate-supply block of the model in the case that $\sigma = 1$, as discussed in section 3.

[21]See Woodford (2003, pp. 242-243, 362-363) for further discussion of the proper interpretation of this parameter in a basic new-Keynesian model of the monetary transmission mechanism.

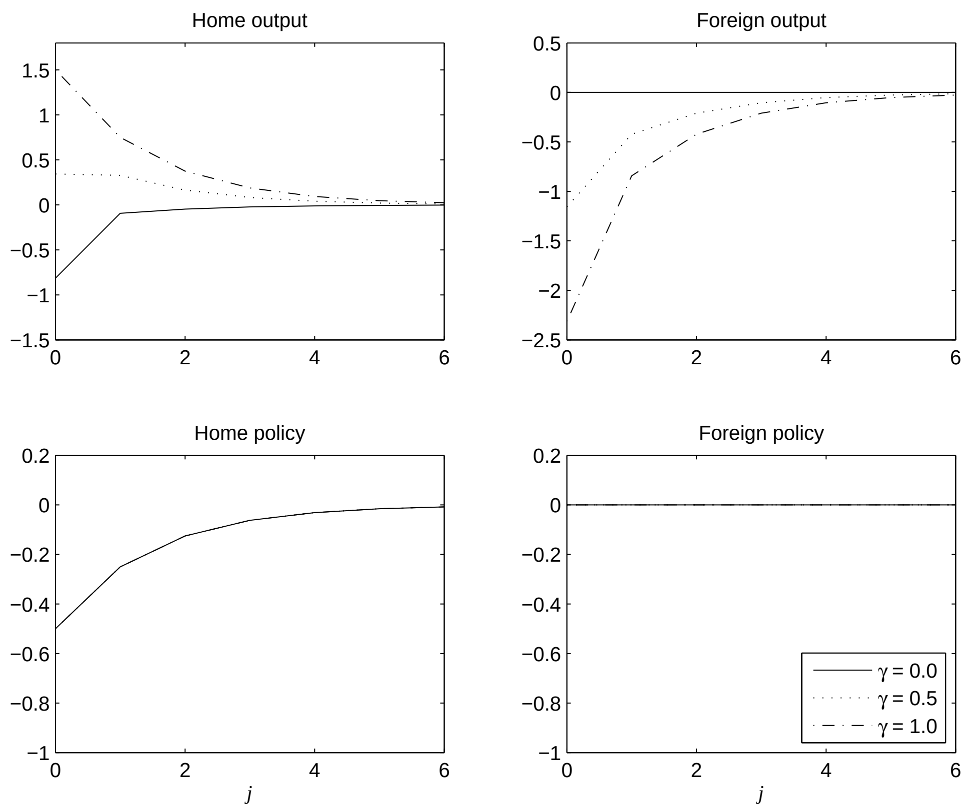

Figure 3: Coefficients of the dynamic AD relation in terms of CPI inflation, when the policy rule is (1.38).

is proportional to σ^{-1}), so there will be a non-zero net effect on home aggregate demand that is *expansionary*. (This is illustrated in the upper right panel of Figure 2.) Nonetheless, the fact that the two effects have opposite signs mean that we may have less reason to expect such spillovers to be quantitatively significant if we are concerned with an AD relation specified in terms of the domestic price index.

It should also be recalled that even if $\sigma = 1$, while it is then possible to choose a Taylor rule that should completely stabilize domestic inflation without requiring any response to foreign variables, this does not mean that one can stabilize *CPI inflation* without responding to foreign variables. Thus the "decoupling" of the aggregate demand curves that occurs in this case would not really imply that a central bank has no need to monitor foreign developments, except under a particular view of its stabilization objectives.

We can also derive an AD relation between the consumer price index and domestic output, as in section 1.1, even if we assume that monetary policy responds to domestic inflation only. Equation (1.36) together with our solution of the form (1.27) for π_{Ht} allow us to derive a relation of the form

$$\pi_t = \sum_{j=0}^{\infty}[\psi_{1,j}E_t\hat{Y}_{t+j} + \psi_{2,j}E_t\hat{Y}^*_{t+j} + \psi_{3,j}E_t\bar{\imath}_{t+j} + \psi_{4,j}E_t\bar{\imath}^*_{t+j}] - \gamma \log S_{t-1}$$

for CPI inflation. (Here the lagged terms of trade matter for CPI inflation determination, contrary to what we found in equation (1.27) previously, because we now assume that the domestic policy rule involves the lagged *domestic* price index, whereas the CPI inflation rate is defined relative to the lagged *consumer* price index.) The coefficient $\psi_{2,0}$ is *more negative* than in the case of the solution for domestic inflation, by an amount that is greater the more open is the economy, owing to the effect of higher foreign output on the terms of trade. Figure 3 plots the coefficients for the same numerical examples as in Figure 2; one observes that the sign of the coefficient $\psi_{2,0}$ is reversed. Thus one finds, once again, that (for these parameter values) stimulative foreign monetary policy will have a contractionary effect on aggregate demand in the home country; indeed, the effect is even stronger than in the model of section 1.1.

1.4 Consequences of Local-Currency Pricing

The argument given above for the ability of domestic monetary policy to control the domestic inflation rate depends, as explained at the end of section 1.1, on a supposition that exchange rate changes automatically imply changes in the prices charged for the same goods in the two different countries. But it is often observed that exchange rate changes are not immediately "passed through" to import prices in this way. If imported goods instead have sticky prices in terms of the currency of the country where they are sold — so that the law of one price need not hold, in the short run — does the argument given for the effectiveness of monetary policy in controlling domestic inflation still hold?

To examine this question, I present a variant of the model of "local-currency pricing" proposed by Betts and Devereux (2000), in which, however, price changes are staggered after the fashion proposed by Calvo (just as in CGG).[22] I shall assume the

[22] The model is essentially a simplified version of the one presented in Benigno (2004).

same preferences as in CGG (and the previous section), so that once again households in the two countries consume the same goods and have identical preferences.

Certain equilibrium conditions of the CGG model, that did not depend on the law of one price, continue to hold in the model with local-currency pricing. Intertemporal optimization by households continues to imply that (1.8) must hold, and likewise the corresponding equation for the starred variables. Log-linearizing these equilibrium relations, we obtain

$$\hat{C}_t = E_t \hat{C}_{t+1} - \sigma(\hat{\imath}_t - E_t \pi_{t+1}),$$

and a corresponding equation for the starred variables. Taking a weighted average of this equation (multiplied by $1-\gamma$) and the corresponding equation for the starred variables (multiplied by γ), we obtain the additional implication that

$$\hat{C}^w_t = E_t \hat{C}^w_{t+1} - \sigma(\hat{\imath}^w_t - E_t \pi^w_{t+1}), \tag{1.44}$$

using the notation $\hat{C}^w_t \equiv \log(C^w_t / k\bar{Y}) = (1-\gamma)\hat{C}_t + \gamma \hat{C}^*_t$, $\hat{\imath}^w_t \equiv (1-\gamma)\hat{\imath}_t + \gamma \hat{\imath}^*_t$, and $\pi^w_t \equiv (1-\gamma)\pi_t + \gamma \pi^*_t$. Moreover, clearing of the goods markets requires (to a first-order approximation[23]) that

$$\hat{C}^w_t = \hat{Y}^w_t,$$

where $\hat{Y}^w_t \equiv (1-\gamma)\hat{Y}_t + \gamma \hat{Y}^*_t$. Using this to substitute for $\hat{C}^w_t$ in (1.44), we obtain

$$\hat{Y}^w_t = E_t \hat{Y}^w_{t+1} - \sigma(\hat{\imath}^w_t - E_t \pi^w_{t+1}). \tag{1.45}$$

Note that (1.45) is just a weighted average of the two conditions (1.21)–(1.22) derived for the model with producer-currency pricing (PCP). In fact, all of the implications of the system (1.21)–(1.22) are contained in the pair of conditions consisting of (1.45) and the condition

$$\hat{\imath}_t - \hat{\imath}^*_t = E_t \pi_{t+1} - E_t \pi^*_{t+1} \tag{1.46}$$

obtained by subtracting (1.22) from (1.21). In order to complete our analysis of the aggregate demand block of the model, we must find the relation corresponding to (1.46) for the model with local-currency pricing (LCP).

[23] Aggregate supply of the composite world good need not equal aggregate demand for it, if the composition of the consumption bundles of households in the two countries are not identical. But even in that case, the discrepancy is of second order in the amplitude of departures from the steady-state allocation.

Another condition derived earlier that continues to hold in the LCP model is (1.11), and again this implies the uncovered interest-parity relation (1.28) when log-linearized. In the model with producer-currency pricing, the result that $z_t = e_t$ together with (1.28) implies the condition (1.46). With local-currency pricing, instead, (1.28) still holds, but z_t need not equal e_t, so that this derivation is no longer possible.

The relation between the relative absolute price levels in the two countries and the exchange rate will instead depend on what we assume about price adjustment. With local-currency pricing, there are four different price-setting problems to consider: for each of the two types of goods (goods produced in the home country and goods produced in the foreign country), prices are set in terms of both the home currency and the foreign currency. Each supplier chooses two prices, and the decisions are independent, in the sense that the price charged in one currency does not constrain the price that can be charged in the other.[24] The two prices for any given good are the prices charged to buyers in the two different countries; there is assumed to be no opportunity for cross-border arbitrage by households. Producers can instead sell the same goods in either country, so that a common marginal cost of supplying additional goods is relevant to their pricing decision in each country. Here I furthermore assume Calvo-style staggered price-setting (as in the model of CGG), and more specifically that there is a common fraction $0 < \alpha < 1$ of prices of each of the four types that remain fixed from one period to the next.[25]

Under this form of price-setting (discussed further in section 3), the index of home goods prices in units of the home currency (which are the prices charged for these goods in the home country) evolves in accordance with a relation of the form

$$\pi_{Ht} = \xi(\mu + \log MC_t - \log P_{Ht}) + \beta E_t \pi_{Ht+1}, \tag{1.47}$$

where MC_t is the nominal marginal cost (in units of the home currency) of supplying additional home goods (a geometric average across the different producers of home goods), $\mu > 0$ is the log of the desired markup of price over marginal cost (reflecting

[24] Similar conclusions would obtain if we were to assume that the producers sell to separate retailers in the two countries, each of which sets the retail price in its market. What is crucial is the assumption that each retailer has a monopoly over sales of the good in a particular country.

[25] It does not matter whether we assume that a given firm reconsiders its prices in both countries at the same time, or at random dates that arrive independently in the two cases.

the market power of the monopolistically competitive suppliers) and $\xi > 0$ is a coefficient (defined in section 3) that is smaller the less frequently prices are reconsidered. The producers of home goods face a similar problem in choosing the prices that they charge for their goods in the foreign country, and in this case the marginal cost of supplying additional home goods in units of the foreign currency is $MC_t/\mathcal{E}_t$. As a result, the evolution of π^*_{Ht} satisfies a corresponding equilibrium relation

$$\pi^*_{Ht} = \xi(\mu + \log MC_t - e_t - \log P^*_{Ht}) + \beta E_t \pi^*_{Ht+1}. \tag{1.48}$$

One then observes that subtraction of (1.48) from (1.47) implies that

$$\Delta z_{Ht} = \xi(e_t - z_{Ht}) + \beta E_t \Delta z_{Ht+1}, \tag{1.49}$$

where $z_{Ht} \equiv \log(P_{Ht}/P^*_{Ht})$ is the differential price of home goods in the two countries. This can alternatively be written as

$$E_t[A(L) z_{Ht+1}] + \xi e_t = 0,$$

where

$$A(L) \equiv \beta - (1 + \beta + \xi)L + L^2. \tag{1.50}$$

We can alternatively write

$$A(L) = \beta(1 - \mu_1 L)(1 - \mu_2 L) = -\mu_1^{-1}(1 - \mu_1 L)(1 - \beta\mu_1 L^{-1})L,$$

where $0 < \mu_1 < 1 < \mu_2$ are the two roots of the characteristic equation

$$\mu^2 A(\mu^{-1}) = 0.$$

It follows that given a difference-stationary process for $\{e_t\}$, there is a unique difference-stationary process for $\{z_{Ht}\}$ consistent with (1.49), given by

$$z_{Ht} = \mu_1 z_{Ht-1} + (1 - \mu_1)(1 - \beta\mu_1) \sum_{j=0}^{\infty} (\beta\mu_1)^j E_t e_{t+j}. \tag{1.51}$$

Similar calculations are possible in the case of the prices set by the producers of foreign goods in the two countries, as a result of which one concludes that the differential price of foreign goods in the two countries, $z_{Ft} \equiv \log(P_{Ft}/P^*_{Ft})$, satisfies *exactly the same* difference equation (1.49). (While the marginal cost of producing foreign goods need not be the same as that of producing home goods, what matters for this calculation is that the *ratio* of the marginal costs of supplying goods in the two countries is in each case given by the exchange rate.) Hence z_{Ft} must also be given by (1.51). It follows that $z_{Ft} = z_{Ht} = z_t$ at all times. The overall price differential between the two countries, z_t, therefore satisfies a difference equation of the form

$$\Delta z_t = \xi(e_t - z_t) + \beta E_t \Delta z_{t+1}, \tag{1.52}$$

the solution to which is given by

$$z_t = \mu_1 z_{t-1} + (1-\mu_1)(1-\beta\mu_1)\sum_{j=0}^{\infty}(\beta\mu_1)^j E_t e_{t+j}. \tag{1.53}$$

Equation (1.53) indicates that the path of z_t (and hence of the inflation differential between the two countries) is completely determined by the path of the exchange rate, just as in the PCP model; this solution replaces the simpler relation $z_t = e_t$ that held under the earlier assumption. Note that (1.53) implies that z_t is a two-sided moving average of past and expected future values of the log exchange rate. The moving average smooths the exchange rate over a longer time window the closer is μ_1 to 1, or alternatively, the smaller is ξ (which is to say, the larger is α). In the limit as $\alpha \to 0$, so that prices are completely flexible, the solution (1.53) reduces simply to $z_t = e_t$.

The complete aggregate-demand block[26] of the model with local-currency pricing then consists of equations (1.19)–(1.20) specifying the monetary policies of the two central banks, and equations (1.28), (1.45), and (1.52) that result from private optimization. Among these equilibrium conditions, all except the last also apply to the model with producer-currency pricing. The PCP model replaces (1.52) with the relation $z_t = e_t$, which is just the limiting case of (1.52) when $\alpha \to 0$. Hence the aggregate-demand relations of the PCP model correspond to the case $\alpha = 0$ of the

[26] It might not seem right to call equation (1.52) part of the "aggregate-demand block" of the model, as it depends on one's model of price-setting behavior, and on the value of the parameter α. However, it is independent of the evolution of marginal cost, and so can be derived without discussing the specification of the production technology, preferences regarding labor supply, or the degree of integration of factor markets. It is also clear that (1.52) plays the same role in the LCP model as the requirement that $z_t = e_t$ in the PCP model, and we did use that relation in deriving the AD equations for the earlier model, despite the fact that it follows from an assumption about the pricing of goods. Finally, we do clearly require (1.52) in order to be able to derive the AD relations for the LCP model.

aggregate-demand relations of the LCP model; under the PCP assumption, however, unlike the LCP model, the aggregate-demand relations are the same regardless of the degree of stickiness of prices.

A pair of aggregate-demand relations parallel to (1.26) in the case of the PCP can also be derived here. As long as the response coefficients of the policy rules satisfy certain inequalities,[27] it is possible to uniquely solve the system of equations consisting of (1.19)–(1.20), (1.28), (1.45), and (1.52) for bounded processes $\{\pi_t, \pi_t^*, \hat{\imath}_t, \hat{\imath}_t^*, e_t - z_t\}$, given any bounded processes $\{\hat{Y}_t, \hat{Y}_t^*, \bar{\imath}_t, \bar{\imath}_t^*\}$. (And once again the solution is purely forward-looking, in the sense that each of the 5 endogenous variables depends only on current and expected future values of the 4 forcing variables.) Again we find that existence of equilibrium places no (local) restrictions on the way in which monetary policy may be independently varied in the two countries, and again we find that adjustment of monetary policy in one country alone can alter the path of inflation in that country (for any given paths of real activity in the two countries).

The effects of monetary policy on inflation (or on the location of the AD curve) can be stated more explicitly in the special case in which $\phi_\pi = \phi_\pi^*$ and $\phi_y = \phi_y^*$. In this case, (1.19)–(1.20) again imply (1.29), and this can again be used to substitute for the interest-rate differential in (1.28), yielding

$$E_t \Delta e_{t+1} = (\bar{\imath}_t - \bar{\imath}_t^*) + \phi_\pi \Delta z_t + \phi_y (\hat{Y}_t - \hat{Y}_t^*). \tag{1.54}$$

However, we can no longer use the requirement that $z_t = e_t$ to transform (1.54) into (1.30). Instead we must solve the system consisting of (1.52) and (1.54) for the paths of e_t and z_t.

This pair of equations can be written in the form

$$\begin{bmatrix} \Delta z_t \\ e_t - z_t \end{bmatrix} = A \begin{bmatrix} E_t \Delta z_{t+1} \\ E_t(e_{t+1} - z_{t+1}) \end{bmatrix} + a\, [\bar{\imath}_t^* - \bar{\imath}_t + \phi_y(\hat{Y}_t^* - \hat{Y}_t)],$$

where

$$A \equiv (1 + \phi_\pi \xi)^{-1} \begin{bmatrix} \xi & 1 \\ 1 & -\phi_\pi \end{bmatrix}$$

and a is the second column of A. One can show that A has both eigenvalues inside the unit circle if and only if $\phi_\pi > 1$; under this assumption, there is a unique bounded

[27] As in section 1.1, these involve only the inflation-response coefficient ϕ_π, ϕ_π^*, and once again it is necessary for a unique solution that $\phi_\pi, \phi_\pi^* > 1$.

solution given by

$$\begin{bmatrix} \Delta z_t \\ e_t - z_t \end{bmatrix} = \sum_{j=0}^{\infty} A^j a \; E_t[\bar{\imath}^*_{t+j} - \bar{\imath}_{t+j} + \phi_y(\hat{Y}^*_{t+j} - \hat{Y}_{t+j})]. \tag{1.55}$$

The first line of (1.55) generalizes our previous solution (1.32) for the inflation differential;[28] while it is algebraically more complex, we again obtain a solution for the inflation differential as a function of the expected future paths of exactly the same variables as before. Once again, we find that a change in monetary policy in one country that is not matched by an equivalent change in the other country's policy necessarily changes the inflation differential between the two countries, for any given paths of output in the two countries. Moreover, in the case that $\phi_y = 0$, one can determine the effect on the inflation differential *independently* of what one may assume about aggregate supply. It is also noteworthy that while the size of the effect of a change in monetary policy on the inflation differential depends on the degree of inflation sensitivity (ϕ_π) of the central banks' reaction functions and the degree of price flexibility (ξ), it does *not* depend on the relative size of the countries (*i.e.*, on γ).

We can complete the derivation of the AD relations for the two countries in this symmetric case, by using (1.19)–(1.20) to substitute for the interest rates in (1.45), yielding a difference equation for the world average inflation rate,

$$\pi^w_t = \phi_\pi^{-1}[E_t\pi^w_{t+1} + \sigma^{-1}E_t\hat{Y}^w_{t+1} - (\sigma^{-1} + \phi_y)\hat{Y}^w_t - \bar{\imath}^w_t]. \tag{1.56}$$

This relation can then be "solved forward" to yield[29]

$$\pi^w_t = -\phi_\pi^{-1}(\sigma^{-1} + \phi_y)\hat{Y}^w_t + \sum_{j=0}^{\infty}\phi_\pi^{-(j+1)}E_t[(\sigma^{-1} - \phi_\pi^{-1}(\sigma^{-1} + \phi_y))\hat{Y}^w_{t+j+1} - \bar{\imath}^w_{t+j}]. \tag{1.57}$$

Since both π_t and π^*_t can be expressed as linear combinations of the world average inflation rate π^w_t and the inflation differential Δz_t, the pair of equations (1.55) and (1.57) completely characterize the AD relations for the two countries.

The AD relation for the home country can again be written in the form (1.27), just as in the case of the PCP model. Figure 4 illustrates the numerical coefficients

[28] Note that the first line of (1.55) reduces precisely to (1.32) in the limit as $\xi \to \infty$.

[29] The necessary and sufficient condition for a unique bounded solution is again that $\phi_\pi > 1$. Under this assumption, the infinite sum is well-defined and bounded in the case of bounded forcing processes.

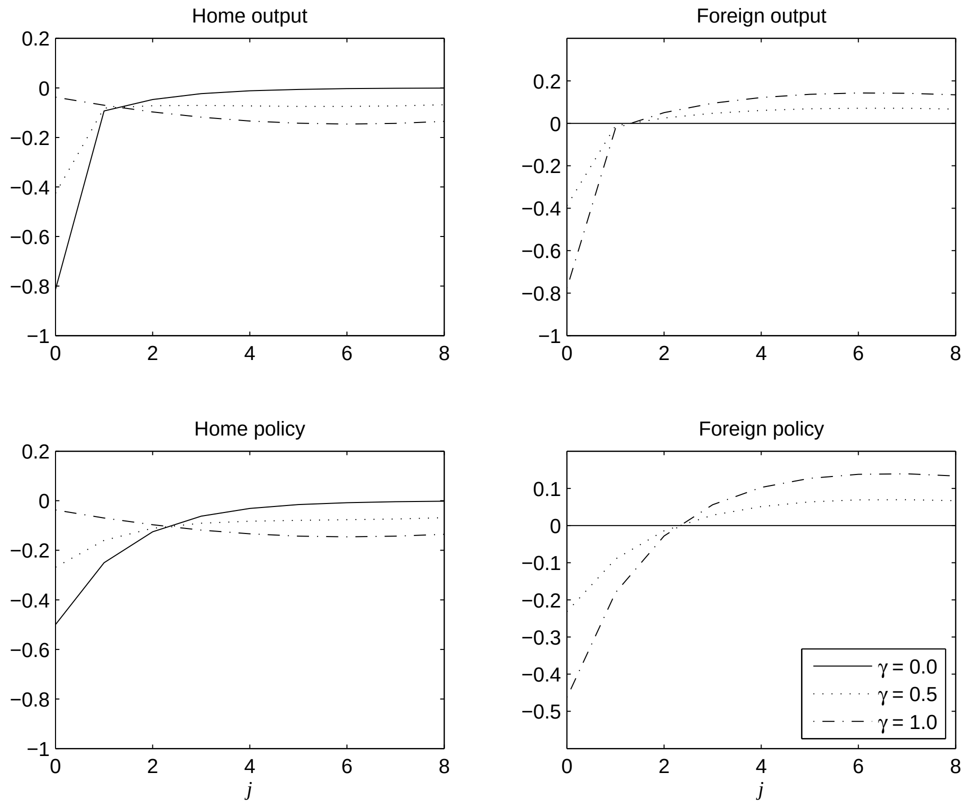

Figure 4: Coefficients of the dynamic AD relation (1.27) for the model with local-currency pricing.

in the case of the same parameter values as before, and assuming in addition that $\xi = 0.04$.[30] Again the coefficients are shown for three different possible values of γ. When $\gamma = 0$ (the closed-economy limit), the LCP model is indistinguishable from the PCP model (as there are no import prices), but for $\gamma > 0$ the two models are no longer equivalent.

Note that in the limiting case of a very small country (the home country in the case that $\gamma \to 1$), domestic monetary policy is no longer able to have any influence on the predicted path of π_t^w given the expected evolution of world output. (Indeed, in this limiting case, π_t^w depends only on foreign output and foreign monetary policy.) But even so, (1.55) implies that the sensitivity of the inflation differential to domestic

[30] This value as well corresponds to the magnitude of this coefficient in the empirical model of Rotemberg and Woodford (1997); see also Woodford (2003, chap. 5).

monetary policy is exactly as great as it would be for a larger country. Hence domestic inflation is still affected by domestic monetary policy, and to a non-trivial extent, as is illustrated by the coefficients in the upper left panel of Figure 4.

It is true that in the LCP model, the slow (and smoothed) pass-through of exchange-rate changes to import prices reduces the size of the immediate effect on domestic inflation of a transitory change in domestic monetary policy, relative to what occurs in the PCP model. However, this does not mean that it is harder for monetary policy to affect inflation than would be the case in a closed economy in which prices are sticky for a similar length of time. While the coefficient $\psi_{1,0}$ becomes quite small in the small-open-economy case, the coefficients $\psi_{1,j}$ indicating the effects of anticipated *future* domestic monetary policy on current inflation no longer die out quickly as the horizon j increases. This means that a *persistent* shift in the central bank's policy reaction function can have a substantial immediate effect. The crucial difference is that in this model it becomes more important for interest rates to be adjusted in a relatively *inertial* way in order to have a substantial impact on aggregate demand.

In fact, a sufficiently persistent shift in policy (that is understood by the private sector) still affects inflation to the same extent as in the LCP model. For example, it follows from (1.55) that a permanent unit increase in the intercept $\bar{\imath}_t$ (corresponding to a reduction in the implicit domestic inflation target of size $(\phi_\pi - 1)^{-1}$) lowers the inflation differential immediately and permanently by the amount of the reduction in the implicit inflation target, which is the same prediction as is implied by (1.32). In the case that the home country is very small, this is also the size of the immediate, permanent reduction in domestic inflation; thus the same size effect on inflation is predicted as in the case of a closed economy.

In the example shown in Figure 4, prices are relatively sticky,[31] as shown by the small value of ξ. This makes the equilibrium dynamics under the LCP model quite different from those of the PCP model. In Figure 5, the coefficients of the dynamic AD relation are instead computed under the assumption that $\xi = 0.4$, implying a short-run aggregate-supply curve that is 10 times as steep. In this case, the difference with

[31] By this I mean that the rate of adjustment of price indices to changing aggregate conditions is relatively slow. This is not due solely to the value assumed for α, but also to the fact that the parameter values used by Rotemberg and Woodford imply substantial "real rigidities." See Woodford (2003, chap. 3) for further discussion.

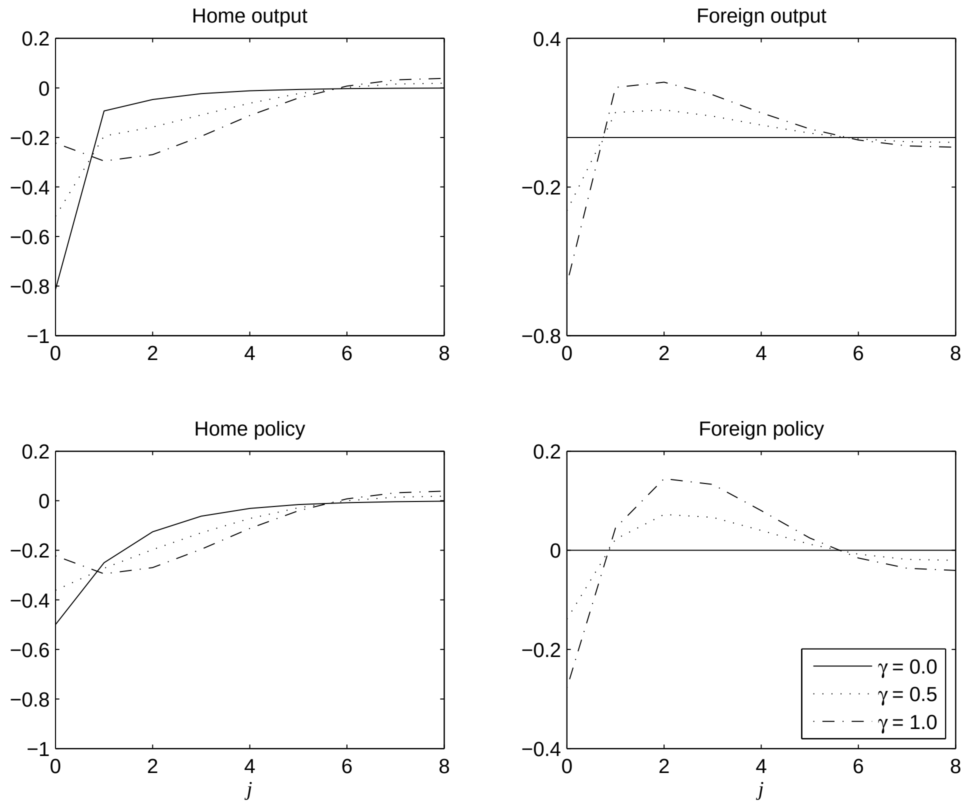

Figure 5: Coefficients of the dynamic AD relation for the LCP model with $\xi = 0.4$.

Figure 1 is less dramatic. As the value of ξ is increased still further, the coefficients for each of the values of γ all approach those shown in Figure 1.

2 "Global Liquidity" and the Instruments of Monetary Policy

Another way in which globalization is sometimes supposed to reduce the significance of individual national monetary policies is by making the aggregate supply of "liquidity" by the world's central banks, rather than that supplied by a given country's central bank alone, the variable that determines the degree of stimulus to aggregate demand (and hence inflationary pressure) in that country as well as abroad. Market analysts in financial institutions have spoken a great deal recently of "global liquidity" as a factor that has supposedly been responsible for asset-price booms worldwide, and it is often proposed that this factor can be measured by growth in some aggregate of the money supplies in different currencies (*e.g.*, Global Research, 2007), following the lead of ECB researchers such as Sousa and Zaghini (2004, 2006) and Rüffer and Stracca (2006). To the extent that such a view is correct in a globally integrated world economy, one might expect that it should mean a reduced ability of national central banks to control national inflation rates, especially in the case of small countries that supply a correspondingly small proportion of "global liquidity."

As noted in the previous section, in an open economy there are channels through which foreign monetary policy developments (among other foreign factors) will generally affect the level of domestic aggregate demand, for any given stance of domestic monetary policy. It may even be the case, though it need not be, that the effect of domestic interest-rate policy on domestic aggregate demand is smaller in the case of a small open economy than it would be for a large economy (or a closed economy). But as explained in the previous section, even in the case of full integration and the limiting case of a very small economy, the effect of domestic monetary policy on domestic demand does not become negligible, and thus the idea that only some global aggregate of liquidity creation by central banks is relevant is clearly mistaken. Moreover, monetary stimulus abroad may contract demand for domestic output, owing to the terms-of-trade effect of the depreciation of the foreign currency; in such a case, while foreign monetary policy is relevant to domestic conditions, the sign of the effect is the opposite of the one suggested by loose talk about "global liquidity."

The analysis in the previous section, however, took for granted the existence of an instrument through which a central bank can control the level of short-term nominal interest rates in terms of its currency, as long as the possibility exists of a savings-investment equilibrium at a different level of interest rates; thus it was assumed that policy can be represented by a Taylor rule, without asking how a central bank is able to implement its operating target for the nominal interest rate. It is often supposed that central-bank control over nominal interest rates depends on the central bank's role as a monopoly supplier of financial claims ("base money") that are uniquely liquid. Might integration of financial markets erode this monopoly power, so that the liquidity premium associated with base money in any country comes to depend on the global supply of liquid assets, rather than the supply by that country's central bank alone? And if so, would this mean that central banks (at least, small central banks) would lose the capacity to control nominal interest rates within their borders?

In order to consider this possibility, I first discuss the instruments through which a central bank's operating target for a domestic short-term nominal interest rate can be implemented in an open economy, relying upon a conventional model of money demand, in which it is assumed that only the liabilities of a given country's central bank are useful for facilitating transactions (and so supply liquidity services) in that country. I then consider the extent to which the conclusions would be changed if globalization were to imply that the liquidity services provided by the liabilities of a given central bank were available equally to households in all countries.

2.1 Money Demand and Monetary Policy Implementation in a Two-Country Model

We can introduce liquidity services from holdings of base money by supposing that the utility of households in the home economy is of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) + w(M_t/P_t)], \tag{2.1}$$

where $u(C)$ is again defined by (1.2)–(1.3), M_t indicates home-currency money balances, and

$$w(m) \equiv \lambda \frac{m^{1-\sigma_m^{-1}}}{1-\sigma_m^{-1}}$$

for some $\sigma_m > 0$. Because of the additive separability of the utility function between consumption and liquidity services, the conclusions of section 1 are not changed by the addition of the new term; this will only affect the demand for money balances (not treated earlier).

Base money is assumed to be a one-period liability of the central bank, that promises a riskless nominal return (in units of the domestic currency) of i_t^m between periods t and $t+1$; the rate i_t^m is an administered rate (rather than market-determined), and the choice of it is an additional potential instrument of policy for the central bank. (Under some regimes, like that of the U.S. at present, $i_t^m = 0$ at all times; but this is a choice, rather than a logical necessity.[32]) The flow budget

[32] See Woodford (2001) and Woodford (2003, chap. 1) for discussion of other countries where interest is paid on central-bank balances, and where variation in the administered deposit rate in accordance with changes in the central bank's interest-rate target plays an important role in the implementation of policy.

constraint of a household is then of the form[33]

$$P_tC_t + M_t + E_t[Q_{t,t+1}A_{t+1}] \leq (1 + i^m_{t-1})M_{t-1} + A_t + P_tY_t - T_t,$$

where A_t denotes the state-contingent nominal value (in units of the home currency) of the household's portfolio of non-monetary financial claims carried into period t and T_t represents net nominal tax collections by the home government. Here it is assumed that (in order for there to exist no arbitrage opportunities) all non-monetary financial assets are priced using the common stochastic discount factor $Q_{t,t+1}$ (so that any portfolio with state-contingent payoff A_{t+1} in period $t + 1$ must cost $E_t[Q_{t,t+1}A_{t+1}]$ in period t), while money is not because of its additional service flow. Under the assumption of complete financial markets, we need not describe any specific non-monetary financial assets, and can suppose that households directly choose the state-contingent future payoffs that they prefer.[34]

One can alternatively write the flow budget constraint in the form[35]

$$P_tC_t + \Delta_tM_t + E_t[Q_{t,t+1}W_{t+1}] \leq W_t + P_tY_t - T_t, \tag{2.2}$$

where $W_t \equiv (1 + i^m_{t-1})M_{t-1} + A_t$ is the total value of nominal financial wealth at the beginning of period t, and

$$\Delta_t \equiv \frac{i_t - i^m_t}{1 + i_t}$$

is the *interest-rate differential* between equally riskless, equally short-maturity *non-monetary* nominal assets (assumed not to yield any "liquidity services") and money. (In the familiar textbook case of zero interest on money balances, Δ_t is simply a monotonic transformation of the nominal interest rate i_t.) It is evident from (2.2) that the differential Δ_t measures the opportunity cost of holding part of one's wealth in monetary form. Consequently household optimization requires that

$$\frac{w'(M_t/P_t)}{u'(C_t)} = \Delta_t \tag{2.3}$$

[33]See the text explaining equations (1.2)–(1.3) of Woodford (2003, chap. 2) for further discussion. The flow budget constraint here is of exactly the same form as in a closed-economy model, as purchases of foreign goods are included as part of the aggregate C_t and the prices of imported goods are included as part of the price index P_t.

[34]Our conclusions about money demand in this section do not depend on the assumption of complete markets; the first-order condition (2.3) derived below for optimal money holdings would also be obtained for an economy with no financial assets other than money and a one-period riskless nominal claim earning the interest rate i_t.

[35]Again, see the discussion of equation (1.7) in Woodford (2003, chap. 2) for explanation.

each period.

We can solve (2.3) for desired real money balances, obtaining

$$\frac{M_t}{P_t} = L(C_t, \Delta_t) \equiv \lambda^{\sigma_m} \frac{C_t^{\sigma_m/\sigma}}{\Delta_t^{\sigma_m}}.$$

Substituting (1.15), we obtain

$$\frac{M_t}{P_t} = \lambda^{\sigma_m} k^{\sigma_m/\sigma} \frac{Y_t^{(1-\gamma)\sigma_m/\sigma} Y_t^{*\gamma\sigma_m/\sigma}}{\Delta_t^{\sigma_m}} \tag{2.4}$$

as an open-economy generalization of the "LM equation" of a canonical closed-economy model. Similar equations hold for the foreign country; in particular, we obtain the equilibrium relation

$$\frac{M_t^*}{P_t^*} = \lambda^{\sigma_m} k^{\sigma_m/\sigma} \frac{Y_t^{(1-\gamma)\sigma_m/\sigma} Y_t^{*\gamma\sigma_m/\sigma}}{\Delta_t^{*\sigma_m}}, \tag{2.5}$$

where M_t^* represents holdings of foreign-currency money balances per foreign household, and Δ_t^* is the corresponding differential between the foreign-currency nominal interest rate i_t^* and the interest rate i_t^{m*} paid by the foreign central bank.

If we represent the monetary policy of each central bank by a path for the monetary base (rather than a Taylor rule), as is often done in models of exchange-rate determination, then the aggregate-demand block of the model (with producer-currency pricing) consists of equations (1.17)–(1.18) and (2.4)–(2.5): two equations for each country (an "IS equation" and an "LM equation"), that jointly suffice to determine the paths of $\{P_t, P_t^*, i_t, i_t^*\}$ given paths for $\{Y_t, Y_t^*\}$ and the policy variables $\{M_t, M_t^*, i_t^m, i_t^{m*}\}$. Alternatively, if we suppose that policy is specified in each country by a Taylor rule, and adjustments of the monetary base (through open-market purchases of securities) are simply used to *implement* the prescriptions of the Taylor rule, then equations (1.17)–(1.18) and (1.19)–(1.20) determine the relations between prices, interest rates, and real activity as before; but equations (2.4)–(2.5) must now also hold, and determine the adjustments of the monetary base and/or the interest paid on base money that are required in order to implement the policies.

Local equilibrium determination can again be studied by log-linearizing equations (2.4)–(2.5), yielding

$$\log M_t - \log P_t = \eta_y \hat{Y}_t + \eta_y^* \hat{Y}_t^* - \eta_i(\hat{\imath}_t - \hat{\imath}_t^m), \tag{2.6}$$

$$\log M_t^* - \log P_t^* = \eta_y \hat{Y}_t + \eta_y^* \hat{Y}_t^* - \eta_i(\hat{\imath}_t^* - \hat{\imath}_t^{m*}), \tag{2.7}$$

where

$$\eta_y \equiv (1-\gamma)\frac{\sigma_m}{\sigma}, \qquad \eta_y^* \equiv \gamma\frac{\sigma_m}{\sigma}, \qquad \eta_i \equiv \left(\frac{1-\bar{\Delta}}{\bar{\Delta}}\right)\sigma_m.$$

Here I have log-linearized around a zero-inflation steady state in which the rate of interest on money is assumed to satisfy

$$0 \leq \bar{\imath}^m < \beta^{-1} - 1,$$

as is necesssary for the existence of such a steady state;

$$\bar{\Delta} \equiv 1 - \beta(1+\bar{\imath}^m) > 0$$

is the implied steady-state interest differential; and

$$\hat{\imath}_t^m \equiv \log(1 + i_t^m / 1 + \bar{\imath}^m)$$

is defined analogously with the previous definition of $\hat{\imath}_t$.[36]

One observes that to this order of approximation, the allowance for two distinct instruments of monetary policy (variations in the base and variations in the rate of interest paid on the base) is redundant. This follows from the fact that it is only the quantity $\log M_t - \eta_i \hat{\imath}_t^m$ that matters in equation (2.6). This means that any policy aim that can be achieved by varying the interest rate paid on money can alternatively be achieved through an appropriate adjustment of the monetary base.[37] In the case of the very conventional assumption made here about the nature of the demand for liquidity, no underestimation of the scope for an independent national monetary policy results from stipulating that $i_t^m = 0$ at all times, as is typically assumed in textbook treatments. One can then represent the monetary policies of

[36] The method and notation follow the treatment of a closed-economy model in Woodford (2003, chap. 2, sec. 3.3). Note that I have also chosen units (as is possible without loss of generality) in which the steady-state level of real money balances is equal to 1 in each country, so that I can drop the constant that would otherwise appear in each of the equations (2.6)–(2.7).

[37] Of course, there could nonetheless be practical advantages to the use of one technique. For example, calculating the interest-rate effect of a given size change in the rate of interest paid on base money is much more straightforward than guessing the size of open-market operation required to achieve the same effect, especially in the presence of disturbances to the money-demand relation, not modeled in the simple treatment here.

the two countries simply in terms of the paths of the two countries' monetary bases, *i.e.,* the supply of "liquidity" by the two central banks.

We see that openness results in the "LM equations" of the two economies' being interrelated, just as was true (in general) of their "IS equations" in section 1. To what extent does it make sense, though, to say that in a globalized economy, the supply of "global liquidity" should be an important determinant of equilibrium in each individual country? Suppose that we derive AD relations for each of the two countries, taking as given the paths of money for the two countries. We can do this by using each country's IS relation to eliminate the nominal interest rate from its LM relation. We obtain a difference equation for the price level of the form

$$(1+\eta_i)\log P_t - \eta_i E_t \log P_{t+1} = \log M_t - \eta_i \hat{\imath}_t^m - (\eta_y + \eta_i\sigma^{-1})\hat{Y}_t^w + \eta_i\sigma^{-1}E_t\hat{Y}_{t+1}^w,$$

which can be solved forward to yield

$$\log P_t = \sum_{j=0}^{\infty}(1-\alpha)\alpha^j E_t[\log M_{t+j} - \eta_i \hat{\imath}_{t+j}^m] - [(1-\alpha)\eta_y + \alpha\sigma^{-1}]\hat{Y}_t^w - \sum_{j=1}^{\infty}(1-\alpha)\alpha^j[\eta_y - \sigma^{-1}]E_t\hat{Y}_{t+j}^w \tag{2.8}$$

for the equilibrium domestic price level corresponding to any expected paths of domestic and foreign output, where

$$\alpha \equiv \frac{\eta_i}{1+\eta_i} < 1.$$

(A similar equation holds for the foreign price level.)

We see that, conditioning on the paths of real activity in the two countries, the price level in a given country depends only on current and expected future monetary policy in *that country alone*, and not on "global liquidity" at all. (This is the same conclusion as we reached in section 1, when monetary policy was instead specified by a Taylor rule for each country.) Thus to the extent that monetary policy spillovers exist between countries, they do not occur through the aggregate demand side of the model, as the notion of "global liquidity" would suggest. And if we specify the supply side of the model in such a way that output is unaffected by monetary policy (for example, by assuming flexible wages and prices), it will follow that inflation in one country will be completely independent of monetary policy in the other country, no matter how small the country in question may be.

If, instead, we assume the existence of nominal rigidities that allow monetary policy to affect real activity, foreign monetary policy will affect inflation determination in the home country (assuming again that home country monetary policy is specified by a given path for the monetary base). However, the spillovers that exist will not be of the sort suggested by the theory of "global liquidity." We observe from (2.6) that a change in the level of foreign economic activity will shift the home country LM curve, for a given home money supply. But (since $\eta_y^* > 0$) expansionary policy in the foreign country, which raises Y^*, will have the same effect as a *contractionary* monetary shock in the home country. This is because higher foreign output increases demand for the home currency, at any given level of domestic output. Such an effect is the *opposite* of the effect that the "global liquidity" thesis would suggest.

2.2 Consequences of Currency Substitution

Some may suppose that the model presented above fails to find a role for "global liquidity" because of the conventional assumption that households in a given country obtain liquidity services only by holding the money issued by their own central bank (on the ground that only this asset has a special role as a means of payment within those borders). What if globalization also means global competition among media for executing payments? There is little evidence that this is already an important phenomenon at present, but one might conjecture that it could happen in the future as a result of the same sorts of improvements in communications technology (and relaxation of regulations) that have already led to great increases in the degree of integration of financial markets. To the extent that this were to occur, would some global liquidity aggregate, rather than the money supplied by the local central bank, become a primary determinant of aggregate demand in all countries? And if so, would this mean a loss of control over domestic inflation by central banks, unless they arrange an appropriate world-wide coordination of their policies?

To clarify ideas, I shall proceed directly to the most extreme hypothetical, of a world in which each of the two central banks' currencies supply liquidity services *of exactly the same kind* to households in either country. Would only "global liquidity" matter in that case? One possible case of this kind is that in which households in each country have the same utility function,

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) + \delta w(M_{Ht}/P_t) + \delta^* w(M_{Ft}/P_t^*)], \tag{2.9}$$

for some weights $\delta, \delta^* > 0$, where $w(m)$ is the same function as before. Here C_t is the household's purchases of the world consumption aggregate, M_{Ht} is its holdings of the home currency, and M_{Ft} its holdings of the foreign currency. (This notation applies to the choices of a household in the home country. A foreign household has an identical utility function, but its choice variables are starred.) The liquidity services obtained from money balances depend on the purchasing power of those balances, in units of the world good (which is what the household cares about purchasing). Because the law of one price holds (in the PCP version of the model), the relevant measure of real balances for households in either country is obtained by deflating home-currency balances by P_t and deflating foreign-currency balances by P_t^*.

In this case, households in each country choose to hold positive balances of both currencies, and the demand for the home currency by households in either country is of the form (2.4), with λ replaced by the appropriate multiplicative factor. Total world demand for the home currency will then equal supply if and only if

$$\begin{aligned}(1-\gamma)M_t &= (1-\gamma)M_{Ht} + \gamma M_{Ht}^* \\ &= (1-\gamma)\delta^{\sigma_m} L(C_t, \Delta_t)P_t + \gamma\delta^{\sigma_m} L(C_t^*, \Delta_t)P_t \\ &= (1-\gamma)\tilde{\lambda}^{\sigma_m} k^{\sigma_m/\sigma}\, \frac{Y_t^{(1-\gamma)\sigma_m/\sigma} Y_t^{*\gamma\sigma_m/\sigma}}{\Delta_t^{\sigma_m}}\, P_t,\end{aligned}$$

where $\tilde{\lambda} \equiv \delta\lambda/(1-\gamma)^{\sigma_m^{-1}}$. This is an equilibrium relation of *exactly the same form* as (2.4), except that λ is replaced by $\tilde{\lambda}$. The two equations are identical, even in scale, if $\delta = (1-\gamma)^{\sigma_m^{-1}}$; but even if not, they have the same form (2.6) when log-linearized. The condition for supply of the foreign currency to equal world demand for it similarly leads to an equilibrium condition of exactly the same form as (2.5). Hence the form of the two "LM equations" is *exactly the same* in this variant of the model, with exactly the same implications for the ability of a central bank to control domestic aggregate demand through the instruments of monetary policy.

Thus the fact that independent variation in the supply of one currency influences the corresponding price level in the way indicated in (2.8) is not at all dependent on assuming that the advantages flowing from holding a particular liquid asset are only available in one country. The only assumption that is essential is the assumption that the two currencies are not *perfect substitutes* as means of facilitating transactions in either country. (Preferences (2.9) imply that the elasticity of substitution between the two types of cash balances in the provision of liquidity services is only σ_m.)

A still more extreme assumption would be to suppose that the two kinds of money are instead perfect substitutes in liquidity provision. One might instead assume that households in each country have preferences of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) + w(M_{Ht}/P_t + M_{Ft}/P_t^*)], \tag{2.10}$$

where $w(m)$ is the same function as before. In this case, one would no longer be able to derive separate demand functions for the two currencies. All households will instead choose to hold only the currency with the lower opportunity cost; if positive quantities of both are supplied, equilibrium is only possible if

$$\Delta_t = \Delta_t^*. \tag{2.11}$$

There will then be a well-behaved demand function for the sum of the two types of real balances, and a corresponding equilibrium condition

$$(1-\gamma)\frac{M_t}{P_t} + \gamma \frac{M_t^*}{P_t^*} = \lambda^{\sigma_m} k^{\sigma_m/\sigma} \, \frac{Y_t^{(1-\gamma)\sigma_m/\sigma} Y_t^{*\gamma\sigma_m/\sigma}}{\Delta_t^{\sigma_m}}. \tag{2.12}$$

The pair of equilibrium conditions (2.11)–(2.12) would replace the conditions (2.4)–(2.5) in the aggregate demand block of a model with perfect currency substitutability.

In this case, it really would be true that only "global liquidity" matters for aggregate demand determination; that is, the money supply of neither country would matter, except through its contribution to aggregate global real balances, defined by the left-hand side of (2.12). In the case of a small country, the monetary base of which would make only a negligible contribution to global real balances, variations in the monetary base would have essentially no effect on aggregate demand there or elsewhere, and so would be irrelevant to domestic inflation determination.

Nonetheless, it would not follow that a small country would be unable to use an independent monetary policy to control domestic inflation. The reason is that in this case the additional instrument of policy, the possibility of varying the interest rate paid on money, would no longer be redundant. Condition (2.11), which can alternatively be written

$$\frac{1+i_t}{1+i_t^*} = \frac{1+i_t^m}{1+i_t^{m*}},$$

implies that the nominal interest-rate differential between the two countries (for non-monetary riskless assets) must be directly determined by the differential between the interest rates paid on money by the two central banks. This means that independent variation in the rate paid on money in a small country can influence aggregate nominal expenditure in that country, whether or not it is accompanied by changes in the monetary base. Thus in a world in which the liabilities of different central banks came to be close substitutes for one another in facilitating transactions worldwide, it would become essential to use variations in the (administratively determined) interest yield on base money as the means through which central-bank operating targets for domestic short-term nominal interest rates are implemented.[38]

As a simple example of how inflation control would be possible using this instrument, consider a small open economy (*i.e.,* one for which γ is essentially equal to 1), so that monetary policy decisions of the small country can have no effect on the evolution of foreign variables such as P_t^*, Y_t^*, i_t^*, or i_t^{m*}. It follows from (2.12) that the small country's policy will be unable to affect the value of Δ_t either. Nonetheless, the small country's central bank can set the interest rate i_t^m on the domestic monetary base as it pleases. Suppose that it sets it in accordance with a reaction function of the form

$$\hat{\imath}_t^m = \bar{\imath}_t + \phi_\pi \pi_t,$$

where $\bar{\imath}_t$ is an exogenous process with respect to the evolution of domestic variables, but may depend on the evolution of foreign variables.

Then subtracting (1.22) from (1.21), and using the log-linearized version of (2.11) to replace the interest-rate differential $\hat{\imath}_t - \hat{\imath}_t^*$ by $\hat{\imath}_t^m - \hat{\imath}_t^{m*}$, we obtain the equilibrium relation

$$\hat{\imath}_t^m - \hat{\imath}_t^{m*} = E_t[\pi_{t+1} - \pi_{t+1}^*].$$

Substituting the reaction function for $\hat{\imath}_t^m$, we find that in equilibrium, the domestic inflation process must satisfy

$$\phi_\pi \pi_t = E_t \pi_{t+1} + (\hat{\imath}_t^{m*} - E_t \pi_{t+1}^* - \bar{\imath}_t).$$

[38] This is already a crucial element in monetary policy implementation in countries with "channel systems" like Canada, Australia, and New Zealand, and their success indicates that it would remain entirely feasible to conduct a national interest-rate policy without any ability to alter the spread between the returns on non-monetary assets and base money. See discussion in Woodford, 2001, of the related issue of monetary policy implementation in a world where central banks have to compete with private suppliers of transactions media.

In the case that $\phi_\pi > 1$, this has a unique bounded solution,

$$\pi_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} E_t[\hat{\imath}^{m*}_{t+j} - \pi^*_{t+j+1} - \bar{\imath}_{t+j}]. \tag{2.13}$$

This shows that variations in the rate of interest paid on the monetary base can still be effectively used to control the domestic rate of inflation, even under the assumption that the liabilities of different central banks are equally useful as sources of liquidity in all parts of the world. It is true that in such a world, foreign developments would matter for inflation determination in the small country, and the interest paid on money would have to be adjusted so as to offset those developments, in order for a stable inflation rate to be maintained in the small country. But even so, it is not true that the central bank's main problem would be offsetting the inflationary impact of variations in "global liquidity". One sees from (2.13) that what the central bank actually needs to offset is variations in *the real rate of return on money balances* in the rest of the world. Moreover, it is *increases* rather than decreases in the real return on money elsewhere in the world that would be inflationary in the small country, if not offset by a corresponding increase in the interest paid on money in the small country.

Of course, "dollarization" does imply reduced efficacy of domestic monetary policy in a small open economy in one respect, if it means not only that the foreign currency can be used a means of payment (and so supplies liquidity services), but also that prices of domestic goods are quoted in, and sticky in, the foreign currency rather than the domestic currency. In that case, it would remain true that domestic monetary policy should be able to stabilize the purchasing power of the domestic currency, but this would no longer imply an ability to *eliminate the distortions due to price stickiness* in the domestic economy.[39] Indeed, if few domestic goods continue to be priced in terms of the domestic currency, then the stability or otherwise of the value of that currency would cease to have any real consequences, and cease to have any welfare consequences — so that domestic monetary policy would indeed be irrelevant. But this is hardly an inevitable result of globalization, even under the assumption that eventually multiple currencies might come to be widely accepted as means of payment in a given location. When one observes prices being fixed in a currency other than the local currency, this is typically because the purchasing power of the local

[39] This has been stressed by David Romer, in a comment on an earlier draft.

currency is expected to be less stable than that of the foreign currency; a central bank that stabilizes a domestic price index in terms of its own currency has little reason to fear that domestic prices will cease to fixed in that currency, even if the costs of transacting in foreign currencies are reduced.

3 "Global Slack" and Inflation Determination

Thus far I have discussed only the aggregate demand block of an open-economy macroeconomic model, asking how monetary policy affects the equilibrium inflation rate that would be associated with any given path for real activity. This has meant leaving aside the question of the extent to which a given effect of national monetary policy on the aggregate demand relation should result in a different rate of inflation as opposed to a different level of real activity. If we are willing to assume that the level of real activity in each country should be determined by factors such as technology and preferences, quite independently of monetary policy in either country (as real business cycle theories assert), then the analysis given above would already offer a complete answer to the question of how monetary policy affects inflation in a globalized economy. But in the presence of nominal rigidities this will not be true, and we need to consider the "aggregate supply block" of the model as well in order to determine the effects of monetary policy on *either* output or inflation.

The question of how globalization should affect aggregate supply relations — the connection that should exist between inflation and real activity as a result of the way that the incentives that firms have to change their prices vary depending on the degree of utilization of productive capacity — is of considerable interest in its own right. It is sometimes argued that increased international trade in goods and services should make inflation in any country more a function of "global slack" — the balance that exists between worldwide productive capacity and world demand — than of the balance between demand and capacity in that country alone. Economists at the BIS in particular (Borio and Filardo, 2007) have argued that in a globalized economy, domestic slack alone should matter less than global slack as a determinant of domestic inflation, and have suggested that there is evidence that this is already true to some extent. (See however Ihrig *et al.,* 2007, for a contrary view of the empirical evidence.)

To the extent that this thesis is correct, one might expect it to pose a threat to central-bank control of domestic inflation, even granting our conclusions above about the continued influence of national monetary policy over aggregate demand. In particular, one might suppose that even if domestic monetary policy can affect aggregate demand for domestic output, if the domestic output gap ceases to be a significant determinant of inflation, a national central bank will cease to have much ability to influence the domestic inflation rate, which will instead depend primarily on the international factors that determine "global slack." Thus one might expect national monetary policy to become ineffective in controlling inflation, especially in the case of a small country that can contribute little to either world demand or world productive capacity. Our conclusions above about the continued significance of national monetary policy for aggregate demand would presumably then imply that monetary policy should have an even *greater* effect on real activity in a globalized economy — but this would be little comfort to those concerned about inflation risk.

Indeed, under the "global slack" hypothesis, the efficacy of domestic monetary policy in affecting the level of real activity, without any notable effect on domestic inflation, might be expected to lead to monetary policies in each country with joint consequences for global slack that are more inflationary than any country would like. Even if one were to grant that central banks should still be able to control inflation, one might fear that they will have less incentive to do so, if they perceive themselves to face a flatter Phillips-curve tradeoff between domestic output expansion and domestic inflation. (This is presumably the reason for the concern of Borio and Filardo that a "more elastic" economy will encourage a loss of monetary discipline.)

In this section, I consider the degree of concern that should be given to threats of this kind, by analyzing the consequences of openness in goods and factor markets for aggregate-supply relations in a model with nominal rigidities. I give particular attention to the consequences of openness for the slope of the Phillips-curve tradeoff, and also to the degree to which it is true that domestic inflation should be determined by "global slack" as opposed to (or in addition to) a domestic output gap. I begin by reviewing the answers to these questions in the canonical two-country model of CGG, and then consider some variations on that model that might be expected to increase the importance of "global slack".

3.1 Aggregate Supply in a Two-Country Model

A variety of arguments have been given for the view that world economic activity, rather than domestic activity alone, should be important for inflation determination in a globalized economy. Bernanke (2006) interprets the global slack hypothesis as a simple observation that if domestic products are sold in global markets, global income (rather than domestic income alone) will become an important determinant of the demand for those products and hence of the incentives that domestic producers have to raise their prices. Note that under this interpretation, it is still the domestic output gap (the balance between the demand for domestic products and domestic productive capacity) that determines domestic inflation, rather than any concept of global slack; but global income affects domestic inflation insofar as it may be an important determinant — perhaps even the main determinant — of domestic aggregate demand.

This mechanism is one that we have already considered in the analysis of aggregate demand in section 1. In the model of consumer demand in a globalized economy presented there, the demand for any given product does indeed depend on world income rather than domestic income, since households in both countries are assumed to allocated their expenditure across different goods in precisely the same proportions. (This is obviously an extreme assumption, that gives the greatest possible weight to the consideration raised by Bernanke.) But this obviously has no consequences for the slope of the Phillips curve, and as already shown in the earlier discussion, it does not imply any reduction in the effectiveness of domestic monetary policy in controlling domestic inflation. The effects of monetary policy on domestic inflation do not decline in the case that γ is made large, even though this means that nearly all of the demand for domestic products is foreign demand.

Another argument, that similarly does not depend on any denial of the link between the domestic output gap and domestic inflation (here understood to be the rate of increase of the prices of domestically produced goods), is to observe that in a globalized economy, a larger part of the consumption basket in the domestic economy will consist of imported goods. Even if domestic inflation depends solely on the domestic output gap, a broader measure of CPI inflation will also depend on the rate of growth of import prices. A naive argument might suggest that just as domestic inflation depends on the domestic output gap, the rate of growth of the prices of foreign goods should depend on the foreign output gap (which would therefore also matter for domestic CPI inflation, and would arguably be the main thing that should matter in the case of a small country that consumes mainly foreign goods). This would be incorrect, as it neglects the effects of exchange-rate changes. Nonetheless, CPI inflation should depend on changes in the terms of trade in addition to the determinants of domestic inflation, and the equilibrium terms of trade should depend on foreign output (though not the foreign output gap).

But the main argument of proponents of the global slack hypothesis seems to be that in a globalized economy, the domestic output gap ceases to be the sole determinant of the incentive that domestic firms have to raise their prices. There are a variety of reasons why the simple relation between real marginal cost (more precisely, the ratio of the marginal cost of domestic production to the price of domestic products) — and hence the incentive of domestic firms to change their prices — and the domestic output gap that holds in a closed-economy model will generally not hold in an open-economy model. Even in the simple model of CGG, where the only variable factor is labor and there is no international mobility of labor, real wage demands should not depend solely on domestic production. This is because of the way in which the representative household's marginal utility of income (in units of domestic goods) depends both on the quantity consumed of foreign as well as domestic goods and on the terms of trade. These factors result in the presence, in general, of foreign-output terms in the domestic aggregate-supply equation of a canonical two-country model.

Here I present a basic model which essentially recapitulates the results of CGG, before turning to an alternative model that incorporates an additional reason for world economic activity to matter. The demand side of the model is the one already explained in section 1.1. The home economy consists of a continuum (of length $1-\gamma$) of households, indexed by h. Each of these seeks to maximize[40]

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) - v(H_t; \bar{H}_t)], \tag{3.1}$$

where the utility from consumption $u(C)$ is again defined by (1.2)–(1.3), H_t is hours worked, $\bar{H}_t$ is an exogenous preference shock,[41] and the disutility of working is as-

[40]Here I again abstract from the liquidity services that may be provided by money balances, as in section 1. Adding additional terms to the utility function, as in (2.1), would make no difference for the issues addressed in this section.

[41]The preference shock $\bar{H}_t$ is introduced in order to allow for a country-specific labor-supply

sumed to be of the form

$$v(H;\bar{H}) = \frac{1}{1+\nu}\left(\frac{H}{\bar{H}}\right)^{1+\nu}$$

for some $\nu \geq 0$. For now I shall assume, like CGG, that firms hire labor only from households in their own country.

Assuming for simplicity a competitive spot market for labor, the preferences (3.1) imply that in each period, the labor supply of each household is given by

$$H_t = \bar{H}_t \left(\frac{W_t}{P_t C_t^{\sigma^{-1}}}\right)^{\nu^{-1}}, \tag{3.2}$$

where W_t is home country nominal wage. We can alternatively invert this relation to write the real wage as a function of per capita labor demand, obtaining

$$\frac{W_t}{P_t} = C_t^{\sigma^{-1}} \left(\frac{H_t}{\bar{H}_t}\right)^{\nu}. \tag{3.3}$$

In each country, there is assumed to be a continuum of length 1 of differentiated goods produced; thus C_{Ht} is a Dixit-Stiglitz (CES) aggregate of the quantities consumed of the continuum of goods produced in the home country (and similarly for C_{Ft}). It follows as usual that optimal allocation of expenditure across goods implies a per capita demand for each good given by

$$y_t(i) = Y_t \left(\frac{p_t(i)}{P_{Ht}}\right)^{-\theta}, \tag{3.4}$$

where Y_t is the per capita demand for the composite home good (as in section 1), $p_t(i)$ is the price of individual home good i, P_{Ht} is the Dixit-Stiglitz index of home goods prices

$$P_{Ht}^{1-\theta} \equiv \int_0^1 p_t(i)^{1-\theta} di \tag{3.5}$$

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shock. CGG allow for one, but in their model it is interpreted as exogenous variation in a "wage markup," due to variation in the elasticity of substitution between the different types of labor supplied by monopolistically competitive households, rather than a preference shock. The assumption of a preference shock here is more conventional, and in addition the assumption here of perfect substitutability of the labor supplied by different households facilitates the discussion of the consequences of globalization of the labor market, in the next section. The difference between the two types of labor-supply shocks would be important in an analysis of optimal stabilization policy, but that is not the concern of this paper.

already introduced in section 1, and $\theta > 1$ is the elasticity of substitution among these goods.

Let us suppose further that the producer of each differentiated good i has a production function of the form

$$y_t(i) = A_t h_t(i)^{1/\phi}, \tag{3.6}$$

where A_t is a productivity factor common to all of the firms in the same country, $h_t(i)$ is the labor input hired by firm i, and $\phi \geq 1$. Here I generalize the specification of CGG to allow for the possibility of diminishing returns to the labor input; the case $\phi > 1$ can be interpreted as a technology with constant returns to scale in capital and labor, but with the capital stock of each firm fixed, as discussed in Woodford (2003, chap. 3). It follows that the labor demanded by each firm will equal

$$h_t(i) = \left(\frac{y_t(i)}{A_t}\right)^{\phi} = \left(\frac{Y_t}{A_t}\right)^{\phi} \left(\frac{p_t(i)}{P_{Ht}}\right)^{-\theta\phi}$$

using the demand curve (3.4) to express the firm's sales as a function of its price. Similarly, the aggregate demand for labor in the home country will equal

$$H_t = \int_0^1 h_t(i)di = \left(\frac{Y_t}{A_t}\right)^{\phi} \delta_t, \tag{3.7}$$

where

$$\delta_t \equiv \int_0^1 \left(\frac{p_t(i)}{P_{Ht}}\right)^{-\theta\phi} di \geq 1$$

is a measure of the dispersion of home goods prices (achieving its minimum value of 1 if and only if all home goods have identical prices).

The producer of each differentiated good is assumed to adjust the price of the goods only at random intervals, as in the model of staggered pricing introduced by Calvo (1983). Let us suppose that a fraction $0 < \alpha < 1$ of the producers leave the prices of their goods unchanged each period; those that revise their prices in period t each choose a new price $p_t(i)$ to maximize

$$E_t \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T}[p_t(i)y_T(i) - \mathcal{C}(y_T(i); W_T, A_T)],$$

where

$$\mathcal{C}_t(y_t(i); W_t, A_t) \equiv W_t \left(\frac{y_t(i)}{A_t}\right)^{\phi}$$

is the (nominal) cost of producing quantity $y_t(i)$, subject to the constraint that the firm's sales will be given by (3.4) in each period. (Here the firm treats the evolution of the variables $\{Y_t, P_t, W_t\}$ as independent of its own pricing decision, because it is small compared to the overall markets for domestic goods and labor.) The optimal price $p_t(i)$ that is chosen then satisfies a first-order condition of the form

$$E_t \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T} y_T(i)[p_t(i) - \tilde{\mu} MC_T(i)] = 0, \tag{3.8}$$

where $MC_t(i)$ is the (nominal) marginal cost of production by firm i in period t, and $\tilde{\mu} \equiv \theta/(\theta-1) > 1$ is each firm's desired markup of price over marginal cost. Thus the price that is chosen is $\tilde{\mu}$ times a weighted average of the marginal cost that is anticipated at each of the future dates at which the currently chosen price may still apply.

Finally, substitution of (3.3) for the wage in the cost function, and (3.7) for the demand for labor in the resulting expression, allows us to derive an expression of the form

$$MC_t(i) = MC_t \left(\frac{y_t(i)}{Y_t}\right)^{\omega_p} \tag{3.9}$$

for the marginal cost of production of firm i, where

$$MC_t = \phi P_t \frac{Y_t^{\omega} C_t^{\sigma^{-1}}}{A_t^{1+\omega} \bar{H}_t^{\nu}} \delta_t^{\nu} \tag{3.10}$$

is a geometric average of the marginal costs of all home firms, and I define the new coefficients[42]

$$\omega \equiv (1+\nu)\phi - 1 \;\geq\; \omega_p \equiv \phi - 1 \geq 0.$$

In the case of a closed-economy model, one would furthermore equate C_t with Y_t, so that (3.10) would imply an elasticity of average real marginal cost with respect to output of $\omega + \sigma^{-1}$, as in Woodford (2003, chap. 3). In the open-economy model of

[42] Here the notation follows Woodford (2003, chap. 3), where these coefficients are defined in the case of more general utility and production functions. The first inequality is strict unless $\nu = 0$ (no increasing marginal disutility of work), and the second inequality is strict unless $\phi = 1$ (no diminishing returns to labor).

CGG, instead, C_t must equal the right-hand side of (1.15).[43] Using this relation to substitute for C_t in (3.10), one obtains the alternative expression

$$MC_t = \phi k^{\sigma^{-1}} \, P_t \, \frac{Y_t^{\omega+\sigma^{-1}(1-\gamma)} Y_t^{*\sigma^{-1}\gamma}}{A_t^{1+\omega} \bar{H}_t^{\nu}} \, \delta_t^{\nu}.$$

(Note that this reduces to the closed-economy marginal-cost function in the case that $\gamma = 0$.) We can instead write marginal cost purely as a function of domestic goods prices and real variables by using (1.34) to substitute for P_t in the above expression, yielding

$$MC_t = \frac{\phi}{k^{1-\sigma^{-1}}} P_{Ht} \, \frac{Y_t^{\omega+\sigma^{-1}+\gamma(1-\sigma^{-1})} Y_t^{*\gamma(\sigma^{-1}-1)}}{A_t^{1+\omega} \bar{H}_t^{\nu}} \, \delta_t^{\nu}. \tag{3.11}$$

Substituting (3.9) for $MC_t(i)$ in (3.8), and using (3.4) to substitute for the relative output of firm i, one obtains an alternative expression for the first-order condition for optimal price-setting,

$$E_t \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T} Y_T P_{HT}^{\theta} [p_t^{\dagger(1+\omega_p\theta)} - \tilde{\mu} MC_T P_{HT}^{\omega_p\theta}] = 0. \tag{3.12}$$

Here I have introduced the notation $p_t^{\dagger}$ for the optimal price chosen by a firm that reconsiders its price at date t (instead called $p_t(i)$ in (3.8)), as we see that the condition is the same for all firms i that reconsider their prices at that date, and we may assume that they all choose the same price. It then follows from the definition (3.5) that the domestic price index evolves according to a law of motion

$$P_{Ht}^{1-\theta} = \alpha P_{Ht-1}^{1-\theta} + (1-\alpha) {p_t}^{\dagger(1-\theta)}, \tag{3.13}$$

and similarly from the definition of δ_t that the price-dispersion measure evolves according to a law of motion

$$\delta_t = \left(\frac{P_{Ht}}{P_{Ht-1}}\right)^{\theta\phi} \left[\alpha\delta_{t-1} + (1-\alpha)\left(\frac{p_t^{\dagger}}{P_{Ht-1}}\right)^{-\theta\phi}\right]. \tag{3.14}$$

[43]Here I assume that $C_t = C_t^* = C_t^w$. It has already been shown in section 1.1 that the ratio C_t/C_t^* must be constant over time, as the growth rate of consumption must always be the same in both countries. If one assumes an appropriate initial wealth distribution (*i.e.*, zero initial net foreign assets for each country), the constant ratio is equal to 1, so that one must have $C_t = C_t^* = C_t^w$. Even without this assumption, C_t would always be a fixed proportion of C_t^w, so that the asserted conclusion about the marginal cost function would still hold, up to a multiplicative constant.

We can further reduce the set of endogenous variables referred to in these equations if we replace $Q_{t,T}$ in (3.12) by

$$Q_{t,T} = \beta \left(\frac{Y_t}{Y_T}\right)^{\sigma^{-1}+\gamma(1-\sigma^{-1})} \left(\frac{Y_t^*}{Y_T^*}\right)^{\gamma(\sigma^{-1}-1)} \frac{P_{Ht}}{P_{HT}}. \tag{3.15}$$

This follows from (1.16), using (1.34) to substitute for the consumer price indices.

The aggregate-supply block of equations for the home economy then consists of the equations (3.11)–(3.14).[44] These equations jointly determine the paths of the domestic variables $\{MC_t, p_t^\dagger, P_{Ht}, \delta_t\}$ consistent with optimal price-setting by each of the domestic firms, given assumed paths for the levels of real activity $\{Y_t, Y_t^*\}$ and initial conditions $P_{H,-1}, \delta_{-1}$. The implied path of the consumer price index is then given by

$$P_t = k^{-1} P_{Ht} Y_t^{\gamma} Y_t^{*-\gamma}, \tag{3.16}$$

which is implied by (1.34). Alternatively, we may think of the aggregate-supply relations as determining the paths of the variables $\{Y_t, MC_t, p_t^\dagger, \delta_t\}$ for given paths of $\{P_{Ht}\}$ (or $\{P_t\}$) and foreign real activity.

Here I have written the aggregate-supply equations for the home country; but a set of equations of the same form applies to the foreign country. For example, (3.10) also holds when all variables (both endogenous and exogenous) are replaced by the corresponding starred variables.[45] Substitutions similar to the ones above then lead to

$$MC_t^* = \frac{\phi}{k^{1-\sigma^{-1}}} P_{Ft}^* \frac{Y_t^{*\omega+\sigma^{-1}+(1-\gamma)(1-\sigma^{-1})} Y_t^{(1-\gamma)(\sigma^{-1}-1)}}{A_t^{*1+\omega} \bar{H}_t^{*\nu}} \delta_t^{*\nu} \tag{3.17}$$

as a relation corresponding to (3.11) for producers in the foreign country. Equations corresponding to (3.12)–(3.14) for the foreign country are similarly straightforward to derive.[46] The complete set of eight equations (four for each country) constitutes the "aggregate supply block" of the two-country model. These equations determine the evolution of domestic prices (and hence the indices P_{Ht} and P_{Ft}^*) in both countries, and hence the consumer price indices P_t and P_t^* as well, given the paths of real activity in both countries. Alternatively, they can be viewed as determining the evolution of

[44] Here it should be understood that $Q_{t,T}$ has been substituted out in (3.12), using (3.15).

[45] Here I allow the technology shock and labor supply shock to be different in the two countries.

[46] In each case, one obtains the corresponding equation for the foreign country by adding stars to all variables, replacing Hs by Fs, and replacing γ by $1-\gamma$ in each place where it occurs.

real activity in both countries given the paths of the general level of prices (specified by either a domestic price index or a consumer price index) in both countries.

We observe that even in this model with full integration of goods markets (not only are all final goods traded, but the same consumption basket is consumed in all parts of the world), foreign variables do not affect the aggregate-supply relations for a given country, except in one respect. This is the relation (3.11) between real activity and the marginal cost of domestic production. Marginal cost depends on foreign production as well as domestic production because the wage demanded by domestic households depends not only on the marginal disutility of labor (which depends only on domestic production, under the present assumption of no international trade in factors of production), but also on the marginal utility of additional income (in units of the domestic currency). The marginal utility of domestic-currency income depends on foreign variables for two reasons. For a given level of domestic production (and hence of consumption of home-produced goods), a higher level of foreign output will mean a higher level of consumption of foreign goods, hence a higher level of consumption of the world composite good, and a *lower* marginal utility of consumption, or marginal utility of income in units of the world composite good. At the same time, a higher level of foreign output will mean an appreciation of the home country's terms of trade, and hence a *higher* marginal of utility of income in units of domestic goods relative to the marginal utility of income in units of the world good.

Since the two effects have opposite signs, there is a tendency of them to cancel one another. In fact, in the case that $\sigma = 1$ exactly (log utility of consumption), the two effects completely cancel, and we observe that (3.11) does not involve any foreign variables. (Similarly, in this case (3.17) does not involve any home-country variables.) In this case, the aggregate-supply tradeoff between P_{Ht} and Y_t takes exactly the same form as in a closed economy: no foreign variables shift this tradeoff, and the slope of the tradeoff (as well as its sensitivity to domestic shocks or to shifts in expectations) is independent of the degree of openness γ, since the value of γ affects none of the equations in the aggregate-supply block in this case. Since we have noted in section 1.2 that in this case the aggregate-demand relation between P_{Ht} and Y_t is also unaffected by foreign variables, or by the economy's degree of openness (as long as domestic monetary policy is of the form (1.41)), it follows that in this special case, we obtain a complete theory of the determination of domestic inflation, output and interest rates that is *independent of the economy's degree of openness.*[47]

In general, of course, the two effects need not cancel altogether. The most empirically realistic case, however, is that in which $\sigma > 1$, as discussed in section 1.2. In this case, the terms-of-trade effect is stronger than the marginal-utility-of-consumption effect, and on net, an increase in foreign output *reduces* the marginal cost of domestic production. While this makes foreign economic activity relevant to the determination of (supply-side) inflationary pressures in the home country, the sign of the effect is not the one predicted by the "global slack" thesis. Not only is it not *only* world activity that matters for domestic inflationary pressure, but foreign activity has an effect with the *opposite sign* of the effect of domestic activity. And rather than implying a reduced slope of the aggregate-supply curve as a consequence of increased openness, this channel implies that greater openness should *increase* the slope of the aggregate-supply relation between domestic inflation and domestic output.

In order to see directly the implications of the above equations for the aggregate-supply relation, it is useful to log-linearize them, as with the aggregate-demand block of the model in section 1. Following CGG (and the literature on the closed-economy "new Keynesian Phillips curve"), I shall log-linearize them around an allocation with zero inflation and zero price dispersion in both countries, as well as constant preferences and technology (identical in the two countries). As in the closed-economy model,[48] log-linearization of (3.12) and (3.13) leads to the equation[49]

$$\pi_{Ht} = \xi(\mu + \log MC_t - \log P_{Ht}) + \beta E_t \pi_{Ht+1} \tag{3.18}$$

for the evolution of the domestic price index, where $\mu \equiv \log \tilde{\mu}$ and

$$\xi \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha(1+\omega_p\theta)} > 0.$$

[47]Benigno and Benigno (2005) generalize this result to the case in which the elasticity of substitution between home and foreign goods in the preferences of households is not necessarily equal to 1, as assumed here and in CGG. In their more general model, domestic inflation and output are determined independently of foreign variables in the case that the intertemporal elasticity of substitution σ is equal to the elasticity of substitution between home and foreign goods.

[48]See Woodford (2003, chap. 3) for details of the derivation.

[49]Note that this is just the equation (1.47) already anticipated in section 1.3. The derivation of this equation is the same in the case of a model with local-currency pricing, though the relation between marginal cost and output is different.

Substituting (3.11) for MC_t in (3.18), we obtain

$$\pi_{Ht} = \kappa_H \hat{Y}_t + \kappa_F \hat{Y}_t^* + \beta E_t \pi_{Ht+1} - \xi \omega q_t \tag{3.19}$$

as an open-economy generalization of the new Keynesian Phillips curve. Here $\hat{Y}_t$ and $\hat{Y}_t^*$ are log deviations from a steady-state level of output as in section 1, and the steady-state output level $\bar{Y}$ is now defined by the relation[50]

$$\bar{Y}^{\omega+\sigma^{-1}} = \frac{k^{1-\sigma^{-1}}}{\phi\tilde{\mu}} A^{1+\omega} \bar{H}^{\nu},$$

where $A, \bar{H}$ are the common steady-state values of the technology and preference factors in the two countries. The exogenous disturbance term q_t indicates the percentage change in domestic output that is required to maintain the marginal disutility of supplying output at its steady-state level;[51] it is defined as

$$\omega q_t \equiv (1+\omega) a_t + \nu \bar{h}_t,$$

where $a_t \equiv \log(A_t/A), \bar{h}_t \equiv \log(\bar{H}_t/\bar{H})$. Note that in this simple model (without government purchases or variation in impatience to consume, for example), q_t is also proportional to the log deviation of the equilibrium level of output in a closed-economy model with flexible wages and prices, or the "natural rate" of output defined in Woodford (2003, chap. 4); it follows from the formulas given there that in the present model,

$$\omega q_t = \kappa \hat{Y}_t^n,$$

where $\kappa \equiv \xi(\omega + \sigma^{-1})$ is the slope of the closed-economy AS curve. Finally, it follows directly from (3.11) that the two output elasticities in the open-economy AS relation are given by

$$\kappa_H = \xi[\omega + \sigma^{-1} + \gamma(1 - \sigma^{-1})],$$

$$\kappa_F = -\xi\gamma(1 - \sigma^{-1}).$$

For the foreign country, we similarly obtain

$$\pi_{Ft}^* = \kappa_H^* \hat{Y}_t + \kappa_F^* \hat{Y}_t^* + \beta E_t \pi_{Ft+1}^* - \xi \omega q_t^*, \tag{3.20}$$

[50] One can easily show that $Y_t = Y_t^* = \bar{Y}$ is the condition under which one will have both $\tilde{\mu} MC_t = P_{Ht}$ and $\tilde{\mu} MC_t^* = P_{Ft}^*$, as is required for a steady state with zero inflation in both countries.

[51] Here again I follow the notation used in Woodford (2003, chap. 4) for the closed-economy model.

where

$$\kappa_H^* = -\xi(1-\gamma)(1-\sigma^{-1}),$$
$$\kappa_F^* = \xi[\omega + \sigma^{-1} + (1-\gamma)(1-\sigma^{-1})],$$

and q_t^* is the corresponding compound of the foreign technology and preference shocks. Equations (3.19)–(3.20) then represent the aggregate supply block of the log-linearized model. Together, they suffice to determine the paths of $\{\pi_{Ht}, \pi_{Ft}^*\}$ given the paths of $\{Y_t, Y_t^*\}$, or vice versa. The CPI inflation rates are also determined if we adjoin the relations

$$\pi_t = \pi_{Ht} + \gamma(\Delta\hat{Y}_t - \Delta\hat{Y}_t^*), \qquad \pi_t^* = \pi_{Ft}^* + (1-\gamma)(\Delta\hat{Y}_t^* - \Delta\hat{Y}_t) \tag{3.21}$$

implied by (3.16) and the corresponding relation for the foreign index.

In the case that the monetary policies of the two central banks are given by equations of the form (1.19)–(1.20), then, as shown in section 1.1, the log-linearized AD block of the model consists of equations (1.21)–(1.24). If we combine these with the log-linearized AS block consisting of equations (3.19)–(3.21), we have a system of 8 equations per period to determine the 8 endogenous variables $\{\pi_t, \pi_{Ht}, \hat{Y}_t, \hat{\imath}_t, \pi_t^*, \pi_{Ft}^*, \hat{Y}_t^*, \hat{\imath}_t^*\}$ each period. In the case that the response coefficients of the two policy rules satisfy certain inequalities, this system has a determinate equilibrium, and when it does, we are able to solve for each of the 8 endogenous variables as a function of current and expected future values of the forcing variables $\{\bar{\imath}_t, \bar{\imath}_t^*, q_t, q_t^*\}$, and the lagged relative output $\hat{Y}_{t-1}^r \equiv \hat{Y}_{t-1} - \hat{Y}_{t-1}^*$.[52] For example, the solution for equilibrium consumer price inflation in the home country will be of the form

$$\pi_t = \sum_{j=0}^{\infty}[\psi_{1,j}E_t\bar{\imath}_{t+j} + \psi_{2,j}E_t\bar{\imath}_{t+j}^* + \psi_{3,j}E_t\hat{Y}_{t+j}^n + \psi_{4,j}E_t\hat{Y}_{t+j}^{n*}] + \delta\hat{Y}_{t-1}^r. \tag{3.22}$$

To what extent do our results imply that globalization should be expected to change the nature of the aggregate-supply relation in each country? One should note first of all that, once again, *financial* globalization has no effect whatsoever in this model. As discussed in section 1, under the preferences assumed here, the equilibrium relation between consumption in each country (and each country's stochastic discount factor) and the world pattern of production is *the same* whether we assume financial

[52]Note that this is the only lagged state variable that appears in any of the 8 structural equations; it appears in (3.21).

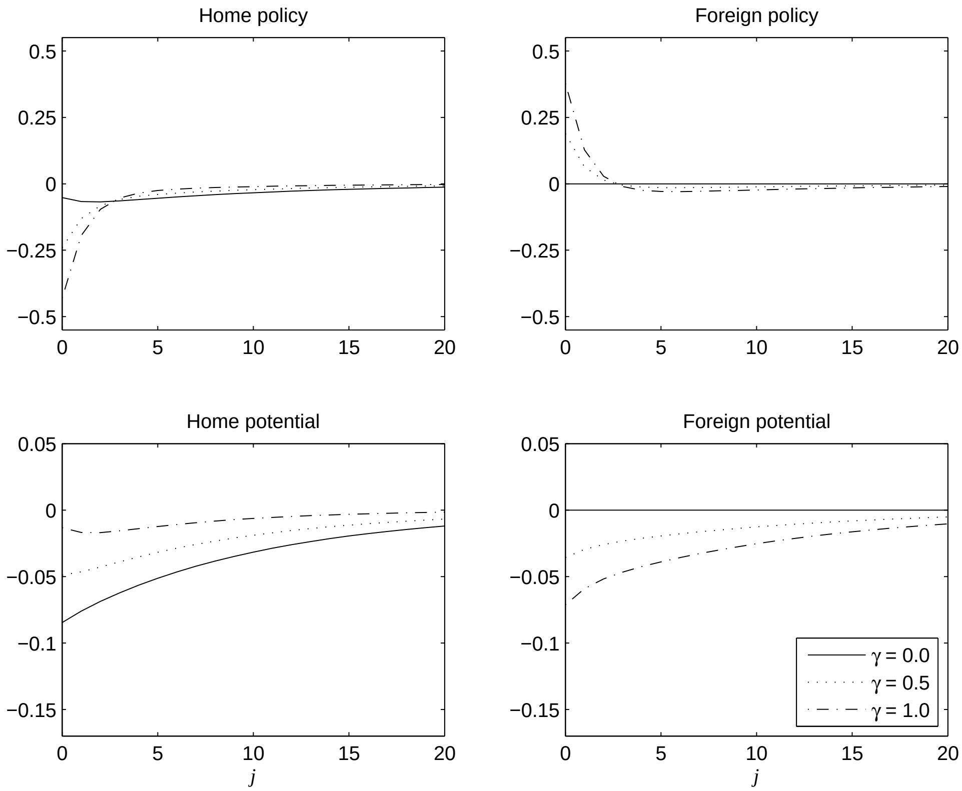

Figure 6: Coefficients of the solution (3.22) for inflation, for alternative degrees of openness.

autarchy, complete international risk sharing, or any kind of incomplete markets or costly international trade in financial assets. Hence the derivation of the aggregate-supply relations above is unaffected by which of these we assume.[53]

[53]This contrasts with the result of Razin and Yuen (2002). These authors do not assume the same preferences as are assumed here (they instead assume the same elasticity of substitution $\theta > 1$ between home and foreign goods as exists among individual home goods or among individual foreign goods), but this is not the main reason for the differing conclusion. Razin and Yuen note that under financial autarchy, consumption each period must fluctuate with domestic income, and assume as a consequence that $\hat{C}_t = \hat{Y}_t$, whereas $\hat{C}_t = \hat{C}_t^*$ (as here) in the case of financial integration. They therefore conclude that domestic consumption (and correspondingly the marginal utility of income of domestic households) will be less sensitive to variations in domestic output in the case of financial integration, making domestic real wage demands less sensitive to domestic output in that case, and hence the slope of the Phillips curve smaller. But their argument neglects the effect of terms of trade changes, which vary with the relative output of the two countries in such a way as to make the

What about the effects of an increase in the degree of integration of goods markets, here modeled by an increase in γ? Figure 6 illustrates the numerical values of the four sequences of coefficients $\{\psi_{k,j}\}$ in (3.22) in the case of policy rules for each country in which $\phi_\pi = 2, \phi_y = 1$, as also assumed in Figure 1, with values for the other structural parameters again taken from the closed-economy model of Rotemberg and Woodford (1997).[54] Once again the figure compares the solutions obtained for three different values of γ. We observe that even in the case of completely integrated goods markets and financial markets, individual national monetary policies still have a substantial effect on the rate of CPI inflation in that country. Indeed, the upper left panel of Figure 6 shows that the immediate effect on inflation of a relatively transitory shift in monetary policy is (at least in the calibrated example) even *larger* in the case of a highly open economy than in the case of an otherwise similar closed economy. Hence whatever other validity there may be to the "global slack" thesis, openness does not reduce the ability of a central bank to influence the local rate of inflation.

3.2 Global Economic Activity and Inflation

Nonetheless, our results above do show that the aggregate supply block of our model, like the aggregate demand block, is affected by the degree of openness of the economy. Equations (3.19) and (3.20) each indicate that in general the other country's level of economic activity is relevant to the determination of a given country's domestic inflation rate. To what extent do they support the view that "global slack" becomes an important determinant of inflation in each country as a result of economic integration?

It is true that for analytical purposes, it may be convenient to solve a model of this kind by first solving for the implied dynamics of "global" endogenous variables, and then solving for national departures from the world averages taking the solution for

number of units of *the consumption basket* that can be purchased with the income from domestic production vary less than does domestic output. In the case of a unit elasticity of substitution between home and foreign goods, as assumed here, the terms of trade effect completely *eliminates* any difference between the effects of variations in Y_t on consumption in the two countries, even under financial autarchy. Under the preferences assumed by Razin and Yuen, the terms of trade effect would be smaller, but will still reduce the degree to which financial integration affects the slope of the Phillips curve, relative to what they find.

[54]In addition to the parameter values used in the numerical illustrations above, I now also assume that $\kappa = 0.0236$.

the world averages as given. Note that (3.21) implies that the world average inflation rate π_t^w (defined as in (1.44)) can also be written as a world average of *domestic* inflation rates,

$$\pi_t^w = (1-\gamma)\pi_{Ht} + \gamma\pi_{Ft}^*.$$

It then follows that we can take a weighted average of (3.19) and (3.20) and obtain

$$\pi_t^w = \kappa(\hat{Y}_t^w - \hat{Y}_t^{nw}) + \beta E_t \pi_{t+1}^w \tag{3.23}$$

as a "global Phillips curve" relation. Here $\hat{Y}_t^w$ is the world average level of output (defined as in (1.45)), and $\hat{Y}_t^{nw}$ is a corresponding average of the *closed-economy* "natural rates of output" for the two economies.

Thus one can argue that "global inflation" is determined by a "global output gap" in this model. In the case that the Taylor-rule coefficients are the same in both countries, the aggregate-demand block of the model also allows us to derive relation (1.56) between world inflation and world output, that does not involve any nation-specific variables. Equations (1.56) and (3.23) then jointly determine the evolution of the world variables $\{\pi_t^w, \hat{Y}_t^w\}$ given the paths of the world disturbances $\{\bar{\imath}_t^w, \hat{Y}_t^{nw}\}$.[55]

In the case of identical Taylor-rule coefficients in the two countries, it is also possible to solve independently for the evolution of the *inflation differential* Δz_t between the two countries. From (3.21) it follows that

$$\Delta z_t = \pi_{Ht} - \pi_{Ft}^* + (\Delta Y_t - \Delta Y_t^*).$$

Then subtracting (3.20) from (3.19) yields a relation of the form

$$\Delta z_t = \beta E_t \Delta z_{t+1} - E_t[C(L)(\hat{Y}_{t+1} - \hat{Y}_{t+1}^*)] - \xi\omega(q_t - q_t^*) \tag{3.24}$$

between the evolution of the inflation differential and the evolution of the output differential, where

$$C(L) \equiv L^2 - (1+\beta+\kappa+\xi(1-\sigma^{-1}))L + \beta.$$

These two variables are also linked by the demand-side equilibrium relation

$$E_t \Delta z_{t+1} = (\bar{\imath}_t - \bar{\imath}_t^*) + \phi_\pi \Delta z_t + \phi_y(\hat{Y}_t - \hat{Y}_t^*), \tag{3.25}$$

[55]This pair of equations has a determinate solution if and only if the Taylor-rule coefficients satisfy the "Taylor Principle" (Woodford, 2003, Prop. 4.3), just as in a closed-economy model. The solutions obtained for the evolution of world inflation and world output are also exactly the same functions of the world disturbances as in the closed-economy model.

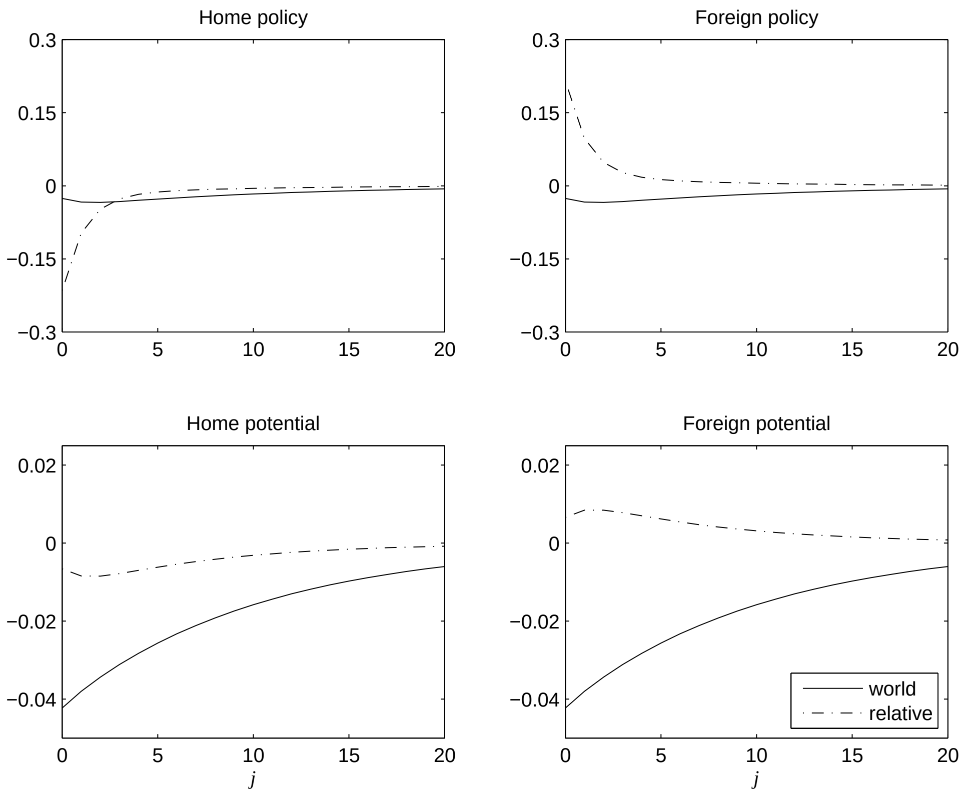

Figure 7: Decomposition of the solution for home-country inflation into solutions for world inflation and relative inflation, shown for the case $\gamma = 0.5$.

which follows from (1.30), when we recall that $e_t = z_t$ in this model. Conditions (3.24)–(3.25) form a system of two equations per period to solve for the evolution of the inflation differential and the output differential, given the paths of the exogenous disturbance $\{q_t - q_t^*\}$ and the policy differential $\{\bar{\imath}_t - \bar{\imath}_t^*\}$. Combining the solution for world inflation with the solution for the inflation differential then yields a solution for inflation in either country; for example,

$$\pi_t = \pi_t^w + \gamma \Delta z_t. \tag{3.26}$$

Figure 7 illustrates the character of the solution for these two components of inflation, in the case of the same parameter values as are assumed in Figure 6. The two lines in each panel indicate the way in which world inflation and relative inflation respectively depend on the current and expected future values of the four forcing variables. To be precise, each panel decomposes the response of CPI inflation to one of the forcing variables shown in Figure 6 for the case $\gamma = 0.5$ into two parts, corresponding to the two terms in (3.26): the effect of the forcing variable on world inflation (the solid line in each panel) and the effect on γ times relative inflation (the dash-dotted line). (If we were to compute a similar decomposition of the inflation responses for any other values of γ than 0.5, the two components would be proportional to those shown in Figure 7, but scaled by factors that depend on γ.) Note that world inflation is affected to precisely the same extent by the forcing variables for each of the countries, while relative inflation is affected by the two countries' forcing variables to the same extent but with the opposite sign.

While this approach to expressing the solution of the complete model has some convenient features, one should not conclude that the "global output gap" is accordingly a crucial determinant of inflation in each country. Our observation about the possibility of writing a "global Phillips curve" relation (3.23) would be equally true in the case of complete *autarchy,* given our assumption of identical parameter values for the two countries (and our use of a log-linear approximation). This might be a useful observation if one were interested in modeling the average world rate of inflation rather than inflation in a single country, but it would not imply any necessity or even convenience of using the concept of the "global output gap" to explain inflation in one country.

Even in the case of two open economies, in the case that $\sigma = 1$, we observe that $\kappa_F = \kappa_H^* = 0$, so that the aggregate-supply relation connects domestic inflation in either country with economic activity in that country alone, as noted by CGG. As shown in section 1.2, the aggregate-demand relations for each economy also connect domestic inflation with domestic output alone in that case, if we assume that monetary policy in each country responds only to the domestic inflation rate. In this case, it is possible to solve equations (1.39), (1.41) and (3.19) for the evolution of the domestic endogenous variables $\{\pi_{Ht}, \hat{Y}_t\}$ given the paths of the domestic endogenous variables $\{\bar{\imath}_t, \hat{Y}_t^n\}$, without any reference to either disturbances or policy in the foreign country. The solution obtained is the same as the one that would be obtained by solving for world average inflation and the inflation differential and summing them; but the latter, more roundabout method conceals the fact that foreign variables actually play no role in determining domestic inflation.

In the more realistic case in which $\sigma > 1$ and monetary policy responds to consumer price inflation rather than to domestic inflation alone, the structural equations for the two countries no longer perfectly decouple. Nonetheless, it remains the case that the mere fact that "global slack" determines the evolution of world inflation through (3.23) does not mean that it will be the main determinant of inflation in individual countries. The upper two panels of Figure 7 (which relate to a case in which $\sigma > 1$ and monetary policy in each country responds to CPI inflation) show that the effects of each country's monetary policy on *relative* inflation swamp the effects on *world* inflation, that are mediated by changes in the world output gap $\hat{Y}_t^w - \hat{Y}_t^{nw}$. Hence the global slack thesis is quite misleading as a guide to understanding the effects of monetary policy on an open economy.

Moreover, in the case in which $\sigma > 1$, we observe that κ_F is *negative,* and thus opposite in sign to κ_H, contrary to what the "global slack" thesis would suggest.[56] Moreover, κ_H is *larger* than the value ($\kappa = \xi(\omega + \sigma^{-1})$ that would be obtained in the case of a closed economy, and by more so the greater the degree of openness. We similarly find that $\kappa_H^* < 0$ and that κ_F^* is larger than the closed-economy value. Hence the supposition on the basis of the global slack thesis that the Phillips-curve tradeoff between domestic inflation and domestic real activity should be *flatter* in a more open economy is not born out.

In the previous paragraph I have considered only the nature of the Phillips-curve tradeoff between domestic inflation and domestic activity. If instead we are interested in the relation between CPI inflation and domestic output, then foreign activity affects this relationship even in the case that $\sigma = 1$, owing to its consequences for the terms of trade. However, the effects of foreign activity on the domestic aggregate-supply relation are again not of the kind suggested by the global slack thesis. The aggregate-supply curve in this case is of the form

$$\log P_t = (\kappa_H + \gamma)\hat{Y}_t + (\kappa_F - \gamma)\hat{Y}_t^*,$$

neglecting the terms corresponding to lagged values, disturbances, and expectations. In this case we have a further reason for openness to *increase* the (positive) slope of the AS curve (*i.e.*, the sensitivity to domestic output), and also for openness to make the effects of foreign output on domestic inflation *more negative*, namely, the way in which both domestic and foreign output affect the terms of trade. Thus to the extent that this model represents the effects of increased international integration of goods

[56] The effect of foreign output is in fact found often to be negative by Ihrig *et al.* (2007).

markets, there is no reason whatsoever to expect that globalization should reduce the sensitivity of domestic inflation to domestic activity.

The global slack thesis is misleading in another respect as well. It suggests that inflationary pressure at home should depend not just on foreign economy, but on foreign activity *relative to potential.* This suggests that domestic monetary policy may need to be conditioned on changes in foreign potential output. This is one of the main reasons why Dallas Fed President Richard Fisher (2006) argues that globalized markets will make the conduct of monetary policy more difficult. "How can we calculate an 'output gap'," he asks, "without knowing the present capacity of, say, the Chinese and Indian economies? How can we fashion a Phillips curve without imputing the behavioral patterns of foreign labor pools?" But according to the model developed above, the Phillips curve for an open economy does not involve foreign potential output or foreign labor supply behavior; the exogenous disturbance term q_t involves only *domestic* technology and preferences regarding labor supply.[57]

In fact, foreign developments affect domestic inflation in this model *solely* through their effects on the terms of trade. The aggregate-supply relation (3.19) can alternatively be written in the form

$$\pi_{Ht} = \kappa(\hat{Y}_t - \hat{Y}_t^n) - \kappa_F \log S_t + \beta E_t \pi_{Ht+1}, \qquad (3.27)$$

where κ is the closed-economy Phillips-curve slope, $\hat{Y}_t^n$ is the closed-economy "natural rate of output" (*i.e.,* the equilibrium level of output in a closed-economy model with flexible prices, which depends only on domestic technology and preferences), and S_t indicates the terms of trade. The domestic aggregate-demand block (consisting of equations (1.39) and (1.41)) can similarly be written entirely in terms of domestic variables and the terms of trade; hence one can solve for the equilibrium paths $\{\pi_{Ht}, \hat{Y}_t\}$ purely as a function of domestic real fundamentals, domestic monetary policy, and the path of the terms of trade.[58] The implied path of CPI inflation,

[57] This is somewhat hidden in the way that the national AS relations are written in Benigno and Benigno (2005). Domestic inflation is written as being determined by a domestic output gap and a terms-of-trade gap, with the "natural" levels of both domestic output and the terms of trade being functions in turn of both q_t and q_t^*. Nonetheless, the domestic aggregate-supply equation actually involves only q_t and not q_t^*, as written here. Benigno and Benigno choose to write the AS relation in terms of their more complicated "gap" variables because of the role of those variables in their expression for the welfare-based stabilization objective; writing the AS equations in terms of the same variables facilitates their characterization of optimal policy.

[58] Even the terms of trade are only relevant to the extent that σ is not equal to 1.

given a path for domestic inflation, also depends only on the terms of trade. Thus while it is true that a policy aimed at stabilizing domestic inflation, CPI inflation, and/or domestic economic activity will need in general to monitor developments with regard to the terms of trade, it will not require a judgment about foreign potential output, except to the extent that views about foreign fundamentals may help one to form a more accurate forecast of the future evolution of the terms of trade. Thus the information requirements for using a Phillips-curve model in the conduct of policy in an open economy are not as daunting as Fisher makes them sound.

Of course, the fact that foreign potential output does not enter the home country's AS relation does not make it irrelevant to equilibrium determination in the home country, as shown by the lower right panel of Figure 6. This is because foreign potential output certainly *does* matter for the foreign AS relation, and hence for the determination of foreign output, inflation, and interest rates, which variables affect the home-economy AD and AS relations. Nonetheless, while Figure 6 indicates that variations in the foreign natural rate of output are of considerable consequence (when γ is large), if one wishes to attribute inflation variations in the home economy to their various ultimate causes, it does not imply that a policymaker in the home country must concern herself with the estimation of foreign potential. In order to correctly understand the structural tradeoffs facing the home economy, it suffices that one be able to forecast the evolution of foreign output, inflation and interest rates; this is especially true in the case of a small economy, that cannot expect its own decisions to have any great effect on the determination of output, inflation or interest rates elsewhere.

3.3 Consequences of Global Factor Markets

The previous section shows that there is no role for "global slack" as a determinant of supply-side inflationary pressure, in an open-economy model where both final goods markets and financial markets are fully integrated, but factor markets are still nation-specific (or perhaps even more segmented). Proponents of the global slack thesis, however, are perhaps concerned with the consequences of global trade in *factors of production* as well. This could mean international integration of labor markets (as emphasized by those who assert that globalization has recently held down real wage demands in countries like the US), or alternatively that internationally traded commodities or imported intermediate goods are important inputs in the domestic production technology, along with labor.

Since both the hypothesis of a global labor market and that of globally traded inputs of other kinds have similar consequences for the way the aggregate-supply relation will come to depend on domestic and foreign real activity, I shall here treat explicitly only the case of a global labor market. I shall also proceed immediately to the extreme case that is most favorable to the global slack thesis. This is the case in which there is only a single kind of homogeneous labor used in production in either country, and a competitive global market for the sale of that labor, so that households in one country can equally easily sell labor to firms in either country. I shall furthermore assume in this section that $\phi = 1$, so that there is no additional fixed (and hence immobile) factor of production, and the marginal cost of production (in units of the world good) will depend *only* on the price of labor in the global market. In such a case, the marginal cost of production is necessarily identical worldwide, regardless of the relative levels of economic activity in the two countries.

The existence of a single global market for labor requires that

$$\frac{W_t}{P_t} = \frac{W_t^*}{P_t^*}, \tag{3.28}$$

so that there is a common world price of labor in units of the world good. Labor supply in each country is still given by a function of the form (3.2), where the real wage is the common world real wage, and the labor employed in each country is still given by (3.7). Hence clearing of the world labor market requires that

$$[(1-\gamma)\bar{H}_t + \gamma\bar{H}_t^*]\left(\frac{W_t}{P_t C_t^{\sigma^{-1}}}\right)^{\nu^{-1}} = (1-\gamma)\frac{Y_t}{A_t}\delta_t + \gamma\frac{Y_t^*}{A_t^*}\delta_t^*. \tag{3.29}$$

(Here I have used (3.28) and the fact that $C_t = C_t^*$ to simplify the left-hand side expression for the world demand for labor.) Equations (3.28)–(3.29) replace the two labor-market clearing conditions (one for each country) in the model with national labor markets that are obtained for each country by equating the right-hand sides of (3.2) and (3.7).

Equation (3.29) can be solved for the world real wage as a function of real activity in the two countries. (Recall that one can use (1.15) to substitute for C_t.) Dividing the real wage by the productivity factor A_t (because we are now assuming a linear production function), we obtain the common marginal cost of production for each firm in the home country. One can again write marginal cost purely as a function of domestic goods prices and real variables by using (1.34) to substitute for P_t, yielding

$$MC_t = \frac{1}{k^{1-\sigma^{-1}} A_t} P_{Ht}\, Y_t^{\gamma+(1-\gamma)\sigma^{-1}} Y_t^{*\gamma(\sigma^{-1}-1)} \left[\frac{(1-\gamma)\frac{Y_t}{A_t}\delta_t + \gamma \frac{Y_t^*}{A_t^*}\delta_t^*}{(1-\gamma)\bar{H}_t + \gamma \bar{H}_t^*} \right]^{\nu}. \qquad (3.30)$$

This condition replaces (3.11) in the case of national labor markets.

The corresponding equation for the marginal cost of production in the foreign country is given by

$$MC_t^* = \frac{1}{k^{1-\sigma^{-1}} A_t^*} P_{Ft}^*\, Y_t^{(1-\gamma)(\sigma^{-1}-1)} Y_t^{*(1-\gamma)+\gamma\sigma^{-1}} \left[\frac{(1-\gamma)\frac{Y_t}{A_t}\delta_t + \gamma \frac{Y_t^*}{A_t^*}\delta_t^*}{(1-\gamma)\bar{H}_t + \gamma \bar{H}_t^*} \right]^{\nu}. \qquad (3.31)$$

Note that even when we assume that there is a single world price for the unique factor of production (and a linear production function), it does not follow that real marginal cost must be the same in the two countries, if we measure real marginal cost in units of the composite domestic good (which is the concept of real marginal cost that measures the incentive for domestic price increases). Instead, MC_t^*/P_{Ft}^* differs from MC_t/P_{Ht}, not only because of the (exogenous) productivity differential between the two countries, but also because of the *terms of trade*. The latter factor depends on the relative output of the two countries, and so can be affected by national monetary policies.

Log-linearizing (3.30) and substituting into (3.18), we obtain an open-economy new-Keynesian Phillips curve for the home economy, given by

$$\pi_{Ht} = \kappa(\hat{Y}_t^w - \hat{Y}_t^{nw}) + \xi\gamma(\hat{Y}_t - \hat{Y}_t^*) + \beta E_t \pi_{Ht+1} - \xi\gamma(a_t - a_t^*). \qquad (3.32)$$

The corresponding aggregate-supply relation for the foreign economy is given by

$$\pi_{Ft}^* = \kappa(\hat{Y}_t^w - \hat{Y}_t^{nw}) - \xi(1-\gamma)(\hat{Y}_t - \hat{Y}_t^*) + \beta E_t \pi_{Ft+1}^* + \xi(1-\gamma)(a_t - a_t^*). \qquad (3.33)$$

Here $\hat{Y}_t^w$ is the same measure of world average output as in (3.23).

Here we find a role for the "global output gap" in determining the evolution of domestic inflation in each country. Nonetheless, even in this most extreme case — when the marginal cost of production in either country depends *solely* on the common world price of a globally traded factor (apart from an exogenous country-specific productivity factor) — it does not follow that domestic monetary policy can

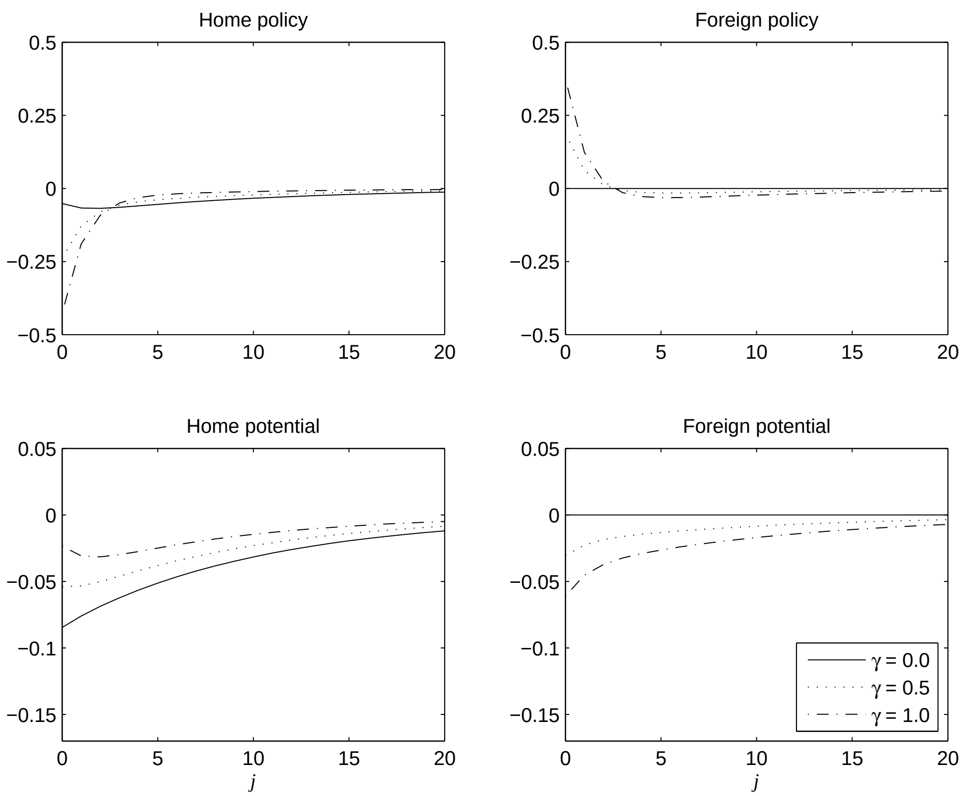

Figure 8: Coefficients of the solution (3.22) for inflation, with a global labor market.

exert no influence over the dynamics of domestic inflation, even in the case of a very small country.

One observes that in the model with a global labor market, the equilibrium solution for home-country inflation is again of the form (3.22). Figure 8 plots the coefficients of this solution, in the same format as in Figure 6, for an economy that is parameterized in the same way as in the earlier figure, except that there is now assumed to be a global labor market.[59] Figure 8 is quite similar to Figure 6; the existence of a global market for all factors of production does not to any notable extent diminish the effect of domestic monetary policy on home-country inflation.

Once again, the key to understanding the effects of domestic monetary policy on

[59]The same value of κ is assumed as in Figures 6 and 7, even though, if we were instead to fix the assumed parameters of the utility function, the assumption here that $\phi = 1$ would imply a different value of κ than the one in the Rotemberg-Woodford model, which involves diminishing returns to labor.

inflation in a small open economy is provided by a consideration of the relations that determine *relative* inflation. If we subtract (3.33) from (3.32), we obtain

$$\Delta z_t = \beta E_t \Delta z_{t+1} - E_t[A(L)(\hat{Y}_{t+1} - \hat{Y}^*_{t+1})] - \xi(a_t - a^*_t), \tag{3.34}$$

where $A(L)$ is again the lag polynomial defined in (1.50). Note that this relation does *not* require the inflation differential to be zero, or even to evolve exogenously in a way determined purely by the evolution of the productivity differential. It also allows for variations in the inflation differential to the extent that there are variations in the relative output of the two countries (owing to a terms-of-trade effect), and the relative output levels depend on the monetary policies of the two countries. In the case that the Taylor-rule coefficients are the same in both countries, equation (3.25) again applies, and equations (3.25) and (3.34) form a system of two equations per period to solve for the evolution of the inflation differential and the output differential, given the paths of the productivity differential $\{a_t - a^*_t\}$ and the policy differential $\{\bar{\imath}_t - \bar{\imath}^*_t\}$.

In the case of a very small country, monetary policy in the home country can have no noticeable effect on the world average inflation rate. But because domestic monetary policy can still affect the inflation differential, it can still affect the domestic inflation rate. (Note that none of the coefficients in either (3.25) or (3.34) depend on γ, so the effects of policy on the inflation differential obtained by solving these equations remains of the same size even if γ approaches 1.) Figure 9 shows how this effect accounts for the results plotted in Figure 8, by decomposing the effects shown in Figure 8 for the case $\gamma = 0.5$ into effects on world inflation and on relative inflation respectively, using the same format as in Figure 7. Even in the case that $\gamma = 0.5$, we observe that the effects of the national monetary policies on relative inflation dominate the effects on world inflation (at least at the short horizons where the effects of policy are largest); since the component of the total effect that results from the effect on relative inflation grows in proportion to γ, the result would be even more dramatic in the case of a larger value of γ (*i.e.*, a smaller open economy).

Nor is it necessarily true, even in the extreme case considered in this section, that global integration of markets reduces the slope of the Phillips-curve tradeoff between domestic inflation and domestic output. One observes that in (3.32), the elasticity of domestic inflation with respect to domestic output is equal to $\tilde{\kappa}_H \equiv \kappa(1-\gamma)+\xi\gamma$. This is smaller than the elasticity κ_H obtained for the open-economy model with national

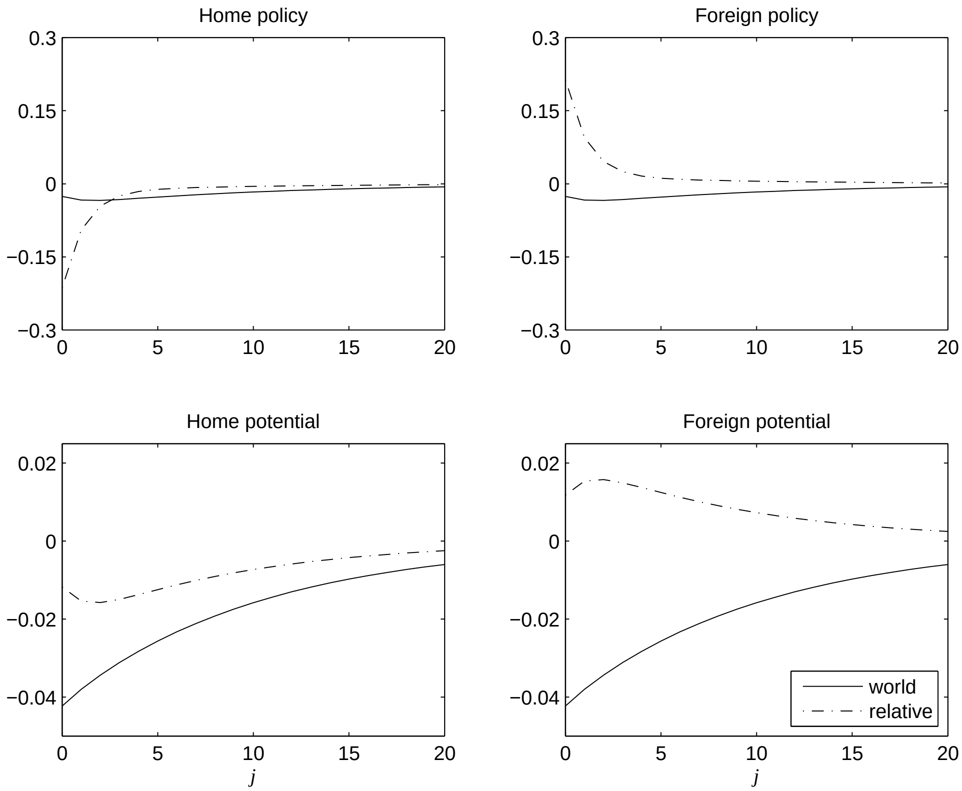

Figure 9: Decomposition of the solution for home-country inflation into solutions for world inflation and relative inflation, in the case of a global labor market.

factor markets (for the same value of γ and all other parameters). However, it is not necessarily smaller than the Phillips-curve slope κ that would obtain in the case of a closed economy. One finds that $\tilde{\kappa}_H < \kappa$ if and only if $\nu + \sigma^{-1} > 1$, which need not be true. For example, it is not true under the calibration adopted by Rotemberg and Woodford (1997) for the US economy (where $\nu + \sigma^{-1} = 0.3$). I have already argued that it is realistic to assume that $\sigma^{-1} < 1$; thus one will have $\tilde{\kappa}_H > \kappa$ for any small enough value of ν, which is to say, in the case of sufficiently elastic labor supply.[60]

[60] In a closed-economy model like that of Rotemberg and Woodford, $\nu+\sigma^{-1}$ measures the elasticity of the real wage with respect to an increase in output that is due to a purely monetary disturbance, *i.e.*, that is not associated with a change in either preferences or technology. Thus if real wages rise less than in proportion to output, one may conclude that $\nu + \sigma^{-1} < 1$. Typical estimates suggest that this is realistic; for example, the VAR study of Christiano, Eichenbaum, and Evans (1996) indicates a real wage response about one-fourth the size of the output response.

Thus even in the extreme case of a world market for all factors of production, common interpretations of the "global slack" thesis would be valid to only a rather limited extent. While foreign economic activity affects the Phillips-curve tradeoff between domestic inflation and domestic activity in such a model, the sign of the effect of foreign output on domestic inflation can easily be *negative*, the opposite of what the global slack thesis would suggest. (Note that $\tilde{\kappa}_F = \gamma(\kappa - \xi) < 0$ if $\omega + \sigma^{-1} < 1$.) Similarly, even if global integration means integration of factor markets as well as final goods markets and financial markets, the slope of the Phillips-curve tradeoff can easily be *increased* by integration rather than being decreased. And certainly global integration of markets does not imply that domestic inflationary pressure ceases to depend on domestic economic activity, so that it ceases to be possible for domestic monetary policy to influence the evolution of domestic inflation. Even in this most extreme case, it remains possible to use monetary policy to stabilize inflation, and this can be done by a national central bank, of even a small country, without requiring coordination with other central banks.

4 Conclusion

All of the arguments made above reach a similar conclusion: it is difficult to think of plausible economic mechanisms through which globalization should impair in any substantial way the ability of central banks to control domestic inflation through national monetary policy. I have considered the consequences of potential increases in international integration of three distinct types — financial integration (including international risk-sharing), goods market integration (including reduction in the share of home goods in a country's consumption basket), and factor market integration — and I have considered the implications of these changes for three distinct links in the transmission mechanism for monetary policy: the relation between interest rates and the intertemporal allocation of expenditure, the means by which central bank actions affect money-market interest rates, and the Phillips-curve relation between real activity and inflation. It has proven difficult to think of cases under which increased openness should lead either to a reduced effect of domestic monetary policy on domestic aggregate demand, or to any substantial reduction of the effects of domestic economic activity on domestic inflation, even when I have considered relatively extreme theoretical possibilities, that go far beyond the degree of international integration that has yet been observed on any of these dimensions.

This does not mean that the degree of openness of an economy is no significance for the conduct of monetary policy. As shown above, changes in the degree of goods market integration, represented by variation in the coefficient γ of preferences, affect the quantitative specification of both the aggregate-demand and aggregate-supply blocks of the simple models of the monetary transmission mechanism considered here; and there would additional quantitative effects of other types of potential changes that have not been taken up here.[61] Furthermore, openness, to the degree that it is significant, forces central bankers to confront a variety of practical issues that would not be present in the case of a closed economy, such as the question whether to stabilize an index of domestic prices only, or an index of the prices of all goods consumed in the domestic economy. And to the extent that the degree of international integration is thought to be changing especially rapidly at present or in the near future, this makes the issue of change over time in the correct quantitative specification of the structural models used in a central bank a more pressing one to consider.

Nonetheless, globalization, even if expected to be rapid, does not seem to justify quite the degree of alarm that some commentators would urge upon central banks. When Richard Fisher declares that "the old models simply no longer apply in our globalized, interconnected and expanded economy," one might imagine that a radical reconceptualization of the determinants of inflation is needed, but I see no reason to expect this. Increased international trade in financial assets, consumer goods and factors of production should lead to quantitative changes in the magnitudes of various key response elasticities relevant to the transmission mechanism for monetary policy, but should not require fundamental reconsideration of the framework of monetary policy analysis. For example, it does not seem that notions such as "global liquidity" or "global slack" are particularly helpful in thinking about the main determinants of inflation, even in the case of a very highly integrated world economy.

[61] For example, the theoretical analysis in this paper deals only with the case in which consumption baskets are identical in all parts of the world, which represents an extreme assumption of integration in one respect; in the case of "home bias" in countries' consumption baskets, the structural relations would be somewhat different. I have also considered only the case of a unit elasticity of substitution between home and foreign goods, in which case financial integration has no consequences for either the aggregate demand or aggregate supply block of the model; but with an elasticity of substitution not exactly equal to one, there would be some quantitative effects (though no radical qualitative changes) of alternative degrees of international financial integration.

Above all, there is little reason to expect that globalization should eliminate, or even substantially weaken, the influence of domestic monetary policy over domestic inflation. Whatever the pace of globalization and however great its eventual extent may be, it should remain possible for a central bank with a consistent strategy directed to the achievement of a clearly formulated inflation target to achieve that goal, without any need for coordination of policy with other central banks. Hence it remains appropriate for central banks to be assigned responsibility for stabilizing a suitably chosen index of domestic prices, despite continuing changes in the real economy, whether domestic or foreign in origin.

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