THE INTERNATIONAL EFFECTS OF MONETARY AND FISCAL POLICY IN A TWO-COUNTRY MODEL

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Abstract

This paper develops a two-country dynamic general equilibrium model with slowly adjusting prices to re-examine the well known analysis by Mundell (1968 Chapter 18) on the international transmission effects of monetary and fiscal policy. We show that the critical factor governing the effects of monetary policy is the currency of export price invoicing, while the critical factor for the effects of fiscal policy is the structure of international assets markets. By contrast, the currency of invoicing is essentially irrelevant for the effects of fiscal policy, while the structure of international assets markets is quantitatively unimportant for the international effects of monetary policy. We present VAR evidence of a positive output comovement and real exchange rate depreciation between the US and the other G7 economies in response to US monetary shocks. This is shown to accord well with the model where export prices are invoiced in foreign currency.

Section 1. Introduction

In Mundell (1968, Chapter 18), Robert Mundell develops a model of the international transmission effects of monetary and fiscal policy shocks in a two-country version of what is now known as the Mundell-Fleming model. Mundell shows that under floating exchange rates, positive monetary policy innovations tend to have a "beggar-thy-neighbor" effect, raising domestic output but, through the effects of real depreciation, lowering foreign output. On the other hand, fiscal policy shocks tend to increase output in both countries.

The intuition behind the Mundell model remains at the center of a vast literature on the international policy transmission mechanism that has developed in the decades since floating

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exchange rates became a reality. It formed the background for
the celebrated Dornbusch (1976) model. Extended versions of the
model were used heavily in the mid-1980's to study the problems
of international macroeconomic policy coordination (e.g.
Mckibbin and Sachs, 1986). More recently, Taylor (1993) uses a
further extended Mundell-type model in an empirical analysis of
international monetary policy in a multi-country environment.

While the Mundell-Fleming model has remained highly
influential in both academic and policy circles, developments in
macro-economics beginning in the late 1970's questioned the use
of models in which the underlying preferences and technology were
not fully specified, and long-run budget constraints were not
satisfied. The re-working of macroeconomic models to encompass
dynamic economic theory is now at an advanced stage. But only
recently have open-economy macro-economists reached the stage
where they can re-address the questions of Mundell within a more
modern framework. An important paper in this regard is that of
Obstfeld and Rogoff (1995)[1] (henceforth OR). They argue that
in order to understand short run macro-economics in the open
economy it is important to move beyond the Mundell-Fleming model
towards a dynamic, utility-maximizing framework, where long run
budget constraints are satisfied.

This paper develops the OR agenda in the direction of re-
addressing the issues analyzed in Mundell (1968). We set up a
two-country, dynamic general equilibrium model where prices
adjust only slowly, and investigate the main characteristics of
the international macro-economic transmission mechanism within
this framework. Two important dimensions of the model that are
explored are a) the currency of export price invoicing, and b)

the degree of completeness of assets markets. In particular, we develop a framework in which export prices may be set in terms of the foreign currency (which we call pricing-to-market), rather than in domestic currency, as assumed by Mundell (1968) and OR. Since prices are sticky, this produces deviations from the Law of One Price (LOOP) which is consistent with the strong recent evidence of deviations from LOOP in traded goods (e.g. Engel and Rogers 1996). The second key feature of the model is that we allow the structure of international assets markets to vary between an environment of complete markets, where there is perfect cross-country coinsurance, and a more limited asset markets environment, where non-contingent bonds are the only asset that may be traded across countries.

We first set out some stylized facts concerning the monetary policy transmission mechanism using G7 data. We show that empirically, positive US monetary policy shocks tend to raise output in both the US and other G7 countries. That is, the international transmission effects of monetary policy on output are positive. In addition, we show that a positive US monetary policy disturbance causes a persistent real exchange rate depreciation, and a persistent fall in US short term interest rates relative to G7 interest rates.

We may summarize our results in two parts. First, for the theoretical analysis of the policy transmission mechanism, there is a sharp dichotomy between the importance of the invoicing currency (or pricing-to-market), and the importance of asset market incompleteness. We find that for the analysis of the international monetary transmission mechanism, the structure of assets markets has very little importance. The monetary

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transmission mechanism differs only slightly between the complete markets environment and the incomplete markets environment. On the other hand, the degree of pricing-to-market is critical to the monetary transmission mechanism. The impacts of monetary policy on output, consumption, the real exchange rate, and the terms of trade are all reversed when we move from a situation of domestic currency export price invoicing to a situation of pricing-to-market.

In the analysis of fiscal policy, we find by contrast that the degree of pricing-to-market is of very little consequence. The international transmission effects of fiscal spending are not sensitive to the currency of export price invoicing. All major aggregates move both qualitatively and quantitatively in the same way under either pricing regime, in response to fiscal spending shocks. However, the structure of international assets markets is critical to the analysis of the transmission of fiscal spending. We find that with complete international assets markets, fiscal spending shocks have no real or nominal exchange rate effects, and no terms of trade impacts at all. Moreover, with complete assets markets, the impact of fiscal spending shocks on consumption and output is identical for all countries. But with limited international assets markets, a domestic fiscal spending expansion will cause a terms of trade deterioration, a real and nominal exchange rate depreciation, and cause domestic and foreign consumption and output to move in opposite directions. Thus, the degree of international insurance available in assets markets is of central importance to the effects of fiscal policy transmission.

The second aspect of our results concerns the match between

our empirical results on the international monetary transmission
mechanism and the findings of our theoretical model. We argue
that the version of the model with pricing-to-market does a good
job of matching the basic stylized facts of the international
monetary transmission mechanism as documented by VAR results.
With pricing-to-market, monetary policy shocks tend to produce a
positive co-movement of output across countries, a persistent
real exchange rate depreciation, and a fall in the international
interest rate differential.

The paper is organized as follows. Section 2 below gives our
empirical results. Section 3 develops the basic model. Section 4
discusses calibration. Section 5 reports the quantitative results
of the model. Section 6 concludes.

Section 2. Empirical Evidence

The goal of the paper is to establish both empirical
evidence and a theoretical model concerning the international
transmission of macroeconomic policy. In this section, we present
some empirical evidence regarding the effects of monetary policy
shocks for output levels, real exchange rates, and interest rates
[2].

We use monthly, seasonally adjusted data from the IMF's
International Financial Statistics data base for the G-7
countries on industrial production, interest rates, aggregate
(CPI) price indices, and bilateral nominal exchange rates with
the US. Using the data for six countries Canada, France, Germany,
Italy, Japan and the UK, we then construct a simple G-7 aggregate
industrial production index, an average price level, an average
short-term, market based nominal interest rate, and an average
nominal bilateral exchange rate with the US. We also employ US

data for each of the first four of these variables, and two measures of US monetary policy instruments; non-borrowed reserves of the Federal Reserve system and the Federal Funds rate. Using the aggregate foreign price index, the US price index and the average nominal exchange rate of the "G-7" aggregate, we construct a multilateral "real exchange rate" between the G-7 aggregate and the US.

We construct and estimate two vector auto-regressions for the purpose of examining the conditional correlation between two measures of orthogonal shocks to US monetary policy, and the interest rates of both the US and the G-7 aggregate, the real exchange rate between the US and the G-7 aggregate, and the output levels of the US and the G-7 aggregate.

The methodology that we employ for estimating and identifying the vector auto-regressions (VAR's) in which the innovation to each variable is orthogonalized is perfectly standard, and we omit a full description of it here **[3].** The basic idea is that we estimate a reduced form VAR, and then identify the Choleski decomposition of this VAR, in which all shocks (including the monetary policy shock) are orthogonalized and in which the monetary shock is ordered first in the empirical model. In other words, we identify an empirical model in which orthogonal shocks to US monetary policy instruments may be construed as "exogenous" policy innovations, in the sense that the setting of values for these shocks by the Fed is independent of current information on outputs, interest rates, and the real exchange rate between the US and the G-7 aggregate, but is conditional on all information on lagged values of these variables.

The two VARs that we estimate are specified as follows. The first is specified in the following vector of endogenous variables which are ordered as indicated in the vector; X = [NBR, I-I*, Y, Y*, RER]'. Here, NBR denotes non-borrowed reserves of the US Federal Reserve, I and I* denote the US and G-7 aggregate short-term net nominal interest rates, Y and Y* are US and G-7 aggregate industrial production indices, and RER=EP*/P denotes the real exchange rate of the US with respect to the G-7 aggregate. In particular, E is the US dollar price of a unit of G-7 aggregate currency, P and P* are the US and G-7 aggregate consumer price indices respectively, and RER is therefore the US consumption goods price of a G-7 aggregate consumption good. All variables are in natural logarithms, except the nominal interest rate differential which is a level. The second VAR is specified in the vector of endogenous variables X = [FF, I*, Y, Y*, RER]'. Here, FF denotes the Federal Funds Rate, and I* denotes the G-7 aggregate short-term, market based net nominal interest rate.

In addition, all variables are H-P filtered and both VARs were estimated with an optimized (by standard criteria) lag length of four. In choosing to H-P filter the data, we are assuming that each of the variables in the VAR are likely to be characterized by a stochastic trend component. Obviously, there are many potential pitfalls in applying the HP filter, especially if the variables are actually stationary. For example, Cogley and Nason (1995) present results indicating that the HP filter induces correlation and business cycle dynamics even if none are present in the original date. However, equally, there are many pitfalls involved in actually testing for stochastic non-stationarity and assuming a VAR specification based on, for

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example, first differencing the data and possibly incorporating error correction terms to account for estimated co-integrating vectors between the relevant series. These pitfalls are largely associated with the power properties of such tests.

We choose to employ the HP filter so as to maintain consistency with data typically used to evaluate business cycle models. We feel that it is unlikely that our variables are co-integrated (for example, due to the presence of productivity trends in the output or real exchange rate series). We did estimate the same VARs using first differenced data, and found that the results are qualitatively unchanged, although the impulse response functions - which map out the dynamic effects for each of the endogenous variables of money shocks – exhibit greater variability.

The results that we obtain for the first and second VAR specifications are illustrated in Figures 1a-1d and Figures 2a-2d respectively. These are the impulse response functions for the real exchange rate, the relevant interest rate variable, and industrial outputs to a one standard deviation expansionary innovation to the relevant monetary policy instrument. As is clear, the qualitative and even quantitative features of the responses of interest rates, industrial output levels, and the real exchange rate are virtually identical across the two specifications. First, there is a large, persistent and significant real exchange rate depreciation associated with either monetary impulse (a one standard deviation positive innovation to NBR and a one standard deviation negative innovation to the Federal Funds rate). Second, in response to a positive innovation to NBR there is a large and significant

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"liquidity effect" for the nominal interest differential, while
in response to a negative innovation to the Federal Funds rate
there is a large and significant liquidity effect for the G-7
aggregate interest rate. Third, US output first experiences a
very small, and barely significant initial decline, but this
is then immediately reversed in the direction of a positive
and highly significant increase **[4]**. Finally, it is
evident that in either specification of monetary policy shocks,
the foreign output response - while delayed for a period of six-
eight months - is ultimately positive and significant.

We found these responses to be robust to several changes in
ordering of the endogenous variables, and to alternative
specifications of the model. In particular, we found that when
the same VARs are estimated separately for each G-7 country vis
the US, our results are qualitatively identical to those which we
report here **[5]**.

Based on earlier empirical work of our own (Betts and
Devereux (1996, 1998)) as well as that of others (Eichenbaum and
Evans (1995) and Schlagenhauf and Wrase (1995)) and the
additional results that we have reported here, we regard the
positive output responses, real exchange rate depreciation, and
liquidity effects for interest rates following monetary policy
innovations as "stylized" facts to be accounted for by any good
model of the international monetary transmission mechanism. We
now develop a model in which, among other things, can account for
the positive output transmission of monetary policy shocks.

**Section 3. A two-country model of the policy transmission
mechanism**

Modern approaches to the analysis of international

macroeconomic policy transmission rely heavily on formal modeling of the type developed in OR. In this section we develop a model which can be used to explore the questions posed by Mundell, except that it based explicitly on formal utility and profit maximization in an inter-temporal setting, and the imposition of inter-temporal budget constraints on all agents.

The model has two countries, which we denote "home" and "foreign". Within each country, there exist consumers, firms and a government. Government spends directly on goods and services, and issues fiat money. To keep the analysis simple, we will not formally distinguish between the central bank and the fiscal authority.

We assume that there is continuum of goods varieties in the world economy of measure 1, and that the relative size of the home and foreign economy's share of these goods is *n* and *1-n* respectively. We choose units so that the population of the home and foreign country is also *n* and *1-n*, respectively. In addition, in each country, a fraction *s* of goods varieties are invoiced in the currency of the buyer, while the remaining *1-s* goods varieties are priced in the currency of the seller. As we describe in greater detail below, firms that produce *s* good varieties are also assumed to be able to segment markets, country by country, while firms that produce *1-s* good varieties cannot. Thus, it is possible for the prices of *s* goods in the home and foreign market to exhibit deviations from the Law of One Price, while the prices of *1-s* goods must always satisfy the Law of One Price.

Let the state of the world be defined as z_t. In each period *t*, there is a finite set of possible states of the world. Let z^t

denote the history of realized states between time 0 and t, i.e.

$z^t = \{z_0, z_1, \dots z_t\}$. The probability of any history, z_t, is denoted by

$\pi(z^t)$.

Typically, we will write the features of the model for the home country economy alone. The conditions for the foreign country are analogously defined in all cases, except those that are explicitly derived.

Consumers

We assume that preferences are identical across countries. In the home country, consumers have preferences given by

(1)
$$EU = \sum_{t=0}^{\infty} \sum_{z^t} \beta^t \pi(z^t) U(C(z^t), \frac{M(z^t)}{P(z^t)}, (1 - h(z^t)))$$

where $C(z^t) = \left(\int_0^1 c(i, z^t)^{1 - 1/\rho} di \right)^{\rho/(\rho - 1)}$, and $c(i, z^t) = \left(\sum_0^N x(i, j, z^t)^{1 - 1/\lambda} \right)^{\lambda/(\lambda - 1)}$. In

addition, we assume the specific functional form given by

$$U(C, \frac{M}{P}, 1 - h) = \frac{C^{1-\sigma}}{1-\sigma} + \frac{\varsigma}{1-\varepsilon} \left(\frac{M}{P} \right)^{1-\varepsilon} + \eta \ln(1 - h).$$

The consumer derives utility from a composite consumption

good $C(z^t)$, real home country money balances $\frac{M(z^t)}{P(z^t)}$, and leisure,

Where $h(z^t)$ represents hours worked. The composite consumption good is an aggregate of a continuum of differentiated varieties, where $c(i, z^t)$ represents the consumption of variety i. Within each variety, there is a further dis-aggregation into N types, so that $x(i, j, z^t)$ represents the consumption of variety i, type j good. We introduce types of good within each variety in order to allow

for a distinction between two key parameters in the model; the elasticity of substitution between home and foreign goods, and the parameter governing price markups over marginal costs.

Households also value real home-currency money balances, where the home CPI is defined as

$$P(z^t) = \left[\int_0^n p(i,z^t)^{1-\rho} \, di + \int_n^{n+(1-n)s} p^*(i,z^t)^{1-\rho} \, di + \int_{n+(1-n)s}^1 (e(z^t)q^*(i,z^t))^{1-\rho} \, di \right]^{1/(1-\rho)}$$

The CPI depends on the price of *n* home goods, and *1-n* foreign goods. Of these foreign goods, *s* goods are priced in domestic currency and have prices denoted $p^*(i,z^t)$, and *1-s* goods are priced in foreign currency and satisfy LOOP, so that the home country price must be $e(z^t)q^*(i,z^t)$ where $e(z^t)$ is the exchange rate (price of foreign currency), and $q^*(i,z^t)$ is the foreign country price of variety *i*. Within each variety, there is a further sub-price index defined as $p(i,z^t) = \left[\sum_0^N p(i,j,z^t)^{1-\lambda} \right]^{1/(1-\lambda)}$.

The representative consumer in the home country receives income in wages and rents from employment and holdings of physical capital respectively, profits from the ownership of domestic firms, income from asset holdings and existing money balances, and accepts transfers and/or pays taxes to the domestic government. Households then consume, accumulate capital and money balances and purchase new assets.

We explore the consequences of two asset market structures. In the first type, there exists full and complete state contingent asset markets. Agents can buy nominal state-contingent bonds. The home country budget constraints are then written as

(2) $\quad P(z^t)C(z^t) + M(z^t) + \sum_{z^{t+1}} w(z^{t+1}, z^t)b(z^{t+1}) + P(z^t)V(z^t) =$

$$W(z^t)h(z^t) + R(z^t)K(z^t) + \Pi(z^t) + M(z^{t-1}) + b(z^t) + TR(z^t)$$

where

$$(3) \quad K(z^t) = \phi\left(\frac{V(z^{t-1})}{K(z^{t-1})}\right)K(z^{t-1}) + (1-\delta)K(z^{t-1})$$

The home consumer purchases a portfolio of state contingent home-currency denominated nominal bonds at price $w(z^{t+1}, z^t)$. In addition, she purchases a composition investment good $V(z^t)$, which requires the same basket of goods as the consumption index, and which forms next period's capital holdings. Since the investment good is constructed in the same way that the composite consumption good is, they have the identical composite price $P(z^t)$. The consumer also receives net transfers $TR(z^t)$ from the government, and nominal, domestic currency profits from all domestic firms which are denoted by $\Pi(z^t)$. In addition, $R(z^t)$ denotes the nominal rental return on a unit of capital, and δ denotes the depreciation rate of capital.

Investment is used to accumulate household capital according to equation *(3)*. Accumulating capital is subject to adjustment costs. An increase in investment of 1 unit raises the next period capital by $\phi'(.)<1$ units. The function $\phi(.)$ must satisfy the conditions $\phi'(.)>0$ and $\phi''(.)<0$.

In the second type of asset market structure, following OR, we assume that the only assets that can be traded are non-state contingent one-period home currency denominated nominal bonds. In this economy, the home consumer's budget constraint is written as

$$(4) \quad P(z^t)C(z^t) + M(z^t) + w(z^t)B(z^t) + P(z^t)V(z^t)$$

$$W(z^t)h(z^t) + R(z^t)K(z^t) + \Pi(z^t) + M(z^{t-1}) + B(z^{t-1}) + TR(z^t)$$

again subject to equation *(3)*, where $w(z^t)$ is the time *t* nominal

bond price. The key difference between (3) and (4) is that in the

latter, the consumer can only smooth out the effects of income

fluctuations over time, and not across states of the world.

    The consumer's optimal consumption, money holdings,

investment, and labor supply may be described by the following

familiar conditions. First, in the complete markets environment

we have the following conditions

$$(5)\quad w(z^{t+1}, z^t)C(z^t)^{-\sigma} = \beta\pi(z^{t+1})\frac{P(z^t)}{P(z^{t+1})}C(z^{t+1})^{-\sigma}$$

$$(6)\quad \frac{M(z^t)}{P(z^t)} = \left[\varsigma C(z^t)^\sigma \frac{1+i(z^t)}{i(z^t)}\right]^{1/\varepsilon}$$

$$(7)\quad \frac{\eta}{1-h(z^t)} = \frac{W(z^t)}{P(z^t)C(z^t)^\sigma}$$

$$(8)\quad \frac{C(z^t)^{-\sigma}}{\phi'\left(\dfrac{V(z^t)}{K(z^t)}\right)} = \beta\sum_{z^{t+1}}\pi(z^{t+1})C(z^{t+1})^{-\sigma}\left[\frac{R(z^{t+1})}{P(z^{t+1})} + J(z^{t+1}, z^t)\right]$$

where

$$J(z^{t+1}, z^t) = \frac{1}{\phi'\left(\dfrac{V(z^{t+1})}{K(z^{t+1})}\right)}\left[\phi\left(\frac{V(z^{t+1})}{K(z^{t+1})}\right) - \phi'\left(\frac{V(z^{t+1})}{K(z^{t+1})}\right)\frac{V(z^{t+1})}{K(z^{t+1})} + (1-\delta)\right]$$

Equation (5) describes the state contingent choice of inter-

temporal consumption smoothing, while (6) gives the implied

demand for money of the consumer. The term $i(z^t)$ represents the

nominal interest rate, where $\dfrac{1}{1+i(z^t)} = \sum_{z^{t+1}} w(z^{t+1}, z^t)$. Equation (7)

describes the labor supply choice, while (8) results from the optimal choice of investment in the presence of adjustment costs.

In the incomplete markets environment, equations (6), (7) and (8) continue to hold (where in (6), the nominal discount factor is now defined as $\dfrac{1}{1+i(z^t)} = w(z^t)$). Equation (5) is replaced by

(9) $\quad w(z^t)C(z^t)^{-\sigma} = \beta \sum_{z^{t+1}} \dfrac{P(z^t)}{P(z^{t+1})} C(z^{t+1})^{-\sigma}$.

Cross-Country Consumption Insurance

The different asset market structures principally affect the possibilities for cross country consumption insurance. In the complete markets environment, it is easy to establish that optimal risk sharing will imply

(10) $\quad \dfrac{C(z^t)}{C^*(z^t)} = \Lambda \left(\dfrac{Q(z^t)e(z^t)}{P(z^t)} \right)^{1/\sigma}$

where Λ is a constant reflecting initial wealth differences. This says that if PPP holds, then consumption levels are equated up to the constant Λ as agents confront identical commodity prices. Here Q represents the foreign price. Movements in the real exchange rate, or departures from PPP, however, will be reflected in different consumption rates. Despite the presence of complete insurance markets, it is not efficient to fully equalize consumption rates across countries unless PPP holds. As we see below, the presence of pricing-to-market will lead to persistent deviations from PPP.

In the bond market economy, on the other hand, there is no

possibility for state contingent consumption insurance. However, the (home currency) nominal interest rate facing domestic and foreign agents is equal. Thus, we have

$$(11)\quad w(z^t)=\beta\sum_{z^{t+1}}\pi(z^{t+1})\frac{P(z^t)}{P(z^{t+1})}\frac{C(z^{t+1})^{-\sigma}}{C(z^t)^{-\sigma}}=\beta\sum_{z^{t+1}}\pi(z^{t+1})\frac{Q(z^t)}{Q(z^{t+1})}\frac{e(z^t)}{e(z^{t+1})}\frac{C^*(z^{t+1})^{-\sigma}}{C^*(z^t)^{-\sigma}}$$

While in the complete markets economy, deviations from PPP determine cross-country differences in the levels of consumption, in the bond market economy they drive a wedge between home and foreign country consumption growth rates. This is the critical difference between the two asset

market structures.

Government

Governments in each country print money and levy taxes, and purchase goods to produce a composite government consumption good. To economize on notation, we assume the government does not issue bonds, and so must always balance its within period budget. It is assumed that the government composite good is produced using the same aggregator that private consumption and investment goods use. The home country government budget constraint is then

$$(12)\quad M(z^t)-M(z^{t-1})=P(z^t)G(z^t)+TR(z^t)$$

where $G(z^t)$ represents the government composite good. We assume that the share of government spending in GDP is set by policy at rate θ_t.

Firms

Firms in each country hire capital and labor to produce output. For each type of good of each variety, there is a separate, price-setting firm. The number of firms within each variety, N, is sufficiently large that each firm ignores the impact of its

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pricing decision on the aggregate price index for that variety. A firm of variety i, type j, has production function given by

(13) $\quad y(i,j,z^t) = k(i,j,z^t)^\alpha \, \ell(i,j,z^t)^{1-\alpha} - v$

where $k(i,j,z^t)$ is capital usage and $\ell(i,j,z^t)$ is labor usage. Firms must also bear a fixed cost of production v.

All firms will choose factor bundles to minimize costs. Thus, we must have

(14) $\quad W(z^t) = MC(z^t)(1-\alpha) \dfrac{y(i,j,z^t)}{\ell(i,j,z^t)}$

(15) $\quad R(z^t) = MC(z^t)\alpha \dfrac{y(i,j,z^t)}{k(i,j,z^t)}$

where $MC(z^t)$ is nominal marginal cost, which must be equal for all firms within the home economy. From (13), (14) and (15), it is clear that all firms in the home economy will have the same capital-labor ratio.

Pricing

We assume that firms must set nominal prices in advance. There are two features to the price setting mechanism. The first concerns the currency of pricing. As we noted above, a subset s of firms set prices in the currency of the buyer. Thus a home firm in this category will set a price p for sale to home consumers, but a price q, denominated in foreign currency, for sale to foreign consumers. An unanticipated change in the exchange rate will cause a deviation from the Law of One Price, which would require that $p=eq$. To avoid the arbitrage opportunity that is implied by this deviation, the firm must be able to segment its home and foreign markets. We denote this type of pricing behavior as that of *pricing-to-market* (PTM). The

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remaining *(1-s)* of firms are unable to segment their markets by country, and must set a unified price. In this case, we assume they price in their home currency. Thus a home firm in this category will set its price *p*, the same price charged to both home and foreign consumers.

The second feature of price setting is the way in which prices adjust. Following Calvo (1983), Yun (1996) and Kimball (1996), we assume that firms change their prices at random intervals dictated by a Poisson arrival rate. Each sector changes its price with probability $(1-\gamma)$ in any period. Thus, the average time between price changes for any one firm is $1/(1-\gamma)$. Then, by the law of large numbers, exactly $(1-\gamma)$ times the number of sectors (and therefore firms) in the economy will be changing their price in any given period.

The exact price-setting problem that is faced by the firm will depend on the degree of market completeness. Take first the case of complete markets. Given preferences as stated above, the firm will at any period face a price elasticity of demand equal to λ. Since its current price choice will affect its future expected profits, the firm will face the problem of choosing prices to maximize state contingent profits. Take the case of a PTM firm in the home economy. Its' state-contingent profits, in present value, may be written as

(16) $\sum_{t=0}^{\infty}\sum_{z^t}\varphi(z^t)\gamma^t[p(i,j,z^t)x_d(i,j,z^t)+e(z^t)q(i,j,z^t)x_d^*(i,j,z^t)$

$$-MC(z^t)(x_d(i,j,z^t)+x_d^*(i,j,z^t))]$$

where $\varphi(z^t)=\prod_{j=1}^{t}w(z^j,z^{j-1})$, for $t=1,2,..$ is the period 0 price of a delivery of one dollar in state z^t, with $\varphi(z^0)=1$.

With incomplete markets, the appropriate objective function for the firm is less clear. We will assume that the firm chooses prices so as to maximize the expected present value of profits, using the market nominal discount factors **[6]**. The firms objective function in this case is then

(17) $E_0 \sum_{t=0}^{\infty} \Omega(z^t) \gamma^t [p(i,j,z^t) x_d(i,j,z^t) + e(z^t) q(i,j,z^t) x_d^*(i,j,z^t)$

$$- MC(z^t)(x_d(i,j,z^t) + x_d^*(i,j,z^t))]$$

where $\Omega(z^t) = \coprod_{j=1}^{t} w(z^{j-1})$, for $t = 1,2,..$, with $\Omega(z^0) = 1$.

A PTM firm that is changing its price in a given period t will choose its prices for the domestic and foreign markets p and q, respectively, to maximize (16) or (17), depending upon the asset market structure. From the structure of the model described above it is clear that each firm will face a constant price elasticity of demand equal to λ. Now define as $\tilde{p}(i,j,z^t)$ the price set by firm j, in sector i, when it newly sets its price at time t, given the history z^t. Choosing $\tilde{p}(i,j,z^t)$ to maximize (16) gives the condition

(18) $\tilde{p}(i,j,z^t) = (1 - \sum_{z^{t+1}} \omega(z^{t+1}, z^t)) \frac{\lambda}{\lambda - 1} MC(z^t) + \sum_{z^{t+1}} \omega(z^{t+1}, z^t) \tilde{p}(i,j,z^{t+1})$

where $\omega(z^{t+1}, z^t) = \dfrac{\gamma w(z^{t+1}, z^t) \sum_{k=t+1}^{\infty} \sum_{z^k} \varphi(z^k) \gamma^{k-t-1} x(i,j,z^k)}{\sum_{k=t}^{\infty} \sum_{z^k} \varphi(z^k) \gamma^{k-t} x(i,j,z^k)}$

That is, the optimal newly set price the firm is a function of current and expected future marginal costs.

Likewise, the newly set price for the foreign market can be described by the condition

(19) $\quad \tilde{q}(i, j, z^t) = (1 - \sum_{z^{t+1}} \vartheta(z^{t+1}, z^t)) \frac{\lambda}{\lambda - 1} \frac{MC(z^t)}{e(z^t)} + \sum_{z^{t+1}} \vartheta(z^{t+1}, z^t) \tilde{q}(i, j, z^{t+1})$

where $\quad \vartheta(z^{t+1}, z^t) = \dfrac{\gamma w(z^{t+1}, z^t) \sum_{k=t+1}^{\infty} \sum_{z^k} \varphi(z^k) \gamma^{k-t-1} x*(i, j, z^k)}{\sum_{k=t}^{\infty} \sum_{z^k} \varphi(z^k) \gamma^{k-t} x*(i, j, z^k)}$

Note in comparing (18) and (19), we see that in a perfectly deterministic environment, the firm would always set its price so that $\tilde{p} = e\tilde{q}$, i.e. the law of one price would hold. This is the result of the fact that the elasticity of demand is constant and the same in the home and foreign market. Furthermore, this will be true of all goods as a result of the symmetry across firms. As a result, in a deterministic environment without monetary or fiscal policy shocks, PPP will hold. But in the presence of exchange rate uncertainty, there will be systematic deviations from the law of one price in the newly set prices.

While we have only examined the case of a PTM firm in the home economy, it is clear that a non-PTM firm's price will be described solely by the condition (18).

In the incomplete assets markets case, the pricing decision will be described exactly as in (18) and (19), save for the fact that the weights ω and ϑ will differ by the different definition of the discount factor. Since all our results are derived by linear approximation, this makes no difference in what follows.

The structure of firms is entirely symmetric, so it is clear that all home firms, in any sector, will set the same value of $\tilde{p}$ and $\tilde{q}$. In addition, for any sector i, we have the price given by (slightly abusing notation) $p_t(i) = (1 - \gamma)\tilde{p} + \gamma p_{t-1}(i)$.

Then defining the home country priceindex for home-priced goods as

$$p(z^t)^{1-\rho} = \int_0^n p(i, z^t)^{1-\rho} di$$

and using the law of large numbers, we see that

(20) $p(z^t)^{1-\rho} = (1-\gamma)\tilde{p}(z^t)^{1-\rho} + \gamma p(z^{t-1})^{1-\rho}$.

In a parallel manner, if we define the index of prices of foreign currency invoiced goods by home country sectors as

$$q(z^t)^{1-\rho} = \int_{n(1-s)}^{ns} q(i, z^t)^{1-\rho} di$$

we may show that

(21) $q(z^t)^{1-\rho} = (1-\gamma)\tilde{q}(z^t)^{1-\rho} + \gamma q(z^{t-1})^{1-\rho}$

Market Clearing

Within a country, all firms use the same capital labor ratio. Therefore we may aggregate across firms and sectors to define the aggregate output in the home economy as

$$y = K^\alpha h^{1-\alpha} - vN$$

Output must equal aggregate demand for the home. Total demand comes from the following sources. First, there is demand for the consumption goods of the non-PTM firms, by both home and foreign consumers. Then there is the demand for the consumption goods of the PTM firms by home consumers and foreign consumers separately. Second, there is demand for investment goods of both non-PTM and PTM firms. Finally, there is the demand by government for the output of all firms. The market clearing equation for the home country may then be written (for ease of notation we ignore the state notation here).

$$(22) \quad (K^\alpha h^{1-\alpha} - vN) = (1-s)\left[\left(\frac{p}{P}\right)^{-\rho} n(C+V+G) + \left(\frac{p}{eQ}\right)^{-\rho}(1-n)(C*+V*+G*)\right]$$

$$+ s\left[\left(\frac{p}{P}\right)^{-\rho} n(C+V+G) + \left(\frac{q}{Q}\right)^{-\rho}(1-n)(C*+V*+G*)\right].$$

The expression on the left-hand side gives the level of average output per capita for the home country. This is smaller, the higher is the fixed cost per sector vN. The first expression on the right hand side indicates that demand for the non-PTM good depends on its price, relative to the price faced by the home consumer, P, and, separately, the price faced by the foreign consumer (in home currency units), eQ. Here we are using the properties of demand implied by the CES aggregator for C, V, and G **[7]**. Likewise, for the PTM firms, the second expression indicates that demand depends on prices facing the home consumer and the foreign consumer separately.

A similar market clearing equation holds for the foreign country;

$$(23) \quad (K*^\alpha h*^{1-\alpha} - vN) = (1-s)\left[\left(\frac{eq*}{P}\right)^{-\rho} n(C+V+G) + \left(\frac{q*}{Q}\right)^{-\rho}(1-n)(C*+V*+G*)\right]$$

$$+ s\left[\left(\frac{p*}{P}\right)^{-\rho} n(C+V+G) + \left(\frac{q*}{Q}\right)^{-\rho}(1-n)(C*+V*+G*)\right].$$

Note finally that, using the defined sub-price indices above, we may write the CPI definitions for the home and foreign country as

$$(24) \quad P(z^t) = \left[np(z^t)^{1-\rho} + (1-n)sp*(z^t)^{1-\rho} + (1-n)(1-s)eq*(z^t)^{1-\rho}\right]^{1/(1-\rho)}$$

$$(25)\quad Q(z^t) = \left[(1-n)q*(z^t)^{1-\rho} + nsq(z^t)^{1-\rho} + n(1-s)\left(\frac{p(z^t)}{e(z^t)} \right)^{1-\rho} \right]^{1/(1-\rho)}.$$

Equilibrium

We may characterize the equilibrium of the two-country economy by collecting the equations set out above. First, for the case of complete asset markets, equations (3), (6) (with (5) substituted in for *w(.,.)*) (7), (8), (14), (15), (18), (19), (20), (21), all with their counterparts for the foreign economy, as well as equations (10), (22), (23), (24), and (25), give 25 equations. This represents a dynamic system in the 25 unknown variables given by $X(z^t)$ where

$$X(z^t) = \{ C, C*, h, h*, V, V*, K, K*, W, W*, R, R*, p, q, p*, q*, P, Q, \tilde{p}, \tilde{q}, \tilde{p}*, \tilde{q}*, MC, MC*, e \}$$

In the economy with incomplete markets, equation (10) is replaced with equation (11). Moreover, because there is not full risk-sharing, we must determine the initial allocation of consumption across countries, which requires use of the balance of payments equation (4). Given (13), we may rewrite (4) as

$$(26)\quad P(z^t)C(z^t) + q(z^t)B(z^t) + P(z^t)V(z^t) + P(z^t)G(z^t) =$$

$$\int_0^{n(1-s)} p(i,z^t)y^1(i,z^t)di + \int_{n(1-s)}^{n} [p(i,z^t)y^2(i,z^t) + e(z^t)q(i,z^t)y^3(i,z^t)]di + B(z^{t-1})$$

Equation (27) is explained as follows. The left-hand side is the value of current home country expenditure on consumption, investment, and government goods, plus the value of new bond purchases from the rest of the world. The right hand side measures the value of output of all home country firms, plus the value of initial bonds. Note that home country firms consist of

non-PTM firms and PTM firms, and these must be summed separately. The variable $y^1(i,z^t)$ for instance measure the output of all firms in sector i, when i is a non-PTM sector.

In general, there will be no easy way to aggregate output values across firms to simplify the right hand side of (27). This is because different sectors will be changing prices at different times. However, in the solution of the model, we take a linear approximation around an initial steady state. In the linear approximation, we can aggregate across sectors directly.

To conclude, we write the solution for the economy with incomplete markets represents 26 equations in the variables $X'(z^t)$, where

$$X'(z^t) =$$

$$\{C, C^*, h, h^*, V, V^*, K, K^*, W, W^*, R, R^*, p, q, p^*, q^*, P, Q, \tilde{p}, \tilde{q}, \tilde{p}^*, \tilde{q}^*, MC, MC^*, e, B(z^t)\}$$

We solve the model by linearizing around an initial zero-shock steady state.

Section 4 Calibration

The calibrated parameters for the baseline case are reported in Table 1. The rationale for the calibration is as follows. For a quarterly frequency, β is chosen to equal .99, which gives a 4 percent steady state annual real interest rate (abstracting from long run growth). The value of η is chosen so that the representative agent in both countries chooses to work 30 percent of available time, the standard calibration in RBC models.

The parameters ε and σ govern the consumption and interest

elasticity of money demand. The consumption elasticity of money

demand is equal to $\dfrac{\sigma}{\varepsilon}$. The interest elasticity of money demand is

$\dfrac{\beta}{\varepsilon(1+\mu)}$. These two elasticities are critical for the response of

the real and the nominal exchange rate to monetary shocks.

Mankiw and Summers (1986) estimate a consumption elasticity of

money demand almost precisely equal to unity. Other estimates

have been reported either higher or lower. Helliwell, Conkerline

and Lafrance (1990) report a large number of estimated money

demand elasticities for G7 countries that are typically used in

macro models. These differ somewhat across countries, but for

many countries the income elasticity for narrower definitions of

money are below unity. For instance, the reported Fair and Taylor

(1983) model uses an estimated elasticity for M1 of .85 for the

US and .55 for Japan.

We choose parameters for our baseline case so that $\dfrac{\sigma}{\varepsilon}$=.85,

consistent with Fair and Taylor's estimate. Estimates of the

interest elasticity of M1 vary from a value of 0.02 reported in

Mankiw and Summers (1986) to values around 0.25 reported in the

Helliwell et al. (1990). We choose a value of 0.12, which is

approximately half way between these estimates. With money growth

rate equal to 6 percent annual, this requires a relatively low

inter-temporal elasticity of substitution, i.e. $\sigma=7$.

The markup parameter λ is set so that markups are equal to

those found by Basu and Fernald for US data, i.e. in the region

of 10 percent. This requires a high elasticity of substitution

between goods within sectors. On the other hand, the elasticity

of substitution between sectors is set so that the elasticity of

substitution between foreign and domestic goods (ρ) is equal to 1.5, the number used in Backus, Kehoe, and Kydland (1994). The steady state depreciation rate of capital is set at 10 percent per year, so that $\delta = 0.025$. The fixed cost parameter ν is then set to produce average profits of zero, in accordance with evidence of very small pure profits in the US economy.

Money Growth rates are set at 6 percent per year, the share of government in GDP is set at 0.2, and the relative size parameter is set at 0.5, so that each country is of equal size. The price adjustment parameter is set so that the firm's average frequency of price adjustment is approximately 4 quarters. This requires $\gamma = 0.75$.

In the steady state, the adjustment cost function ϕ must equal the rate of depreciation. In addition, we also need to set the elasticity of Tobin's q (which is $1/\phi'$), with respect to investment. The higher is this elasticity, the greater time it takes to adjust the capital stock. Following Baxter and Crucini (1993), we set this elasticity so that the variability of investment relative to output in the simulated model is at reasonable levels.

Finally, we vary the pricing to market parameter, *s*, between 0 and 1.

Section 5.   Quantitative evaluation of the model.

We now explore the characteristics of the calibrated model by deriving the theoretical impulse responses to monetary and government spending shocks. The Figures show the response of 8 key variables; the real exchange rate, output levels, the nominal interest rate differential, consumption, the terms of trade, prices, investment levels, and the nominal exchange rate. The

responses for other variables, such as the trade balance or interest rate differentials can be inferred from the variables illustrated in the Figures. Results are derived for both complete and incomplete markets, and for the economy with and without PTM.

Monetary Shocks

Figures 3-6 describe the impact of an unanticipated, permanent one percentage point expansion in the home country money supply, beginning in a steady state. Figures 3 and 4 represent the $s=0$ case, for complete and incomplete markets, respectively, while Figures 5 and 6 the $s=1$ case, for complete and incomplete markets.

As to be expected, when s=0, there is no real exchange rate effect of a monetary disturbance, since, even with sticky prices, PPP holds at all times. The monetary expansion causes an immediate permanent depreciation in the nominal exchange rate, in exact proportion to the increase in money (Figure 3b). It follows, since uncovered interest rate parity must hold in this economy, that the interest rate differential is unchanged by the monetary shock. Since prices take some time to adjust to the money shock (Figure 3e), the nominal exchange rate depreciation causes a change in the terms of trade. How does the terms of trade respond? In the $s=0$ case, export prices are invoiced in home currency and import prices in foreign currency. Thus, a nominal depreciation causes a deterioration in the terms of trade (Figure 3d). The fall in the terms of trade causes an "expenditure switching" of world demand away from the foreign country towards the home country. As a result, there is a rise in home output, and a fall in foreign output (Figure 3a). The international transmission of monetary policy in the $s=0$ case is

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negative, for reasons essentially identical to Mundell (1968). Note that even though output levels move in different directions, consumption moves in the same way in both countries, due to complete risk sharing (Figure 3c). Consumption rises immediately, but then gradually falls back to its steady state level.

This illustrates the importance of differentiating output responses from consumption or welfare responses, a point emphasized by OR. In fact, in this complete markets economy, the home country will have lower welfare than the foreign country as a result of the monetary expansion, since home agents must work to produce a higher level of home output which will be shared equally with consumers abroad **[8]**.

Finally, note that investment will rise in both countries (Figure 3f). Since real interest rates can be inferred directly from the rate of growth of consumption (which in this case is equated across countries), we can deduce from Figure 3c that the home monetary expansion reduces real interest rates in both countries. This stimulates an increase in investment expenditure.

How important are financial markets in generating these results? Let us now investigate the effects of monetary policy shocks when there is only trade in non-contingent nominal bonds. This is the market structure that is used in OR. They show that an unanticipated monetary expansion will lead to a less than proportional rise in the nominal exchange rate, and a home country trade surplus, which leads to a permanent increase in home consumption, relative to foreign consumption. Figure 4 illustrates the result for our model in the case of incomplete markets. As before of course, there is no impact on the real

exchange rate when *s=0*. The nominal exchange rate now rises slightly less than proportionally to money. Again, the terms of trade falls, precipitating an expenditure switching towards the home country output, with a negative international transmission. But now there is a slightly higher increase in home consumption than foreign consumption (Figure 4c), as the first period home country trade account surplus increases home assets, leading to a permanent carrying forward of home wealth into the future. The relatively large increase in home consumption implies that steady state output is lower in the home economy (Figure 4a), due to the wealth effects of consumption on labor supply.

We notice that in comparing Figure 3 with Figure 4, the asset market structure makes little difference to the central properties of the international monetary transmission mechanism. Although consumption does not respond in identical ways here, the pattern of response is almost identical in both countries. Quantitatively, the difference in the response of the exchange rate between the two asset market structures is very small (1 as opposed to 0.99). Due to the persistence of the initial current account surplus, the home country will have a permanently larger steady state consumption, as emphasized in OR. But quantitatively, the difference in consumption levels is miniscule. A one percent surprise increase in the home country money supply increases steady state home country consumption by less than a hundredth of 1 percent of its initial level.

Figures 5 and 6 illustrate the case of monetary policy under pricing-to-market, for complete and incomplete markets, respectively. Since PPP does not hold in the short run, the real exchange rate now responds to an unanticipated monetary shock.

The immediate effect of the shock is to cause a real and nominal exchange rate depreciation (Figures 5a and 5h). In fact the nominal exchange rate now "overshoots", rising more in the short run than in the long run. This causes a fall in the nominal interest rate differential, (Figure 5c). The movement in the real exchange rate causes consumption responses to diverge, even in the complete markets case (Figure 5d), since with $s=1$, optimal risk sharing is conditioned on movements in the real exchange rate (see equation (10) above).

The response of the terms of trade is now the opposite of the $s=0$ case. Exports are all invoiced in foreign currency, and imports in domestic currency. An exchange rate depreciation therefore raises the relative price of exports, i.e. improves the terms of trade (Figure 5e). The impact of the monetary shock on foreign output is also now opposite to the $s=0$ case. The presence of full pricing-to-market implies that there is no immediate pass-through from exchange rates to prices. Thus, there is no expenditure switching impact of an exchange rate depreciation. Rather, thereis a balanced expansion in demand for the goods of both the home and foreign country. Output of the home and foreign country's rise by equal amounts initially (Figure 5b). Following this, home country output remain higher for a period. This is due to the fact that home country investment is expanded by the monetary disturbance.

Finally, we see that investment rises in the home country, while falling slightly in the foreign country (Figure 5g). In the presence of departures from PPP, there is no longer equality of

real interest rates between countries. As can be deduced from the changes in consumption growth rates, home real interest rates fall, while foreign rates rise slightly.

Thus, the currency of pricing is a critical factor in the direction of the international transmission of monetary policy on output. Unlike the Mundell (1968) or the OR specification, an exchange rate depreciation with local currency invoicing of export prices does not generate negative international output transmission. In general, comparing the effects of monetary policy across the two different pricing regimes, we see there are substantial differences in international transmission. The direction of movements in output, consumption and investment, and the terms of trade are reversed when we move from the *s=0* case to the *s=1* case.

However, comparing Figures 5 and 6, as well as Figures 3 and 4, it is apparent that the asset market structure makes almost no difference to the international monetary transmission mechanism, with our without pricing-to-market.

It seems valid to conclude that for monetary policy transmission, the critical dichotomy is the currency of invoicing. Relative to this, the structure of international assets markets is much less important.

When we compare Figures 5 and 6 to the empirical impulse responses for output levels, real exchange rates, and nominal interest rates as described in Figure 1 and 2, a number of things are apparent. First, the positive cross-country correlation of output in the data is captured by the theoretical monetary transmission mechanism in the *s=1* case. Secondly, the positive and persistent impact of the money shock on the real exchange

rate is also reflected in the theoretical results for the *s=1* case. Finally the effects of monetary policy shocks on nominal interest rate differentials also seem to be captured well by the model with *s=1*. Thus, the empirical international monetary transmission mechanism seems to be in accord with the economy where pricing-to-market is predominant.

Government Spending Shocks

We now turn to the analysis of government spending policies, as illustrated in Figures 7 and 8. The first thing to note is that in the case of complete markets government spending shocks have identical effects on all home and foreign variables. Unlike the classic Mundell model, government spending is not exclusively allocated to home country goods, but involves purchases of the composite consumption good **[9]**. That is, an increase in government spending of either country increases the demand for all goods produced in the home and foreign country. When markets are complete, the wealth effects of financing this increased expenditure are shared equally by both the home and foreign country. The response of output, consumption, and investment are then identical to those in a closed economy (e.g. Barro 1987). Both home and foreign output rise, stimulated by an increase in employment and investment, and consumption falls. There is no response in either the real or the nominal exchange rate (even in the s=1 case), and no effects on the terms of trade or the trade balance. Moreover, due to the absence of exchange rate effects, the currency of invoicing is irrelevant. The degree of pricing-to-market has no consequences at all for the impact of fiscal policy shocks in the complete markets economy.

If markets are incomplete, however, the impact of government

spending shocks are quite different. An expansion in home country government spending now leads to a permanent increase in the home consumer's tax bill, which is not shared with foreign consumers through co-insurance arrangements, as in the complete markets case. Home country consumers reduce their consumption, (Figure (7c) and expand labor supply in response to the fall in real wealth. Home output rises, and since employment is higher, home investment is stimulated, leading to further increases in output over time (Figure 7a).

When $s=0$, there are of course no real exchange rate effects of the government spending shock, but the rise in home output leads to a terms of trade deterioration for the home economy (Figure 7d), which is exacerbated over time as home output continues to rise. Thus, the government spending increases causes a permanent increase in home output, and a permanent fall in the terms of trade.

What impacts are there for the foreign country? Initially, the rise in government spending will increase foreign output, since demand for foreign products rise, and prices are sticky. However, as prices adjust, the wealth effects of higher terms of trade, and higher consumption begin to come into force. Foreign labor supply falls, and foreign output falls to a permanently lower level (Figure 7a). Thus, the initial stimulation of foreign output is reversed in the new steady state. By contrast, with a permanently higher terms of trade, foreign consumption is higher in the new steady state.

A fiscal expansion also has an effect on the nominal exchange rate (as shown also by OR). To restore money market equilibrium in face of an increase in foreign consumption and a

fall in domestic consumption, there must be a rise in the domestic CPI and a fall in the foreign CPI. From the PPP conditions, this requires a nominal exchange rate depreciation. The exchange rate depreciation is immediate and permanent.

Figure 8 illustrates the effects of fiscal policy with pricing to market (s=1). The impact is almost the same as the s=0 case, save for the response of the real and nominal exchange rate. With no immediate pass-through of the exchange rate to domestic and foreign prices (Figure 8f), the foreign price level does not move at the time of the shock, and the rise in the home price level is smaller than the s=0 case. As a result, both the fall in home consumption and the rise in foreign consumption are slightly smaller (Figure 8d). The nominal exchange rate then rises by more in the short run than in the long run (Figure 8g), and there is an immediate real exchange rate depreciation (Figure 8a). The reduced effect on consumption implies a smaller movement in labor supply, which reduces the magnitude of the output responses for both countries (Figure 8b).

Nevertheless, the main features of the international transmission of fiscal shocks remain unaffected by changes in the currency of invoicing. We still see an immediate positive cross-country transmission in output initially, and a negative transmission in consumption. The terms of trade deteriorates, and the nominal exchange rate depreciates.

In contrast to the case for money shocks, however, the structure of assets markets is now of key importance for the understanding of the international transmission of fiscal shocks. If assets markets are complete, there is no exchange rate effects, no terms of trade effects, and no differential output or

consumption responses to a home country fiscal policy
disturbance.

Discussion

A conclusion we may then draw from our analysis is the
following. When we re-examine the central questions of Mundell
(1968) in light of modern inter-temporal optimizing sticky-price
models, the impact of money shocks on the international
transmission process rely not on the structure of assets markets,
but rather on the currency of invoicing, or the degree of
"pricing-to-market". When exports prices are preset in the
currency of the buyer rather than the seller, the international
transmission of monetary policy is significantly altered.
However, when assets markets are limited to non-contingent bonds
trade rather than allowing full consumption co-insurance, the
implications for the monetary transmission process are quite
minor. One way to interpret the result is that the macroeconomic
effects of monetary policy are not substantially altered by
moving from the simple assumption of capital mobility, used by
Mundell and the subsequent literature, to a world of more
sophisticated financial integration.

The consequences for fiscal policy are just the opposite.
Approximately, the implications of the currency of invoicing for
fiscal policy shocks are irrelevant. The main elements of the
international transmission mechanism are unchanged by changes in
the currency of invoicing. On the other hand, changes in the
asset market structure have substantial effects on the nature of
the fiscal policy transmission mechanism. If agents cannot co-
insure across countries, the effects of fiscal policy are

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fundamentally different than those in the complete markets environment.

Section 6. Conclusions

This paper has built on a number of recent contributions in international macroeconomics to examine a time-honored question in the field; the international transmission effects of monetary and fiscal policy. Mundell's (1968) contribution became the benchmark for thinking about this problem. Our results indicate that when we re-examine the effects of monetary and fiscal policy in a modern framework, where careful attention is paid to assets markets and pricing, we find some important differences from earlier analysis, and we obtain some clear insights that would not have been available using earlier approaches. In particular, we find that the critical issue pertaining to the international effects of monetary policy is the currency of export pricing, while the critical issue regarding the effects of fiscal policy is the structure of assets markets.

Footnotes

[1] This new literature has grown very quickly. An important early paper was Svensson and van Wijnbergen (1989). More recent contributions include Bergin (1995), Corsetti and Pesenti (1998), Chari, Kehoe and McGrattan (1998), Kollman, (1997), Hau (1998), Senay (1998), Stockman and Ohanian (1997) and Tille (1998). Lane (1998) provides an insightful survey into this area.

[2] Since we do not have a widely agreed identifying scheme for government spending shocks, in the empirical investigation we restrict our attention to the effects of monetary shocks.

[3] For a review of this methodology, see Betts and Devereux (1998).

[4] This initial negative response, while very small in our results, is consistent with evidence established in the closed economy versions of this empirical characterization of monetary policy shocks presented by Christiano and Eichenbaum (1995), and with open economy versions such as Schlagenhauf and Wrase (1995).

[5] Results available upon request from the authors.

[6] Since we are not allowing for state contingent pricing,the difference between the objective functions turns out to be unimportant for the pricing decision in any case.

[7] We assume that governments minimize the cost of producing a given amount of the final government good *G*, or *G**.

[8] This statement is based on the assumption that the welfare effects coming from changes in the supply of real money balances are sufficiently small that they can be ignored.

[9] Tille (1998) examines the impact of government spending in a two country model under the alternative assumption that government spending is biased more towards domestic goods.

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Economics; 37, pp. 345-370

Table 1					
β	0.99	α	0.36	n	0.5
σ	7	δ	0.025	s	0,1.
ε	8.2	ν	1.1	γ	0.75
ς	1	μ	0.06	ϕ	0.025
η	3	$\mu*$	0.06	ϕ'	0.02
ρ	1.9	θ	0.2		
λ	10	$\theta*$	0.2		

Figure 1A EP*/P Response to US Money Shock
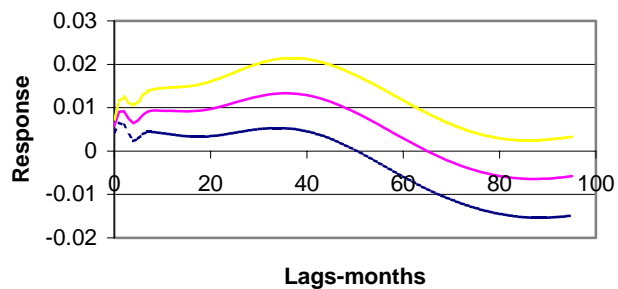
Figure 1B Y Response to US Money Shock
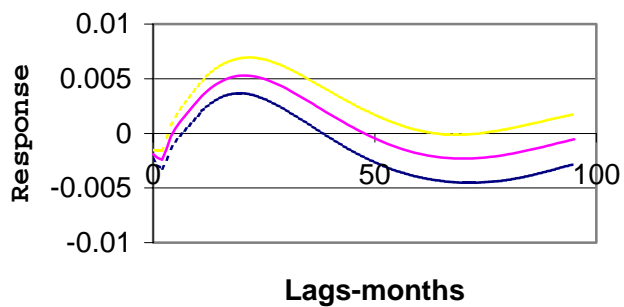
Figure 1C I-I* Response to US Money Shock
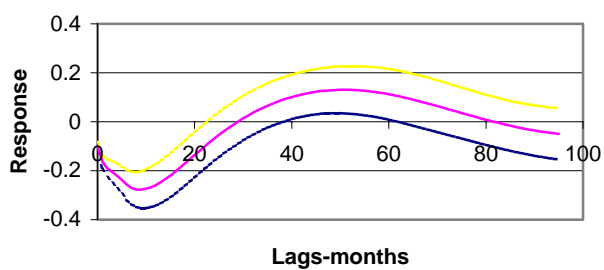
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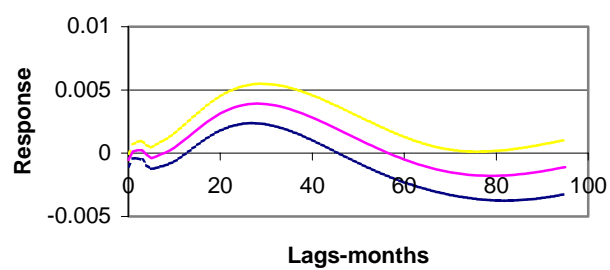
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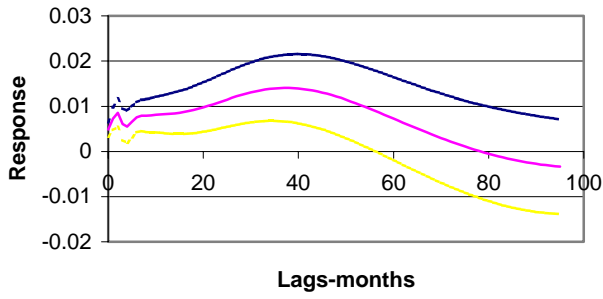
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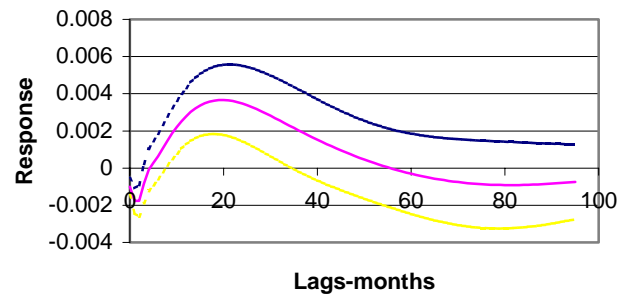
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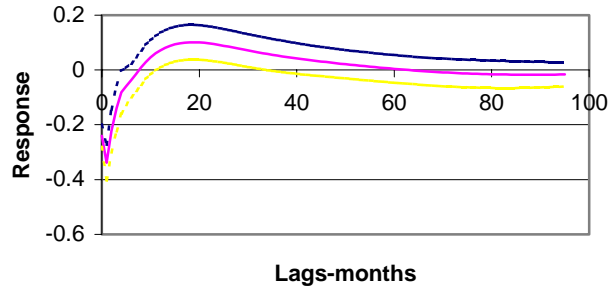
Figure 2D Y* Response to US Money Shock
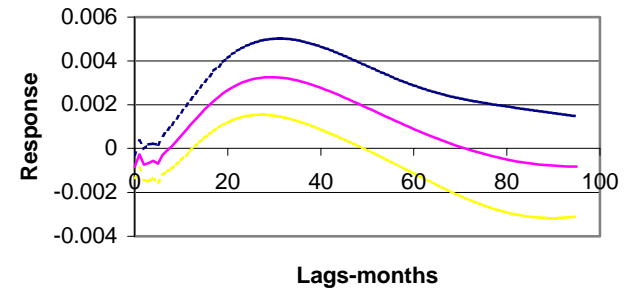
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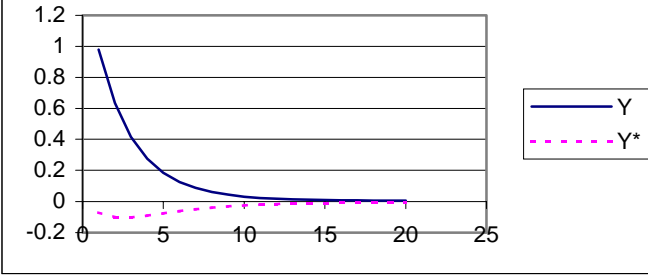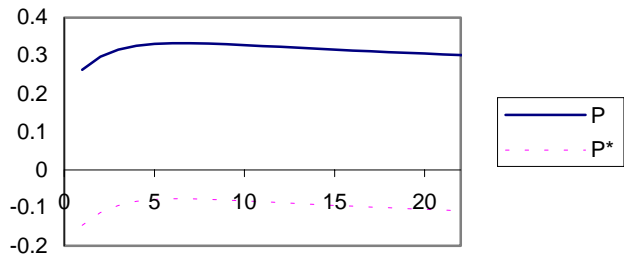

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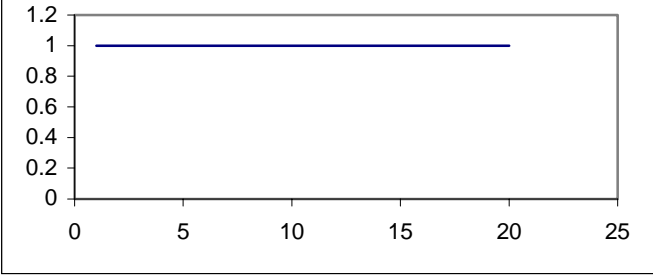
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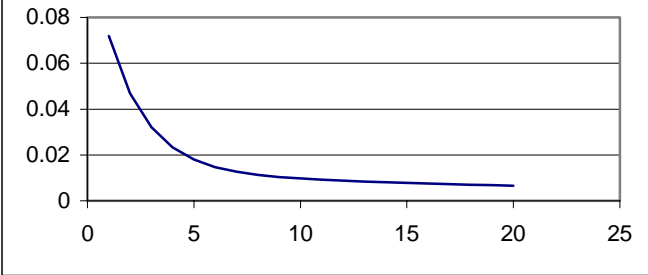
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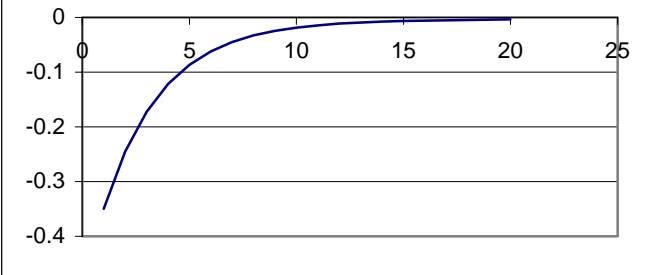
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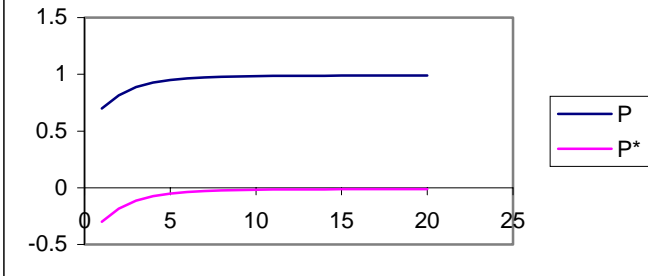
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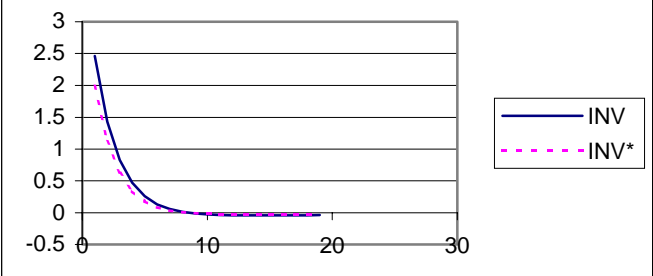
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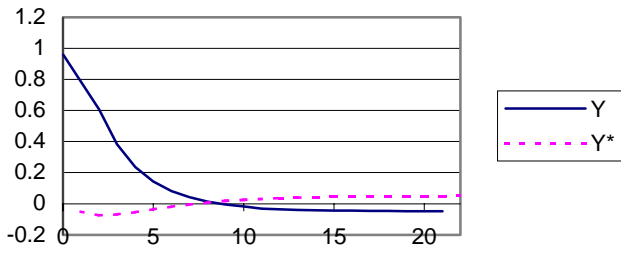
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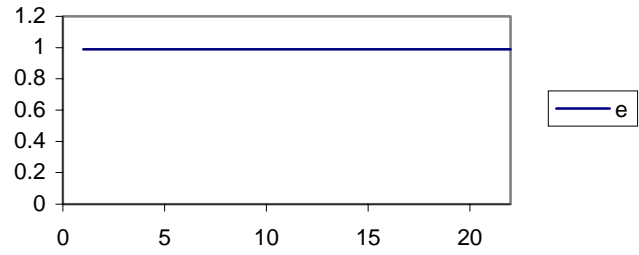
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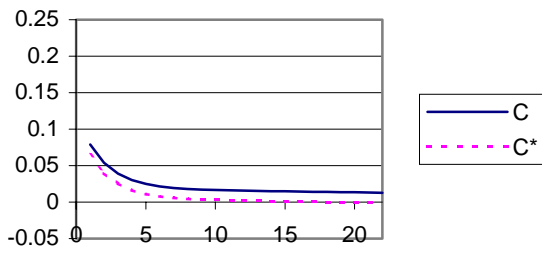
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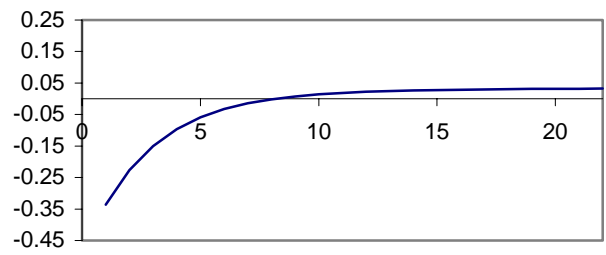
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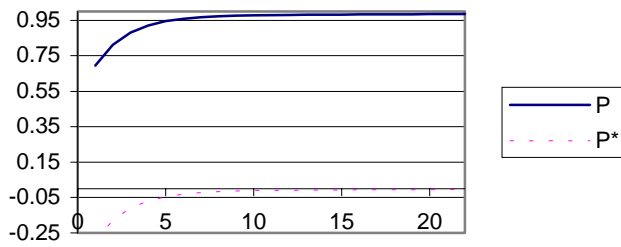
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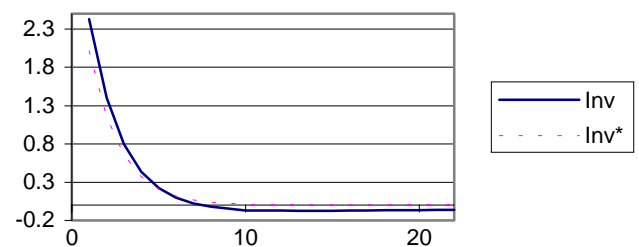
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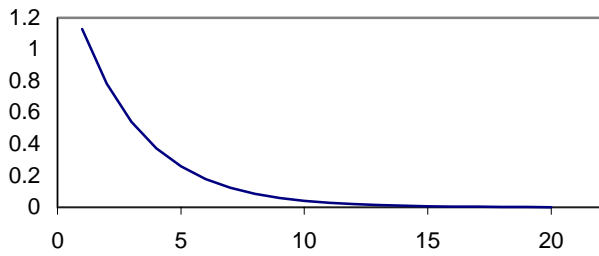
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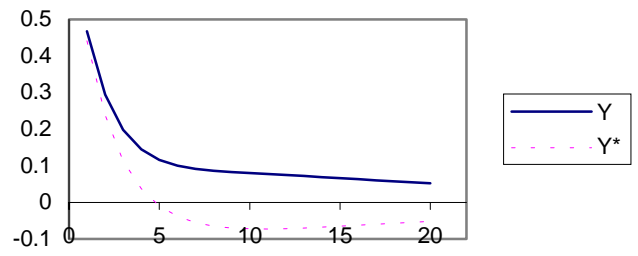
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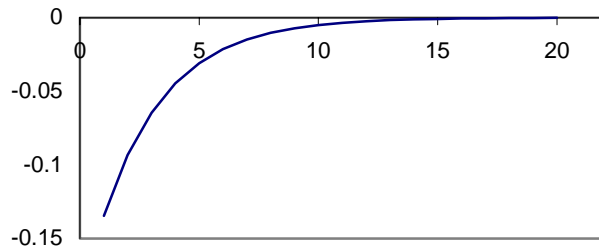
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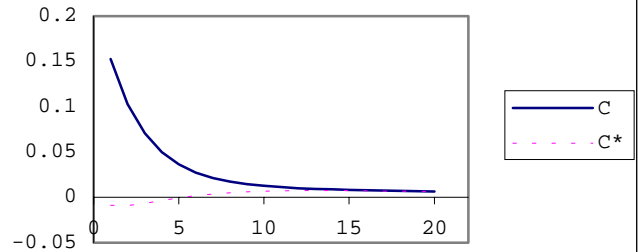
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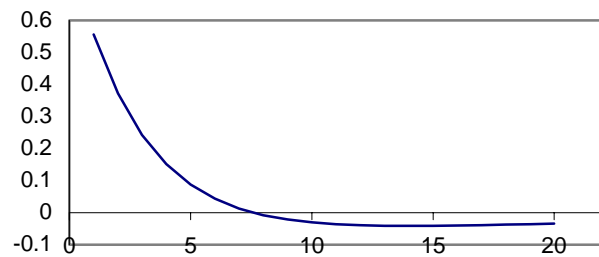
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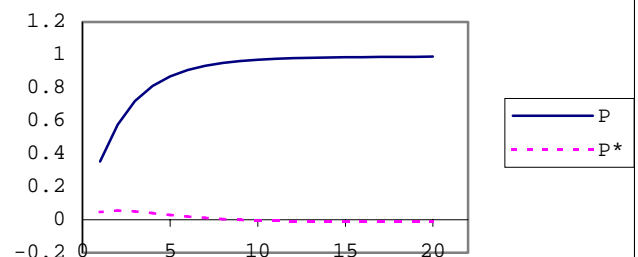
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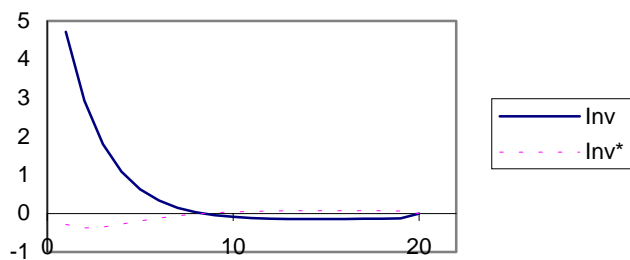
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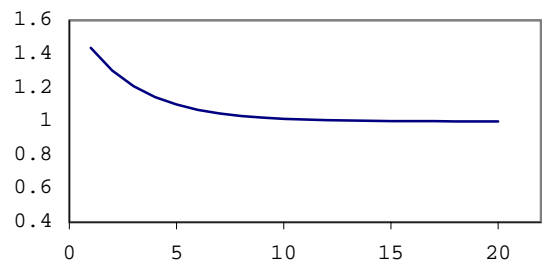
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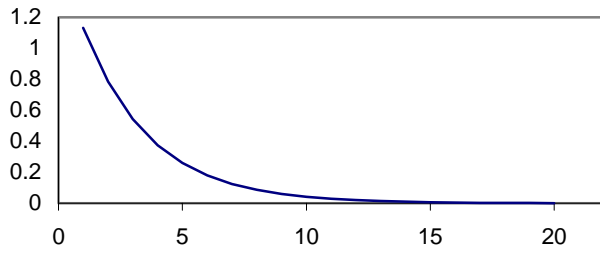
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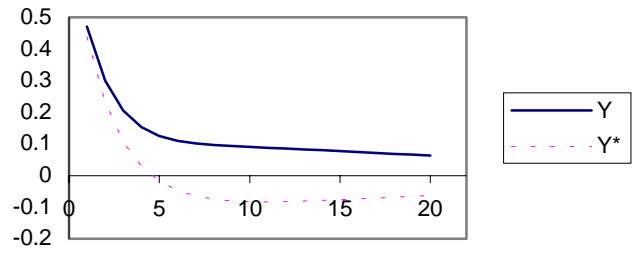
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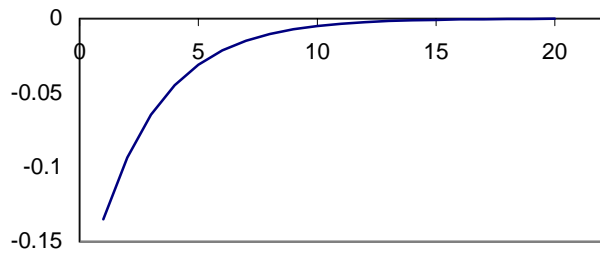
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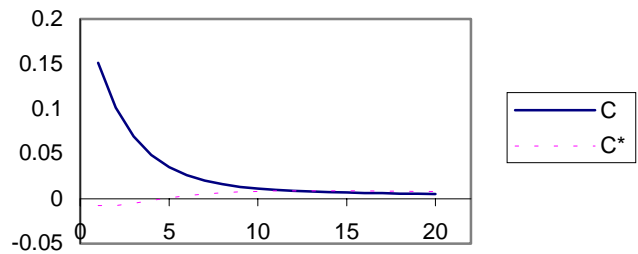
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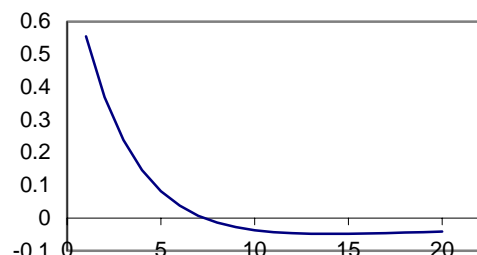
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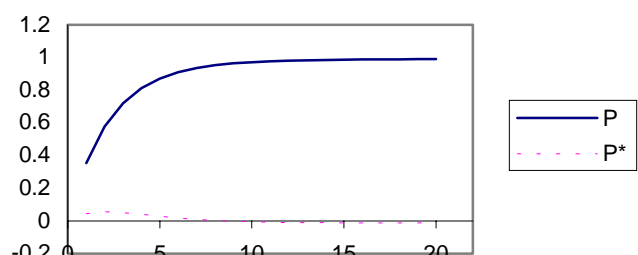
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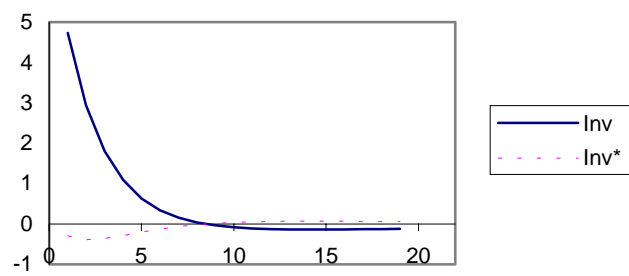
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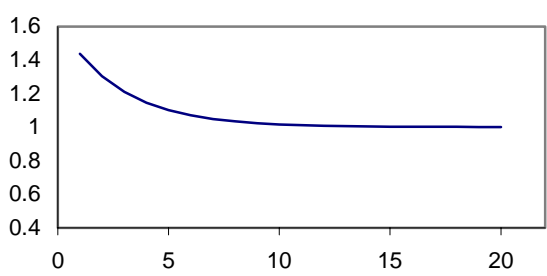
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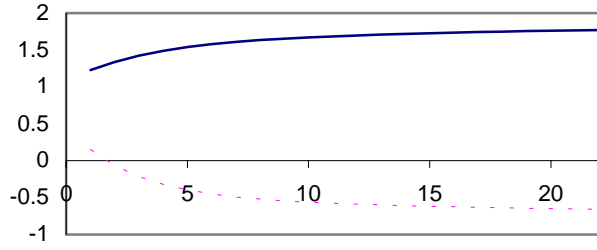
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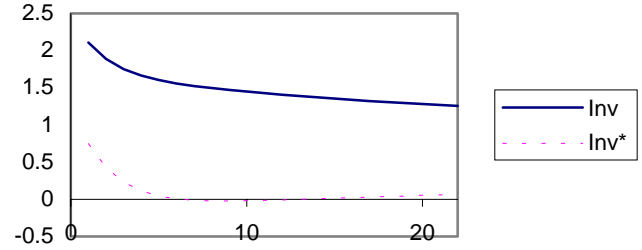
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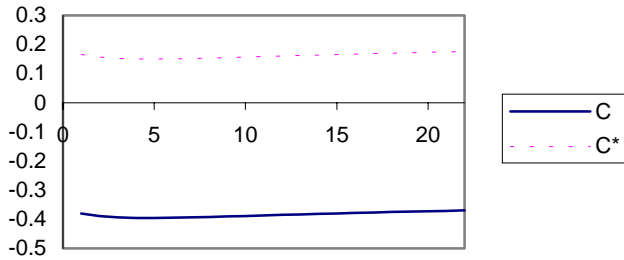
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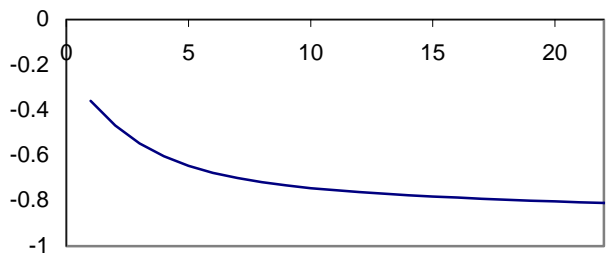
Figure 7e Price Level

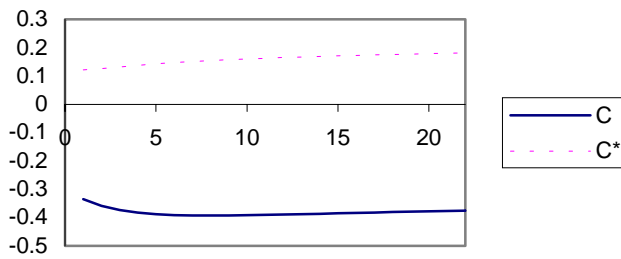## Figure 7f Nominal Exchange Rate
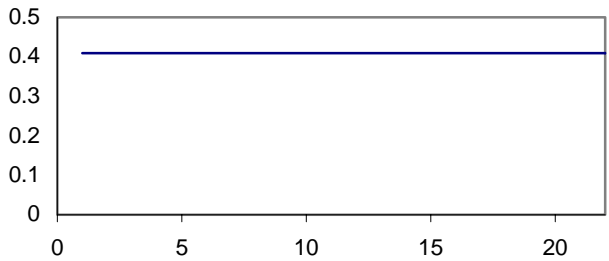
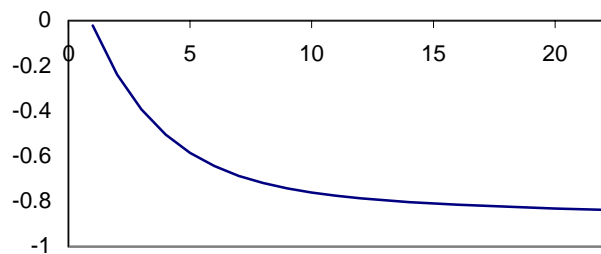**Figure 8a Real Exchange Rate**
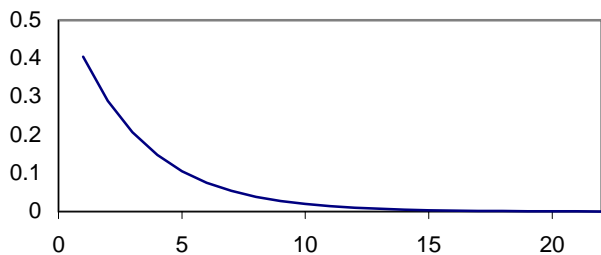
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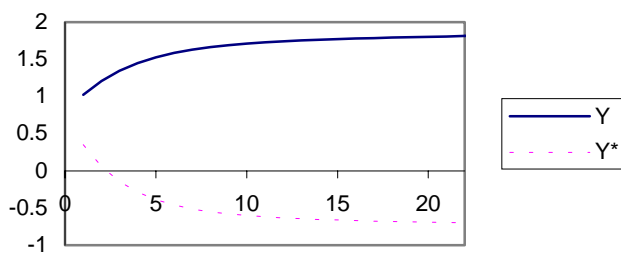
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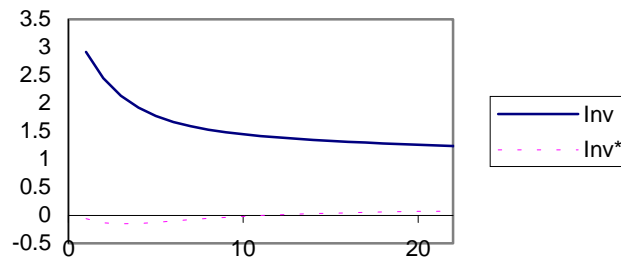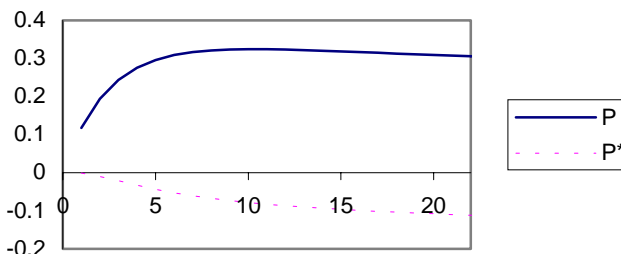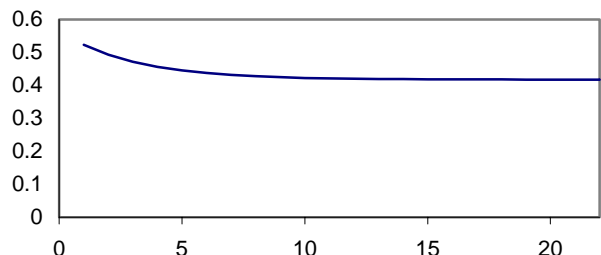
Figure 8d Consumption

Figure 8e Terms of Trade

Figure 8f Price Level

Figure 8g Nominal Exchange Rate

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