Explaining International Comovements of Output and Asset Returns:  
The Role of Money and Nominal Rigidities

Robert Kollmann(*)  
University of Paris XII  
June 2000

Abstract: Output and asset returns are highly positively correlated across  
the U.S. and the remaining major industrialized countries. Standard  
business cycle models that assume flexible prices and wages, in the Real  
Business Cycle (RBC) tradition, have great difficulties explaining this  
fact. This paper presents a dynamic-optimizing stochastic general  
equilibrium model of a two-country world with sticky nominal prices and  
wages. The structure here generates cross-country correlations of output  
and returns that are markedly higher, and hence closer to the data, than  
the cross-country correlations that obtain when flexible prices and wages  
are assumed.

JEL code: E4, F3, F4. Key words: International business cycles; Nominal  
rigidities; Monetary policy; Asset returns.

(*) Department of Economics; University of Paris XII  
61, Av. du Général de Gaulle; F-94010 Créteil Cedex; France  
e-mail: robert_kollmann@yahoo.com

I thank three anonymous referees for detailed and constructive comments and  
suggestions. Thanks for useful discussions are due to seminar participants  
at Board of Governors of the Federal Reserve System, CEPREMAP, INSEAD,  
International Monetary Fund, London School of Economics, New York Fed, the  
Universities of Berlin (Humboldt), Birmingham, Bonn, Brussels, Essen,  
Exeter, Kiel, Munich, Paris I, Pennsylvania, Rutgers, Tilburg, North  
American Winter Meeting of the Econometric Society, Meeting of the Society  
for Economic Dynamics, Econometric Society European Meeting, European  
Economic Association Congress, as well as to Michael Devereux, Chris Erceg,  
Harald Hau, Dale Henderson, Olivier Jeanne, Philip Lanne, Paolo Pesenti,  
Alessandro Prati, Ken Rogoff, Stephanie Schmitt-Grohé, Partha Sen, Cédric  
Tille, Harald Uhlig and Martin Uribe. This project was supported by a  
research grant from the Social Sciences and Humanities Research Council of  
Canada (1994-97). I also received financial support from the Institute for  
Quantitative Investment Research Europe and from University of Paris XII.
1. Introduction

Empirically, output, interest rates and equity returns are highly positively correlated across the U.S. and the remaining major industrialized countries. In recent years, much attention in International Macroeconomics has been devoted to dynamic-optimizing stochastic general equilibrium (DSGE) models of international business cycles that assume flexible prices and wages, in the Real Business Cycle (RBC) tradition. A widely discussed shortcoming of models of this type is that they generally fail to capture the high degree of comovement among the economies of the main industrialized countries (see the survey of International RBC models in Backus, Kehoe and Kydland (1995) and Baxter (1995)).

This paper presents a DSGE model of a two-country world with sticky nominal prices and wages. The model assumes a flexible exchange rate, fully integrated international bond markets and two types of exogenous shocks: productivity shocks and money supply shifts. Overlapping price and wage contracts, à la Calvo (1983), are postulated. In the baseline version of the model, the average duration between price and wage changes, at the microeconomic level, is set at 4 quarters (a duration consistent with empirical evidence on price and wage adjustment). In the structure here, firms with predetermined prices satisfy any demand that is addressed to them (at these prices)--the short run supply schedule of these firms is, hence, infinitely elastic. The analysis here stresses, thus, the role of changes in the demand for goods, as a source of short run output fluctuations.
changes when nominal rigidities are assumed. The nominal rigidities model here predicts that an exogenous money supply increase, in a given country, induces a sizable rise in that country's output, consumption and investment, a fall in its interest rate, as well as a nominal and real depreciation of its currency. Foreign output, consumption and investment are likewise predicted to rise (for plausible elasticities of substitution between domestic and foreign goods). Nominal rigidities influence also the response of the economy to productivity shocks: in the nominal rigidities structure considered here, these shocks induce output responses that are much more strongly positively correlated across countries, than predicted responses to productivity shocks generated by standard models with flexible prices and wages.

When money supply and productivity shocks occur simultaneously, the nominal rigidities structure generates, thus, cross-country correlations of output that are markedly higher, and hence closer to the data, than the correlations that obtain when flexible prices and wages are postulated. In that structure, physical investment and equity returns are likewise predicted to be more highly positively correlated across countries (compared to flexible-prices/flexible-wages models). It appears that assuming simultaneous stickiness of prices and of wages is helpful for explaining observed international comovements: versions of the model that postulate that prices only are sticky or that only wages are sticky generate lower cross-country correlations than versions with price and wage stickiness.

It is also found that the predicted variability of nominal and real exchange rates is higher—and somewhat closer to the data—when nominal
rigidities are assumed, compared to structures without such rigidities (the
nominal rigidities model presented here generates Dornbusch (1976) style
exchange rate overshooting, in response to permanent money supply shocks).

The basic Keynesian open economy model with sticky prices developed
by Mundell (1968, ch. 18) predicts a negative response of foreign output to
a positive money supply shock at home, when the exchange rate is flexible,
as the depreciation in the home currency (that is induced by the home money
supply shock) raises the price of foreign goods, relative to that of home
goods, which induces agents to substitute foreign goods with home goods.
The present analysis stresses two additional channels of international
transmission that turn out to be, quantitatively, more important, in the
structure here: (i) The demand for foreign goods rises, as part of the rise
in aggregate demand in the home country (that is induced by the fall in the
home interest rate, see above) is directed to foreign goods. (ii) The
foreign price level falls, as the depreciation of the home currency reduces
the foreign currency price of imports purchased by the foreign country;
this raises foreign real balances, which reduces the foreign interest rate,
and provides a further stimulus to demand for foreign goods. The same logic
explains also why, in the structure with nominal rigidities, productivity
shocks induce sizable positive cross-country output correlations.

The paper shows that nominal rigidities have important implications
for the behavior of equity returns. For example, the nominal rigidities
model here predicts that an unanticipated money supply increase in a given
country induces, on impact, a significant increase in the national equity
return, which is consistent with the data (e.g., Thorbecke (1997)). In
contrast, standard business cycle models without nominal rigidities fail to
generate a sizable response of equity returns to money supply shocks (e.g., Marshall (1992)).

In assuming nominal rigidities, the work here is related to Keynesian open economy models developed during the 1960s and 1970s (see, e.g., Mundell (1968) and Dornbusch (1976)). However, these models lack the explicit micro-foundations regarding the private sector's consumption, investment and production decisions that characterize the dynamic-optimizing approach adopted here. The paper builds on Obstfeld and Rogoff's (1995) widely discussed dynamic-optimizing open economy model in which nominal prices are fixed in the short run, as firms are assumed to set their prices one period in advance. However, these authors' analysis is entirely qualitative and their model is more stylized than the structure here—e.g., there is no physical capital in their model. For plausible parameter values, that model predicts strong negative international transmission of money shocks.¹ In contrast to Obstfeld-Rogoff, the paper here assumes physical capital and multi-period pricing.²

¹Hau's (1998) version of the Obstfeld-Rogoff framework that assumes nominal wage rigidity (wages that are set one period in advance), rather than price rigidities in goods markets, likewise predicts strong negative international transmission of money supply shocks.

²The price adjustment mechanism assumed by Obstfeld and Rogoff generates very simple dynamics: e.g., after a permanent money supply shock, the economy is predicted to adjust to its new long run equilibrium in a single period; the model here yields richer dynamics.
The present structure extends the quantitative small open economy model in Kollmann (1996b) to a two-country world. Methodologically, it builds on much recent work on calibrated DSGE models of closed economies with sticky prices or wages (e.g., Hairault and Portier (1993), Kim (1996), Yun (1996), Ireland (1997), Rotemberg and Woodford (1998), Erceg et al. (1999)).

The failure of standard RBC models to capture key features of international macroeconomic data has also motivated recent work by Betts and Devereux (1998) and by Chari, Kehoe and McGrattan (1998) who present quantitative dynamic-optimizing two-country models with sticky prices. In contrast to the paper here, these studies focus mainly on exchange rate dynamics. The present paper also differs from these studies by using a model that assumes sticky wages and incomplete international asset markets, by studying model implications for a wider set of variables (i.a. asset returns) and by investigating how nominal rigidities influence the international effects of productivity shocks (the studies that were just cited do not consider productivity shocks).

Chari et al. and Kollmann (1996b) find that a high degree of price stickiness has to be postulated to rationalize the high volatility of real exchange rates seen in the data. Using a model without capital and in which prices are set one period in advance, Betts-Devereux argue that "pricing to

The basic structure in the present paper was developed before I became aware of Betts-Devereux and Chari et al. (see Kollmann (1993, 1996b))--the present work is, thus, an independent and complementary analysis.
market" (PTM) behavior by firms—limited "pass through" of exchange rate movements into prices, due to local currency price setting—matters greatly for international comovements. In their model, output is highly negatively correlated across countries, unless all (or close to 100% of) firms use PTM; when all firms use PTM, then the cross-country output correlation is unity. By contrast, the structure here (with capital and multiperiod pricing), generates sizable cross-country correlations, irrespective of whether full exchange rate pass through or PTM is assumed (empirical estimates of the incidence of PTM behavior vary widely, by country and industrial sector; see, e.g., Hooper and Marquez (1995)).

Section 2 of the paper outlines the model. Section 3 discusses empirical regularities about international business cycles. Section 4 presents simulation results. Section 5 concludes.

2. The Model

A world with two countries, called Home and Foreign, is considered. In each country there are firms, a representative household and a government that issues a national currency.

The following description focuses on the Home country. The Foreign country is a mirror image of the Home country (preferences and technologies are symmetric across the two countries). Foreign variables are denoted by an asterisk.

2.1. Household preferences

The preferences of the Home household are described by:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, M_t/P_t, L_t).$$

(1)
\( E_0 \) denotes the mathematical expectation conditional on information available in period \( t=0 \). \( 0 < \delta < 1 \) is a subjective discount factor and \( U(.) \) is an instantaneous utility function. \( C_t \) is period \( t \) consumption. \( \frac{M_t}{P_t} \) represents the household's real balances, where \( M_t \) denotes nominal balances held at the beginning of period \( t \), while \( P_t \) is the price of consumption in period \( t \). \( L_t \) represents labor effort in period \( t \). The household can provide labor services of different types, indexed by \( h \in [0,1] \). \( L_t \) is defined as
\[
L_t \equiv \int_0^1 l_t(h) \, dh,
\]
where \( l_t(h) \) denotes the number of hours of type \( h \) labor.

The utility function \( U \) is assumed to be of the following form:
\[
U(C, M/P, L) = (1-\psi)^{-1} \left\{ \left[ C^{\sigma} + \kappa \left( \frac{M}{P} \right)^{\Gamma} \right]^{1/\sigma} \right\}^{1-\psi} - L,
\]
where \( \psi, \sigma, \Gamma \) and \( \kappa \) are parameters.\(^4\)

2.2. Technologies, firms and the structure of goods markets

Each country produces a single final good and a continuum of intermediate goods indexed by \( s \in [0,1] \). The final good sector is perfectly competitive. Each country's final good is produced from domestic and imported intermediate goods; the final good can be consumed or used as an investment good. In contrast, there is monopolistic competition in the markets for intermediate goods—each intermediate good is produced by a single firm. Producers of intermediate goods use domestic physical capital and domestic labor as inputs (labor and physical capital are immobile internationally). Final goods cannot be traded internationally; however, intermediate goods

---

\(^4\)Labor enters linearly in the utility function. Such a specification is widely used in the RBC literature, as it seems best suited for capturing the observed variability of hours worked (e.g., Hansen (1985)).
are tradable. There exists a perfectly competitive rental market for physical capital, in each country. Firms are price takers in the markets for their inputs.

2.2.1. Final good production

The Home final good is produced using the aggregate technology

\[ Q_t = ((1-\alpha)^{1/\phi} \cdot D_t^{\phi-1}/\phi + \alpha^{1/\phi} \cdot Z_t^{\phi-1}/\phi)^{\phi/(\phi-1)} \]

with \(0<\alpha<1\), \(\phi>0\). (3)

\(Q_t\) is Home final good output, while \(D_t\) and \(Z_t\) are indexes of domestically produced and of imported intermediate goods, respectively (the parameter \(\phi\) is the elasticity of substitution between \(D_t\) and \(Z_t\)).

\[ D_t = \left(\int_0^1 d_t(s)/(\nu-1) ds\right)^{\nu/(\nu-1)} \]

and

\[ Z_t = \left(\int_0^1 z_t(s)/(\nu-1) ds\right)^{\nu/(\nu-1)} \]

with \(\nu>1\).

d_t(s) and z_t(s) denote, respectively, the quantities of the Home produced and of the Foreign intermediate good of type \(s\) that are used in Home final good production. Let \(p_d_t(s)\) and \(p_z_t(s)\) denote the prices of these two types of goods, in terms of Home currency. Throughout the paper, all prices are expressed in the buyer's currency. Cost minimization conditions for Home final good producers can be written as:

\[ d_t(s) = D_t \cdot (p_d_t(s)/PD_t)^{1-\nu}, \quad z_t(s) = Z_t \cdot (p_z_t(s)/PZ_t)^{1-\nu} \]

and

\[ D_t = (1-\alpha) \cdot (PD_t/P_t)^{-\phi} \cdot Q_t, \quad Z_t = \alpha \cdot (PZ_t/P_t)^{-\phi} \cdot Q_t, \]

with

\[ PD_t = \left(\int_0^1 (p_d_t(s))^{1-\nu} ds\right)^{1/(1-\nu)}, \quad PZ_t = \left(\int_0^1 (p_z_t(s))^{1-\nu} ds\right)^{1/(1-\nu)}, \]

and

\[ P_t = ((1-\alpha)PD_t^{1-\phi} + \alpha PZ_t^{1-\phi})^{1/(1-\phi)}. \]

Perfect competition in the final good market implies that the date t price of the Home final good equals \(P_t\) (the right-hand side of (7) is the
marginal cost of producing the final good).  

2.2.2. Intermediate goods producers

The production function of the firm producing intermediate good 's', in the Home country, is:

\[ y_t(s) = \theta_t (K_t(s))^{\psi} (L_t(s))^{1-\psi}, \quad 0<\psi<1 \]  

(8)

at date t, where \( y_t(s) \) is the firm's output. \( \theta_t \) is an exogenous productivity parameter (productivity is identical for all Home intermediate goods producers). \( K_t(s) \) is the physical capital stock used by the firm at date t, while \( L_t(s) \) is an index of the different type of labor used by the firm: 

\[ L_t(s) = \int_0^1 \ell_t(h; s)(y-1)/y \ dh \ y/(y-1), \quad \text{with} \quad y>1, \quad \text{where} \quad \ell_t(h; s) \]

represents the quantity of type h labor used by the firm at date t.

Let \( R_t \) and \( w_t(h) \) be the Home nominal rental rate of capital and the Home nominal wage for type h labor, respectively, at date t. The cost function of a Home intermediate good producer is:

\[ \Phi_t(y) = \min_{K, \ell(h)} R_t K^y \int_0^1 w_t(h) \ell(h) dh \quad \text{s.t.} \quad y = \theta_t (K^{\psi} \int_0^1 \ell(h)(y-1)/y \ dh)(y/(y-1))(1-\psi) \]

Cost minimization implies:

\[ \ell_t(h; s) = L_t(s) \left[ w_t(h)/W_t \right]^{\gamma} \quad \text{and} \quad L_t(s) = ((1-\psi)/\psi) R_t K_t(s)/W_t, \]

(9)

where

\[ W_t = \int_0^1 w_t(h)^{1-\gamma} dh \quad \text{and} \quad \gamma = (1-\psi)/\psi \]

(10)

\[ {\mathcal{P}}_D_t \text{ and } {\mathcal{P}}_Z_t \text{ are price indices that represent the minimal expenditure, in Home currency, needed to purchase one unit of the composite inputs } D_t \text{ and } Z_t, \text{ respectively (4) implies that } {\mathcal{P}}_D_t \cdot D_t = \int_0^1 p_D(s) \cdot d_t(s) ds \text{ and } {\mathcal{P}}_Z_t \cdot Z_t = \int_0^1 p_Z(s) \cdot z_t(s) ds ). \]
is an aggregate wage index. 6

As the production function exhibits constant returns to scale, \( \bar{\Theta}_t(y) = y \cdot \bar{\Theta}_t' \) holds, where \( \bar{\Theta}_t' \) is the firm's marginal cost function:

\[
\bar{\Theta}_t' = (1/\bar{\Theta}_t) (R_t)^{\psi} (W_t)^{1 - \psi} \psi (1 - \psi)^{-1 - \psi}
\]  

(11)

The demand function of the Home producer of intermediate good \( s \) in its domestic market is given in (4). The firm faces the following demand function in its export market:

\[
z_t^* = \bar{Z}_t^* \left( \rho \bar{Z}_t^* (s)/PZ_t^* \right)^{-\nu},
\]  

(12)

where \( \rho \bar{Z}_t^* (s) \) is the firm's export price, in terms of Foreign currency, and

\( PZ_t^* = \{ \int (\rho \bar{Z}_t^* (s))^{1 - \nu} ds \}^{1/(1 - \nu)} \). 7 The firm's output equals the demand for its good:

\[
y_t(s) = d_t(s) + z_t^*(s).
\]  

(13)

At \( t \), the profit of the producer of Home intermediate good \( s \) is, thus:

\[
\rho d_t(s) d_t(s) + e_t \rho \bar{Z}_t^* (s) z_t^*(s) - \bar{\Theta}_t^* (d_t(s) + z_t^*(s)),
\]

where \( e_t \) is the nominal exchange rate between the two countries, defined as the Home currency price of one unit of Foreign currency.

Following Obstfeld and Rogoff (1995), it is assumed that there are no

6 \( W_t \) represents the minimal expenditure, in Home currency, needed to purchase one unit of the composite labor input \( \ell \) in period \( t \).

7 The Foreign final good technology is analogous to (3), i.e.

\[
Q_t^* = ((1 - \alpha)/\Theta_t^* (\Theta - 1)/\Theta + \alpha/\Theta (Z_t^* (\Theta - 1))/\Theta (\Theta - 1), D_t^* = \{ \int d_t^* (s) (\nu - 1)/\nu \nu (\nu - 1) \}
\]

\[
Z_t^* = \{ \int Z_t^* (s) (\nu - 1)/\nu \nu (\nu - 1) \}, \text{ where } d_t^*(s) \text{ is the quantity of the Foreign produced intermediate input of type } s \text{ that is used in Foreign final good production.}
costs to trade between the countries, which implies that the price of each intermediate goods is the same in both markets, i.e.

\[ \rho q_t^*(s) = \rho_d_t(s)/e_t, \]  

which implies

\[ \rho P^*_t = \rho P^D_t/\rho D_t/e_t. \]  

These equations and the demand functions for intermediate goods derived above imply that the nominal profit of the producer of Home intermediate good \( s \) can be expressed as the following function of its Home currency price, \( \rho_d_t(s) \):

\[ \pi_t(\rho_d_t(s)) = (\rho_d_t(s) - \rho D_t^*) \cdot (D_t + Z_t^*) \cdot \left( \frac{\rho_d_t(s)}{\rho P D_t} \right)^{-\nu}. \]

**Determination of intermediate goods prices**

Prices for intermediate goods are set in a staggered fashion, à la Calvo (1983), in terms of the currency of their producers: producers are not allowed to change these prices, unless they receive a random "price-change" signal. The probability that the price of an intermediate good of a given type, in terms of the currency of its producer, can be changed in any particular period is \( 1-\delta \), a constant (as there is a continuum of intermediate goods. \( 1-\delta \) represents also the fraction of all prices, in producer currency, that are changed each period; furthermore, the average time between price changes is \( 1/(1-\delta) \)).

Consider a Home intermediate good producer that is "allowed" at date \( t \) to set a new Home currency price for its good and let \( \rho_d_{t,t} \) denote this new price. With probability \( \delta^T \), \( \rho_d_{t,t} \) is still in effect at date \( t+\tau \). Hence, the firm sets \( \rho_d_{t,t} \) at

\[ \rho_d_{t,t} = \operatorname{ArgMax}_{\rho_d} \sum_{t=0}^{\tau-1} \delta^\tau E_t \{ \rho_d_{t+t, t+t} \pi_{t+t} (\rho_d ) / P_{t+t} \}. \]  

(16)

where \( \rho_{t,t+\tau} \) is the pricing kernel used by the firm at date \( t \) to value
random date $t+\tau$ pay-offs (that are expressed in units of the Home final good). As discussed below, it is assumed that Home firms are owned by that country’s representative household; hence, it is assumed that $\rho_{t,t+\tau}$ equals the intertemporal marginal rate of substitution in consumption of the Home household:

$$\rho_{t,t+\tau} = \beta^T U_{C,t+\tau}/U_{C,t},$$  \hspace{1cm} (17)

where $U_{C,t+\tau}$ is the household’s marginal utility of consumption at date $t+\tau$.

The solution of the maximization problem in (16) is: \(^8\)

$$\rho_{t,t} = (\nu/(\nu-1)) \frac{\left\{ \sum_{\tau=0}^{\tau=\infty} \delta^\tau E_t \{ \varepsilon_{t,t+\tau} \} \right\}}{\left\{ \sum_{\tau=0}^{\tau=\infty} \delta^\tau E_t \{ Z_{t,t+\tau} \} \right\}},$$  \hspace{1cm} (18)

where

$$\varepsilon_{t,t+\tau} \equiv (1/\rho_{t+\tau}) \cdot (D_{t+\tau} + Z_{t+\tau}) \cdot (P \cdot D_{t+\tau})^\nu.$$  \hspace{1cm} (19)

Note that the analysis here presupposes that firms that set a new price at date $t$ satisfy the demand for their good, at that price, as long as the price remains in effect (see (13)). In other words, firms with predetermined prices (prices that were set in previous periods) have an infinitely elastic output supply schedule. \(^9\)

---

\(^8\) Very similar expressions are derived by Yun (1996, p.352) who also studies a dynamic general equilibrium model with price setting à la Calvo.

\(^9\) This assumption is standard in models with price rigidities (e.g., Mankiw (1997, ch.8)). (18) implies that, up to a certainty equivalent approximation, the price $\rho_{t,t}$ equals a weighted average of current and expected future marginal production costs, multiplied by a constant mark up factor, $\nu/(\nu-1)>1$. When prices are fully flexible ($\delta=0$), then (18) implies that the price $\rho_{t,t}$ is set at the current marginal cost, multiplied by $\nu/(\nu-1)$. When prices are sticky ($\delta>0$), then $\rho_{t,t}$ depends on future
At date $t$, a fraction $(1-\delta)\delta^\tau$ of Home producers of intermediate goods are posting Home currency prices that were set at $r=0$ periods ago. The definition of the price index $P_D_t$ (see (6)) implies, hence, that the law of motion of $P_D_t$ is:

$$
(P_D_t)^{1-\nu} = b (P_D_{t-1})^{1-\nu} + (1-\delta) (\rho d_{t,t})^{1-\nu}.
$$

(20)

2.2.3. The demand and supply of physical capital

Equations (4), (8), (9), and (12)-(15) imply that the total demand for physical capital, by Home intermediate good firms can be expressed as:

$$K_t = \int_0^1 K_t(s)ds = (D_t + Z_t^e) (P_D_t/P_D_{t-1})^{-\nu} \theta_t^{-\psi} \{ \psi (1-\psi)^{-1} \psi / R_t \}^{1-\psi},
$$

(21)

where $P_D_t = \{\rho d_t(s)^{-\nu}ds\}^{-1/\nu}$ is a price index that evolves according to:

$$(P_D_t)^{-\nu} = b (P_D_{t-1})^{-\nu} + (1-\delta) (\rho d_{t,t})^{-\nu}.
$$

(22)

The supply of physical capital, in the Home country, reflects investment decisions made by capital rental firms (who rent capital to that country's intermediate goods producers). The law of motion of the stock of Home physical capital is:

$$K_{t+1} + \phi(K_{t+1}, K_t) = K_t (1-d) + I_t,
$$

(23)

where $I_t$, gross investment, denotes what quantity of the Home final good is required to change the capital stock from $K_t$ to $K_{t+1}$. $0<d<1$ is the depreciation rate of the capital stock and $\phi(\ldots)$ is a convex adjustment cost function that is homogeneous of degree one in $K_{t+1}$ and $K_t$:

$$\phi(K_{t+1}, K_t) = 0.5 \phi \{ (K_{t+1} - K_t)^2 / K_t \}, \phi>0.
$$

(24)

Home capital rental firms maximize

$$\sum_{t=0}^{T=\infty} E_t \{ \rho_{t,t+\tau} (R_{t+\tau} K_{t+\tau} - P_{t+\tau} I_{t+\tau})/P_{t+\tau} \},
$$

(=average) cost, it is not in its interest to ration its customers.

14
where $R_{t+\tau} K_{t+\tau} - P_{t+\tau} I_{t+\tau}$ is the nominal cash flow of these firms, in period $t+\tau$. Optimal investment decisions by capital rental firms can be characterized by the following Euler equation:

$$1 = E_t \{ \rho_{t,t+1} \cdot \left[ \frac{R_{t+1}}{P_{t+1}} + 1 - d + \phi_{2,t+1} \right]/\left( 1 + \phi_{1,t} \right) \},$$

(25)

where $\phi_{1,t} = \partial \phi (K_{t+1}, K_t)/\partial K_{t+1}$ and $\phi_{2,t+1} = \partial \phi (K_{t+2}, K_{t+1})/\partial K_{t+1}$.

2.3. Asset markets, household consumption and investment decisions

The Home representative household can hold the following assets: (i) Home money; (ii) a stock that represents a claim to the aggregate cash flow of all Home producers of intermediate goods and of all Home capital rental firms; (iii) risk-free nominal one-period bonds denominated in Home currency and in Foreign currency.\(^{10}\)

Given this set of assets, the period $t$ budget constraint of the Home household is:

$$M_{t+1} + A_{t+1} + e_t B_{t+1} + \sigma_t S_{t+1} + P_t C_t = M_t + T_t + A_t (1+r_t) + e_t B_t (1+r_t^*) + \sigma_{t-1} S_t (1+r_s_t) + \int_0^1 \int_0^1 W_t(h) \ell_t(h,s) \, dh \, ds,$$

(26)

with

$$\int_0^1 \int_0^1 \ell_t(h,s) \, dh \, ds = (1+r_s_t) \equiv (\sigma_t + P_t K_t - P_t I_t)/\sigma_{t-1},$$

(27)

---

\(^{10}\)The household's international financial transactions are, thus, restricted to trade in bonds. This asset market structure is consistent with the well documented home-country bias in investors' equity portfolios (e.g., French and Poterba (1991)). Kollmann (1995, 1996 a, 1998) compares models in which bonds only are traded internationally to models that also allow for international trade in state-contingent assets--it is found that the former models capture key international business cycle stylized facts better.
where \( \Pi_t = \int_0^1 \pi_t(\rho d_t(s))ds = P D_t^*(D_t^*Z_t^*) - R_tK_t - \int_0^1 \int_0^1 w_t(h)\ell_t(h;s)dh\,ds \)
represents total profits of Home intermediate good producers. \( A_t \) and \( B_t \)
are, respectively, the (net) stocks of Home currency bonds and of Foreign
currency bonds that are held by the Home household, at the beginning of
period \( t \) (end of period \( t-1 \)). \( r_t \) and \( r_t^* \) are the nominal interest rates on
these two types of bonds. \( \sigma_t \) is the nominal price (ex-dividend) of one
equity share, in period \( t \), while \( S_t \) is the number of equity shares held by
the household, at the end of period \( t-1 \). \( (1+r_{t+1}) \) is the nominal gross
return on Home equity, between periods \( t-1 \) and \( t \) (\( \Pi_t + R_tK_t - P_tI_t \) is the total
cash flow generated by all Home firms). \( T_t \) is a government cash transfer.
The last term on the right-hand side of (26) is the household's total wage
income.

The Home household seeks to maximize her expected life-time utility
(1) subject to the restriction that the budget constraint (26) holds in all
periods and for all states of the world. Ruling out Ponzi games, the
following equations are first-order conditions of this decision problem:

\[
1 = (1+r_{t+1}) \beta E_t\{(U_{C,t+1}/U_{C,t}) (P_t/P_{t+1})\}, \tag{28}
\]

\[
1 = (1+r_{t+1}) \beta E_t\{(U_{C,t+1}/U_{C,t}) (P_t/P_{t+1}) (e_{t+1}/e_t)\}, \tag{29}
\]

\[
1 = \beta E_t\{(U_{C,t+1}/U_{C,t}) (P_t/P_{t+1}) (1+r_{t+1})\}, \tag{30}
\]

\[
\kappa (\Gamma/\sigma)E_t\{U_{C,t+1} (C_{t+1})^{1-\sigma}(M_{t+1}/P_{t+1})^{\Gamma-1}/P_{t+1}\} = r_{t+1} E_t\{U_{C,t+1}/P_{t+1}\}. \tag{31}
\]

Equations (28)-(30) are Euler conditions, while (31) can be interpreted as
a money demand equation.
2.4. Wage determination

Overlapping nominal wage contracts of random duration are assumed. The household acts as a wage setter, subject to the constraint that the wage rate for labor of a given type can only be changed when she receives a random "wage-change signal" (for labor of that type). The probability that the wage rate for labor of a given type can be changed in any particular period is $\delta$, a constant. Assume that the Home household is "allowed" at date $t$ to set a new wage rate for type $h$ labor and let $w_{t,t}(h)$ denote this new wage rate. With probability $\delta_t$, $w_{t,t}(h)$ is still in effect at date $t+\tau$. The household sets the wage $w_{t,t}(h)$ that maximizes her expected lifetime utility subject to her budget constraint (26), to the demand schedule for type $h$ labor shown below and subject to the wage adjustment pattern that was just described (it is assumed that the household meets the demand for type $h$ labor at the wage $w_{t,t}(h)$ until the next wage-change signal is received). The demand schedule for type $h$ labor is (from (9)):

$$l_t(w_t(h))=\int_0^t l_t(h,s)ds=\left((2\psi)/\psi\right)\cdot (w_t(h))^{1-\gamma} \cdot R_t \cdot K_t \cdot (w_t)^{-\gamma-1},$$

where $K_t=\int_0^t K(s)ds$. Assume that when setting $w_{t,t}(h)$ the household takes the current and future average wage $(\bar{w})$ and other aggregate variables as given.\textsuperscript{11} Then $w_{t,t}(h)$ has to satisfy the following first-order condition:

\textsuperscript{11}A note available from the author considers a variant of the model with a continuum of households, where each household monopolistically provides a single type of labor. In that structure, an individual household's wage setting decisions have no effect on economywide variables. The wage equation (33) below holds in that structure and the dynamics of aggregate variables is likewise unchanged (compared to the model in the
\[ \sum_{\tau=0}^{\infty} (\beta D)^\tau E_t \left\{ U_{C,t,\tau} \cdot \frac{\partial \ln t_{t\tau}(z_{t,t}(h))}{\partial \omega_{t,t}(h)} \right\} = \sum_{\tau=0}^{\infty} (\beta D)^\tau E_t \left\{ U_{L,t,\tau} \cdot \frac{\partial \omega_{t,t}(h)}{\partial \omega_{t,t}(h)} \right\} \]  

\[ \omega_{t,t}(h) = (\gamma/(\gamma-1)) \sum_{\tau=0}^{\infty} (\beta D)^\tau E_t [\chi_{t+\tau} - \sum_{\tau=0}^{\infty} (\beta D)^\tau E_t \left\{ U_{C,t+\tau} \cdot \chi_{t+\tau} \right\}] \]  

where \( U_{L,t,\tau} = -1 \) is the marginal disutility of labor effort and \( \chi_{t+\tau} \equiv ((1-\psi/\psi) R_{t+\tau} K_{t+\tau} (W_{t+\tau})^{-1/\gamma} \)  

For a fraction \((1-D)D^\tau\) of labor types, the wage rate in effect at date \( t \) was set in period \( t-\tau \). Hence, the law of motion of the aggregate wage index is (from (10)):  

\[ (W_{t})^{1-\gamma} = D (W_{t-1})^{1-\gamma} + (1-D) (W_{t,t})^{1-\gamma} \]  

---

12 The left-hand side of (32) represents the effect on the household's expected life-time utility of the change in the stream of labor income that results from a variation in \( \omega_{t,t}(h) \), while the right-hand side shows the effect on life-time utility of the ensuing change in current and future labor effort. Intuitively, these two expressions have to be equal, at an interior solution of the household’s decision problem. Note that (33) implies that the same wage is set for all labor types for which a wage change occurs at \( t \).

13 N.B. When the wage rate is fully flexible (\( D=0 \)), and the own-wage elasticity of labor demand is infinite (\( \gamma=\infty \)), then (33), (35) imply \( \omega_{t,t}=1/U_{C,t,t} \) which corresponds to the familiar first-order condition that
2.5. Government

Each country's government prints the local currency. Let \( M_t \) be the Home money supply, at the beginning of period \( t \). Increases in the money stock are paid out to the representative household in the form of lump-sum transfers:

\[
M_{t+1} = M_t + T_t.
\]  

(36)

The money supply is exogenous (the government makes no attempt to influence the exchange rate, i.e. the exchange rate floats freely).

2.6. Market clearing conditions

Supply equals demand in labor markets and in the markets for intermediate goods as, by assumption, the household always meets the demand for her labor services and as producers of intermediate goods likewise always meet the demand that they face.

Market clearing for the Home final good requires:

\[
Q_t = C_t + I_t.
\]  

(37)

Each country's currency is only held by its residents. Equilibrium in the Home money market requires, thus:

\[
M_t = M_t,
\]  

(38)

where \( M_t \) and \( M_t \) are the Home money supply, and the desired money balances of the Home household, respectively.

prescribes the equalization of the marginal rate of substitution between consumption and leisure to the real wage rate (this marginal rate of substitution is given by \( 1/U_{C,t} \), as the marginal utility of leisure equals unity, for the utility function assumed here).
Governments do not issue bonds. Market clearing in bond markets requires, thus:

\[ A_t^* + A_t^* = 0 \quad \text{and} \quad B_t^* + B_t^* = 0, \]  

(39)

where \( A_t^* \) and \( B_t^* \) are the foreign household's stock of Home currency bonds and her stock of Foreign currency bonds, respectively.

Market clearing in the Home rental market for physical capital requires:

\[ K_t = X_t, \]  

(40)

where \( K_t \) is the aggregate Home capital stock, while \( X_t \) is total demand for capital, by Home intermediate good producers (see (21)).

Market clearing in the Home stock market requires that the demand for equity shares by the Home household equals the supply of shares. Normalizing the supply of shares to unity, the market clearing condition in the Home stock market is, thus:

\[ S_t = 1. \]  

(41)

2.7. Solution method

Given exogenous processes for productivity and the money supply in the two countries \( \{ \theta_t, M_t, \theta_t, M_t \}_{t=0}^{t=\infty} \), and given \( K_0, A_0, B_0, r_0, W_{-1}, PD_{-1}, PD_{-1}, K_0, W_{-1}, PD^{*}_{-1}, PD^{*}_{-1} \), equations (3), (5), (7), (11), (15), (17)-(31), (33)-(41) and the corresponding conditions for the Foreign country determine the endogenous aggregate variables \( \{ Q_t, C_t, D_t, Z_t, P_t, pd_t, t, PD_t, PD_t, PD_t, W_t, t, W_t, R_t, K_{t+1}, I_t, R_t, K_{t+1}, I_t, t, R_t, I_t, R_t, t, e_t, t \}_{t=0}^{t=\infty} \).

An approximate model solution can be obtained by taking a linear approximation of these equations around a deterministic steady state, i.e.
around an equilibrium in which all exogenous and endogenous variables are constant. This approximation yields a system of linear expectational difference equations that can be solved using standard techniques (here, the formulae of Blanchard and Kahn (1980) are used). In the simulations below, the model is linearized around a deterministic steady state that is symmetric across countries (i.e. in which all variables have the same values in both countries), and in which each country's net stock of foreign currency bonds is zero.

2.8. Parameter values

2.8.1. Preference, technology and price and wage adjustment parameters

The coefficient of relative risk aversion is set at \( \Psi=2 \). This value lies in the range of risk aversion coefficients usually assumed in the business cycle literature (Friend and Blume (1975) present evidence consistent with this value of the risk aversion coefficient). The subjective discount factor is set at \( \beta=1/1.01 \) which implies that the steady state real interest rate is 1%--in steady state, \( \beta \cdot (1+r)=1 \) holds, where \( r \) is the steady state interest rate (business cycle models that are calibrated to quarterly data commonly assume a steady state real interest rate in the range of 1%, a value that corresponds roughly to the long run average return on capital).

As mentioned above, equation (31) can be interpreted as a money demand equation. Up to a certainty equivalent approximation, (31) can be written as:

\[ \kappa \left( \frac{\Gamma}{\sigma} \right) \left( \frac{M_{t+1}}{P_{t+1}} \right)^{\Gamma-1} = r_{t+1} \left( C_{t+1}^{\theta} \right)^{\sigma-1} + v_{t+1}, \]

where \( v_{t+1} \) is a forecast error (\( E_{t} v_{t+1} = 0 \)). Hence, the elasticities of money demand with respect to consumption and with respect to the domestic nominal interest rate are given by \( \varepsilon_{c} = (\sigma-1)/(\Gamma-1) \) and \( \varepsilon_{r} = 1/(\Gamma-1) \), respectively. The
simulations assume \( \varepsilon_c = 0.20 \) and \( \varepsilon_r = -0.01 \), which pins down the preference parameters \( \sigma \) and \( \Gamma \) (see (2)): \( \sigma = -19 \), \( \Gamma = -99 \). These values of \( \varepsilon_c \) and \( \varepsilon_r \) are in the range of estimates of the transactions elasticity and interest rate elasticity of money demand that are reported in econometric studies on money demand in the U.S. and in the remaining G7 countries (e.g., McCallum (1989), Goldfeld and Sichel (1990), Fair (1987)).

The preference parameter \( \kappa \) (see (2)) is set in such a way that the steady state consumption velocity (ratio of nominal consumption expenditure to the money stock) equals unity.

---

14 These estimates pertain to short-run (quarterly) money demand elasticities. Estimates of short-run elasticities are used to calibrate the model, because the focus of the present paper is on high frequency movements in interest rates and other macroeconomic variables (empirically, long-run money demand elasticities are higher than short-run elasticities—e.g., estimation results presented by McCallum (1989) suggest that the long run elasticity of money demand with respect to the transactions proxy is approximately 0.50). The key result discussed below—that nominal rigidities raise cross-country correlations of real economic activity and of returns—is robust to changes in money demand elasticities.

15 The model predictions discussed below are not sensitive to the assumed steady state velocity (a unit velocity is roughly consistent with data on the M1 consumption velocity in the G7 countries, during the post-Bretton Woods era; e.g., in the U.S. that velocity was 0.93 in 1994).
\( \theta \), a country's elasticity of substitution between (composite) Home and Foreign intermediate goods, in final good production, equals the price elasticity of its import demand function (see (5)). For the G7 countries, the vast majority of estimates of price elasticities of international trade range between 0 and 1.5; see, e.g., Hooper and Marquez's (1995, Table 4.1) recent survey of the relevant empirical literature (a similar picture emerges from Goldstein and Khan's (1985) survey). Estimates for the U.S. are typically larger than those for the remaining G7 countries. The medians of the price elasticities reported by Hooper and Marquez for the U.S., Japan, the U.K., Canada and Germany are 1.05, 0.76, 0.44, 1.00 and 0.55, respectively. The simulations consider a baseline case in which \( \theta \) is set at \( \theta=1 \).\(^{16}\) \(^{17}\) A sensitivity analysis is conducted, around that value.

\(^{16}\)The baseline case assumes thus a Cobb-Douglas final good technology, \( Q_t = D_t/(1-\alpha) \) \((1-\alpha)/(2-\alpha)\) \( \alpha \), and a final good price given by \( P_t = P_D_t^\alpha \) \( P^\alpha \) \( P^\alpha \) (these expressions correspond to the limits of (3) and (7), for \( \theta \to 1 \)).

\(^{17}\)An older literature survey by Stern et al. (1976) reports "best guess" estimate of price elasticities of U.S. imports and exports that exceed unity (1.66 and 1.41, respectively). However, as representative estimates of \( \theta \) for other large G7 countries are below unity, it seems reasonable to use \( \theta=1 \), as a baseline value.

The assumption in the model that the elasticity of substitution is identical across countries is made for simplicity of exposition only. It appears that, in a variant of the model in which Home and Foreign elasticities, denoted \( \theta \) and \( \theta^* \), are allowed to differ, predictions for the
The technology parameter $\alpha$ (see (3)) determines the ratio of the value of imports to GDP. The simulations assume $\alpha=0.1$ as, for the US, the ratio of imports to GDP has been approximately 10% during the post-Bretton Woods era.\(^{18}\)

\[\text{variables discussed below (cross-country correlations of output etc.; see Tables 2, 3) hinge on the mean elasticity } (\varphi+\varphi^*)/2: \text{ combinations of } \varphi \text{ and } \varphi^* \text{ for which } (\varphi+\varphi^*)/2 \text{ is identical, are observationally equivalent, in this sense. Computing a weighted average (using the GDP weights reported in the Data Appendix) of } \varphi \text{ for Japan, the U.K., Canada and Germany, and then taking the arithmetic mean of this weighted average and of the estimate for the U.S. yields an elasticity of 0.85, when the above estimates based on Marquez et al. are used. The same procedure yields a mean elasticity of 1.20, when the "best guess" estimates of Stern et al. are used.}\]

The estimates that were just discussed pertain to long-run trade elasticities. Estimates of short-run elasticities are clearly below unity, for each of the G7 countries (e.g., Goldstein and Khan (1985), Marquez et al. (1998)). As the emphasis of the present paper is on high frequency movements in output and other macroeconomic variables, this too militates in favor of using a conservative value for $\varphi$.

\[^{18}\text{Denoting Home nominal GDP by } Y, \text{ we have: } Y_t = P_t \cdot (C_t + I_t) + PD_tZ_t^* - PD_tZ_t^*, \text{ according to standard National Accounts definitions. The value of the final good sector’s output equals its total cost (as that sector is competitive): } P_t \cdot Q_t = PD_t \cdot D_t + PD_tZ_t^*. \text{ (N.B. } Q_t = C_t + I_t). \text{ Thus, } Y_t = PD_t \cdot (D_t + Z_t^*); \text{ a country’s GDP equals the value of its intermediate goods output (N.B. the model assumes}\]
In steady state, the markup factor of price over marginal cost in the production of intermediate goods is \( \nu/(\nu-1) \) (\( \nu \) is the own-price elasticity of the demand curve faced by an intermediate good producer; see (4)). \( \nu/(\nu-1)=1.2 \) is assumed, consistent with estimates of mark ups (in U.S. manufacturing) reported in Basu and Fernald (1993).\(^{19}\)

In the U.S. and in the remaining G7 countries, the share of total value added going to labor is roughly 0.66. In the model, the steady state share of wage payments in GDP is \( (1-\psi)(\nu-1)/\nu \), where \( \psi \) is the elasticity of the production function of intermediate goods with respect to capital (see (8)). Hence, \( \psi \) is set at \( \psi=0.208 \).

Aggregate data indicate a capital depreciation rate of roughly 2.5% per quarter and, hence, \( d=0.025 \) is assumed. The capital adjustment cost

---

that a country's entire labor force and its entire capital stock are used in that country's intermediate goods sector; hence, a country's entire value added (GDP) is generated in that sector. As described above, the model is linearized around a symmetric deterministic steady state. In such a steady state, net exports are zero (0=\( PD\ast Z-PZ\ast Z \)), and imported inputs account for a fraction \( \alpha \) of the final good sector's cost (\( PZ\ast Z=\alpha P\ast Q \)), which implies that, in such a steady state, the ratio of imports to GDP equals \( \alpha \).

\(^{19}\)It appears that the cyclical properties of the aggregate price/quantity variables on which the discussions below focus are invariant to the own-wage elasticity of labor demand, \( \gamma \), and hence no specific value has to be assigned to that parameter (the linearization of the model yields a system of equations in the aggregate variables that does not depend on \( \gamma \)).
parameter $\phi$ (see (24)) is set at $\phi=8$, in order to match the observation that the standard deviation of investment is approximately 4 times as large as that of output, in the U.S. and in the G6 (for lower values of $\phi$, investment is excessively volatile, relative to the variability of output).

The simulations consider a baseline case in which the average time between price changes (in producer's currency) at the firm level is 4 periods, where 1 period represents one quarter in calendar time (as the model is calibrated to quarterly data). This is motivated by recent empirical studies that suggest average time intervals between price adjustments in the range of 1 year, for a wide range of products (Romer (1996, p.294)). Thus, the parameter $\delta$ is set at $\delta=0.75$, i.e. a fraction $0.25 (=1-\delta)$ of all prices are changed each period. The average interval between wage changes is likewise assumed to be four quarters, i.e. $\omega=0.75$ is used.\footnote{Hall and Taylor (1997, p.434) argue that wage adjustments for non-union workers occur typically once every year, in the U.S. (wage contracts of union workers are changed less frequently).}

[ INSERT TABLE 1 ABOUT HERE ]

2.8.2. Exogenous variables

Table 1 reports estimation results for a vector autoregression (VAR) of order 1 that was fitted to quarterly money (M1) growth rates in the U.S. and in an aggregate of the remaining G7 countries (G6, henceforth), for the
period 1973:Q3–1994:Q3. The results show that the growth rate of money is positively serially correlated: the estimates of the diagonal elements of the matrix of autoregressive coefficients of the VAR are positive and highly statistically significant; in contrast, the off-diagonal elements are not statistically significant—the data are consistent with the hypothesis that a money supply innovation in one country has no effect on the money supply in the other country, in subsequent periods. Based on these findings, the simulations assume the following money supply process:

\[
\begin{bmatrix}
\Delta \ln(M_{t+1}) \\
\Delta \ln(M^*_t)
\end{bmatrix} = \begin{bmatrix}
0.3 & 0 \\
0 & 0.3
\end{bmatrix} \cdot \begin{bmatrix}
\Delta \ln(M_t) \\
\Delta \ln(M^*_t)
\end{bmatrix} + \begin{bmatrix}
\zeta_t \\
\zeta_t^*
\end{bmatrix},
\]

where \( \Delta \) is the difference operator (i.e. \( \Delta \ln(M_{t+1}) = \ln(M_{t+1}) - \ln(M_t) \)); \( \zeta_t \) and \( \zeta_t^* \) are normal white noises with a standard deviation of 0.009; the correlation between \( \zeta_t^1 \) and \( \zeta_t^* \) is 0.20.\(^\text{22}\)

\(^{21}\) See Section 3 and the Appendix for a discussion of the data. Standard Augmented Dickey-Fuller unit root tests fail to reject the hypothesis that log U.S. and G6 money supplies follow unit root processes and Phillips and Ouliaris (1990) cointegration tests suggest that these series are not cointegrated. Hence, the series can be modeled as a VAR in first differences (see Campbell and Perron (1991, p.170)). The order of the VAR was chosen using the Akaike criterion.

\(^{22}\) To simplify the discussion of the results, a symmetric shock process is assumed; the assumed autocorrelation of the money growth rate and the assumed standard deviation of money supply innovations correspond to the mean values of the corresponding statistics for the U.S. and the G6
Log productivity is assumed to follow a VAR:

\[
\begin{bmatrix}
\ln(\theta_t^*) \\
\ln(\theta_t^*)
\end{bmatrix} = \begin{bmatrix} 0.906 & 0.088 \\ 0.088 & 0.906 \end{bmatrix} \cdot \begin{bmatrix} \ln(\theta_{t-1}^*) \\ \ln(\theta_{t-1}^*) \end{bmatrix} + \begin{bmatrix} \xi_t \\ \xi_t^* \end{bmatrix},
\]

(43)

where \( \xi_t \) and \( \xi_t^* \) are normal white noises with a standard deviation of 0.0085. The correlation between \( \xi_t \) and \( \xi_t^* \) is 0.258. The parameters of this process are taken from Backus et al. (1995) who argue that (43) captures well the time series properties of total factor productivity in the U.S. and in an aggregate of European countries. This time series process for productivity has widely been assumed in the International RBC literature (see Backus et al. (1995)). (43) implies that productivity is highly positively serially correlated, and that positive productivity innovations that occur in a given country raise productivity in the other country, with a lag.

3. Stylized facts (Post-Bretton Woods era)

The last columns of Table 2 (labelled "Data") document the business cycle stylized facts described in Section 1, for the U.S. and for the aggregate of the remaining G7 countries referred to here as the G6. Standard deviations of (detrended) quarterly macroeconomic and financial variables are reported, as well as cross-correlations between these variables, for the period 1973:Q1-94:Q3. The time series for the G6 are weighted averages of time series for each of the G6 countries, using as weights the shares of money series. N.B. as \( M_{t+1} \) is the money stock at the end of period \( t \), the money supply innovation in (42) is assumed to belong to the period \( t \) information set.
these countries in total G6 output, in 1980 (for interest rates and stock returns, a weighted arithmetic average is used; for the remaining variables, a geometric average is used). The empirical measure of output used in Table 2 is real GDP, consumption is private non-durables plus services consumption and the money supply measure is M1; interest rates and equity returns are expressed on a quarterly basis. Detailed information on the data is provided in the Appendix. All historical time series have been detrended using the Hodrick and Prescott (1997) filter; before applying this filter, all series (with the exception of interest rates and equity returns) were logged.

In the U.S. and the G6, physical investment is more volatile than output, while the price level is roughly as volatile as output (the standard deviations of U.S. and G6 output are 1.83% and 1.09%, respectively). Standard deviations of consumption and interest rates are smaller than those of output. In contrast, the real and nominal exchange rates between the U.S. and the G6, as well as stock returns are much more volatile than output (standard deviation of exchange rates and stock returns about 7%-8%).

Output, investment, the price level and the nominal interest rate are highly positively correlated across the U.S. and the G6 (the cross-country correlations of these variables are in the 0.50-0.65 range; these cross-correlations are all statistically significant, at the 1% level). The cross-country (U.S.-G6) correlations of consumption and money stocks are somewhat lower (in the range of 0.30). Cross-country correlations of stock returns (around 0.70) are higher than those of output.

[ INSERT TABLE 2 ABOUT HERE ]