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# THIRD-COUNTRY EFFECTS OF THE U.S. POLICIES ON THE "RELATIVE" REAL EXCHANGE RATES IN THE G-7 COUNTRIES*

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*This paper provides a three-country exchange rate model to explore ways in which a country(especially the United States)'s domestic shocks influence the third-countries' exchange rates. Using the same framework, a traditional proposition concerning the exchange rate and capital flows is examined in the three-country version. Our study indicates that the third-country effects of the U.S. policies on the relative exchange rates are not trivial, depending on the source of disturbances, economic conditions and the world excess demand elasticities of goods for each country in multilateral world. It is also shown that a traditional relationship between the exchange rate and capital flows would hold even in the three-country version under the large-country assumption. An evidence using quarterly data for the G-7 countries over the period 1978 Q1 to 1993 Q2 generally supports the model.*

## I. INTRODUCTION

It is widespread that different shocks in a large country such as the United States would affect the exchange rates of third countries as well as the bilateral ones between the United States and the others.[1] However, most exchange rate models are experessed in a two-country framework, where one country may or may not be 'small'. Bilateral specification of the exchange rate in the two-country

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[1] An empirical work by Calvo, Liederman and Reinhart(1993) has shown that disturbances originating from the United States explain the greatest share of variances of capital flow (trade deficit) and real exchange rates in the Latin American countries that experienced no major changes in domestic policies.

models is expedient, both because bilateral data are more convenient to use and because comprehensive multilateral data typically do not exist. Third country effects are implicitly viewed as not relevant, or the issue is simply ignored in these studies.

Although a few studies by Driskill(1981) and Hayens and Stone(1994)[2] have pointed out the importance of third country effects, they lack any structural model to explain the third-country effects of real shocks in a country. This paper provides a three-country exchange rate model to explore ways in which a country (especially *the United States*)'s domestic shocks influence the third-countries' exchange rates. Using the same framework, a traditional proposition concerning the exchange rate and capital flows is briefly examined in the three-country version. Throughout this paper we refer to the exchange rates between third countries as the *relative* exchange rates.

Our study indicates that the third-country effects of the U.S. policies on the *relative* exchange rates are not trivial, depending on the source of disturbances, economic conditions and the world excess demand elasticities of goods for each country in multilateral world. It is also shown that a traditional relationship between the exchange rate and capital flows would hold even in the three-country version under the large-country asumption. An evidence using quarterly data for the G-7 countries over the period 1978 Q1 to 1993 Q2 generally supports the model.

Our model is compatible with the equilibrium models of the exchange rate developed by Stockman(1987), Edwards(1989) and Neary(1988). In these models, the real exchange rate(the *Purchasing Power Parity version*) is endogenously determined in the system, depending on the nature of disturbances and the economic structure of each country. The next section presents the model and the third-country effects on the exchange rates of U.S. real shocks will be discussed in section Ⅲ. In a later part of the same section, we deal briefly with the relationship between the exchange rate and capital flows in the three-country version. Supporting evidence and policy implications are provided in section Ⅳ and conclusions are in the final section.

## Ⅱ. THE MODEL

The three-large-country/three-good model is used to observe the behavior of the relative exchange rate between country B and C responding to the other country A's domestic shocks. Consider the case in which country A (the United

[2] Haynes and Stone (1994) have demonstrated that a bilateral exchange rate in a n-country world may be expressed solely as a function of bilateral variables only if (i) cross-rates are consistent (ii) multilateral weights of exchange rate are symmetric and, (iii) exchange rates are linear functions of domestic and foreign country variables.

States) produces goods 1, 2, and 3 and exports good 1 to countries B and C (foreign countries). Countries B and C produces goods 1 and 2, and goods 1 and 3 respectively. The United States imports good 2 from country B and good 3 from country C. It is assumed that countries B and C are not involved directly in trade with each other, since country B's and C's export goods are not gross substitutes.

The utility function in each country is assumed to be homogeneous of degree one with a Cobb-Douglas functional form but with different parameters across countries. For simplicity, utility is normalized such that an expenditure on a unit of utility equals one.[3] Each country's production function is assumed to be homothetic, concave and twice differentiable. Equations (1) through (3) are three countries' resource constraints which is bounded by capital flows.[4] Trade balance is simply determined by capital flows.[5] This idea is completely opposite to the elasticity approach in which the possibility of capital flows is assumed away in a static model.[6]

$$E^a(p_1^a, p_2^a, p_3^a, G^a, u^a) - R^a(p_1^a, p_2^a, p_3^a, G^a, V^a) + G^a = T^a \quad (1)$$

$$E^b(p_1^b, p_2^b, G^b, u^b) - R^b(p_1^b, p_2^b, G^b, V^b) + G^b = -s_b\ T^b \quad (2)$$

$$E^c(p_1^c, p_3^c, G^c, u^c) - R^c(p_1^c, p_3^c, G^c, V^c) + G^c = -s_c\ T^c \quad (3)$$

where country $i$'s expenditure ($E^i$) and revenue functions ($R^i$) are homogeneous of degree one in good $j$'s price ($p_j^i$) and increasing in utility ($u^i$) and factor endowments ($V^i$). $T^a$ is the U.S. overall capital inflow, which is equivalent to its overall trade deficit. $T^b$ and $T^c$ are the bilateral capital outflows of country B and C to the United States in terms of the U.S. dollar. $s_b$ and $s_c$ are country B and C's currencies per U.S. dollar. $G^i$ is government spending financed by a lump-sum tax for country $i$ under a balanced budget constraint. Following Ahmed(1986), government spending is assumed to provide public services by substituting for a fraction ($\alpha_u^G$) of private spending and being directly productive,

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[3] For the homothetic utility function, we can normalize utility such that $E_u^a = e^a(p_1^a, p_2^a, p_3^a) = 1$, where $E_u^a$ is an expenditure of a unit utility level and $e$ is an exact price index (Deaton and Muellbauer(1980)).

[4] See Chipman (1980, p160-162) for such a definition of a country's trade activity as capital constraints.

[5] An alternative way to get endogenous capital flows in the model is to treat capital flows as an intertemporal decision to smooth the excess expenditure over periods.

[6] Presumably, the elasticity approach deals only with the real side of the exchange rates and the trade balance even though it allows the assumption of perfect capital mobility in the model to satisfy the accounting identity.

with a marginal product ($\alpha_R^G$). Equations (4) through (7) indicate trade arbitrage conditions for perfectly substitutable goods.

$$p_1^a - \frac{p_1^b}{s_b} = 0 \tag{4}$$

$$p_1^a - \frac{p_1^c}{s_c} = 0 \tag{5}$$

$$p_2^a - \frac{p_2^b}{s_b} = 0 \tag{6}$$

$$p_3^a - \frac{p_3^c}{s_c} = 0 \tag{7}$$

A geometric price index is used for each country. Equations (8) through (10) define and normalize price levels in the three countries. This normalization has the advantage that the nominal exchange rate, $s_i$, becomes the *Purchasing Power Parity* version of the real exchange rate.[7]

$$(p_1^a)^{\alpha_1}\,(p_2^a)^{\alpha_2}\,(p_3^a)^{\alpha_3} = 1 \tag{8}$$

$$(p_1^b)^{\beta_1}\,(p_2^b)^{\beta_2} = 1 \tag{9}$$

$$(p_1^c)^{\gamma_1}\,(p_3^c)^{\gamma_3} = 1 \tag{10}$$

where $\alpha_j$, $\beta_j$ and $\gamma_j$ are expenditure shares on good $j$ for countries A, B, and C respectively. $\alpha_1 + \alpha_2 + \alpha_3 = 1$, $\beta_1 + \beta_2 = 1$ and $\gamma_1 + \gamma_3 = 1$. Equations (11) and (12) are the goods market clearing conditions. There are three markets, one for each good. By Walras's law, we need consider the market-clearing conditions for only two of the three goods. We assume, following Frenkel and Razin (1987), that government spending directly falls on the goods.

$$E_2^a + E_2^b - R_2^a - R_2^b + \frac{\alpha_2^G G^a}{p_2^a} + \frac{\beta_2^G G^b}{p_2^b} = 0 \tag{11}$$

$$E_3^a + E_3^c - R_3^a - R_3^c + \frac{\alpha_3^G G^a}{p_3^a} + \frac{\gamma_3^G G^c}{p_3^c} = 0 \tag{12}$$

[7] An alternative way found in the literature to normalize goods prices is to allow price level to be flexible and take one good price as a numeraire under a fixed exchange rate.

where $E_j^i$ and $R_j^i$ are a Hicksian demand and supply of good $j$ in country $i$ respectively. $\alpha_j^G$, $\beta_j^G$ and $\gamma_j^G$ are consumption shares of government spending on good $j$ by the three countries. $\alpha_1^G + \alpha_2^G + \alpha_3^G = 1$, $\beta_1^G + \beta_2^G = 1$ and $\gamma_1^G + \gamma_3^G = 1$.

Equations (13) and (14) show the financial market conditions for each country's capital flow. The U.S. overall capital inflow is financed by bilateral capital outflows of countries B and C to the United States. Capital flows are assumed to be imperfectly mobile because financial assets are imperfect substitutes.[8] Given international capital mobility and the U.S. interest rate, country B's bilateral capital outflow (to the United States) relative to that of country C is negatively related to the real interest rate differential $(r^b - r^c)$ between the two countries.

$$T^b + T^c = T^a \tag{13}$$

$$\frac{T^b}{T^c} = \rho e^{\lambda (r^b - r^c)} \tag{14}$$

where $\rho$ is a constant and $\lambda$ is a degree of international capital mobility. $\lambda$ represents a semielasticity of capital flow with respect to the interest rate differential. $\lambda$ is negative and finite by assuming that capital flows are imperfectly mobile.[9] Although the interest rates in country $B$ and $C$ could be affected by real disturbances such as government spending and capital productivity, they are assumed to be exogenously determined in the system for simplicity.

Capital flows derived by change in the real interest rate expand or shrink the resource constraints for each country. This, in turn, has an impact on relative prices through the wealth effect. The exchange rate, facilitating relative price changes, would tend to be correlated with capital flows. In the system, the unknown variables are real incomes $(u^a, u^b, u^c)$, the prices of goods $(p_1^a, p_1^b, p_1^c, p_2^a, p_2^b, p_3^a, p_3^c)$, exchange rates $(s_b, s_c)$ and capital flows $(T^b, T^c)$. Among real shoks considered are change in the U.S. government spending, change in the U.S. factor endowment of capital and technology changes.

## Ⅲ. THIRD-COUNTRY EFFECTS OF THE U.S. POLICIES ON THE EXCHANGE RATES

In this section, we discuss the third-country effects of the U.S. domestic real shocks on the relative exchange rates between two other countries. A traditional

[8] We implicitly assume that financial assets are narrowed to domestic and foreign money only.

[9] When capital flows are perfectly mobile across countries, $\lambda$ is negative and infinite. This implies that real interest rates equal each other in the two countries $B$ and $C$ under the interest parity condition.

proposition concerning the exchange rate and capital flows is briefly examined in the three-country version. To make the calculation tractable, we assume that real shocks occur only in the United States and that the U.S. government spending in the United States falls on export good (good 1) only, so that $\alpha_1^G = 1$ and $\alpha_2^G = \alpha_3^G = 0$.

## 1. Government Spending

Government spending is real consumption by the government not available to the private sector. However, government spending is assumed to provide public services such as an imperfect substitution for private spending ($\alpha_u^G$) and a positive effect on private production ($\alpha_R^G$), following Ahmed (1986). Net real consumption per dollar of government spending is 1 less its substitution effect.[10]

A rise in the U.S. government spending is financed mainly by a reduction in private real income given the U.S. overall capital constraint. Private real spending decreases by the net real consumption of government spending. This change in private spending causes relative prices (*the terms of trade*) to adjust internationally in a large-country model. This, in turn, may enforce or lessen an initial real spending change by the U.S. government spending through TOT effect. Changes in the exchange rates are required to accommodate relative price changes, maintaining the law of one price as well as fixed price indices for each country.

By totally differentiating the system, we can obtain the third-country effect of change in the U.S. govrnment spending on the relative exchange rate of country B's currency against country C's currency.[11] A change in the relative exchange rate between country B and C, defined as $s_b/s_c$, depends on expenditure shares of goods and the world excess demand elasticities of the export goods for each country.

$$\hat{S}_b - \hat{S}_c = \frac{\dfrac{\eta_{22}^{*}\gamma_3\alpha_3}{T^c q_3^c} - \dfrac{\eta_{33}^{*}\beta_2\alpha_2}{T^b q_2^b}}{\eta_{22}^{*}\eta_{33}^{*}}\,\alpha^G\, d\,G^a \tag{15}$$

[10] Government spending may substitute imperfectly for privately purchased consumption. Then the private purchase of consumption falls by $\alpha_u^G$ times the government spending change. $\alpha_u^G$ is a degree of substitutability. The private production effect is that government spending may be used for the production as an input. If we let $\alpha_R^G$ be the marginal productivity of government spending, the total amount of production change is $\alpha_R^G$ times the government spending change. Evidently $\alpha_u^G$ is between 0.2 and 0.4 in the U.S.(Kormendi(1983)) and the estimated value of $\alpha_R^G$ is around 0.4 in the U.K.(Ahmed (1986)).

[11] Contact the author for the detailed procedure of solving the system in this paper.

where a "$\wedge$" indicates a percentage change and $\alpha^G = 1-\alpha^G_u-\alpha^G_R$, representing the net income effect of the U.S. government spending. $\eta^*_{jj}$ is the own-price elasticity of world excess demand of good $j$, a sum of the excess demand elasticities in the three countries. $q^i_j$ is a share of export value of good $j$ in the trade balance for country $i$.

If country B's export good faces a relatively elastic excess demand, then a rise in the U.S. government spending tends to appreciate the real value of country B's currency relative to that of country C. Consider the extreme case in which the elasticity of world excess demand for good 2 is infinite, but that for good 3 is finite. A rise in the U.S. government spending would appreciate the relative exchange rate between country B and C. This would be the case when country B is so small that it cannot affect the price of its export good. When the elasticities of world excess demand for all goods are infinite, a change in the U.S. government spending would not affect the relative exchange rate at all.[12]

## 2. Factor Endowment

A factor endowment change(i.e. capital formation) affects relative prices and the exchange rate through the wealth effect and the production effect. The production effect tends to increase goods supply, while the wealth effect because of factor augmentation raises goods demand. Thus, the combined effect of factor endowment change affects relative prices ambiguously. The relative exchange rate, facilitating relative price changes, depends on the relative magnitude of the production and wealth effects and on the world excess demand elasticities for goods. The following equation (16) is the third-country effect of change in the U. S. capital formation on the relative exchange rate of country B and C.

$$\hat{S}_b - \hat{S}_c = \frac{\dfrac{\eta^*_{22}\gamma_3}{T^c q^c_3}(\lambda^a_3 - \alpha_3) - \dfrac{\eta^*_{33}\beta_2}{T^b q^b_2}(\lambda^a_2 - \alpha_2)}{\eta^*_{22}\,\eta^*_{33}}\; Y^a_v\ \hat{V}^a \tag{16}$$

where $\lambda^a_j$ is a capital use (income) share of industry $j$ in the U.S. total capital income and $Y^a_v$ is the U.S. total capital income. Note that $\lambda^a_j$ represents the production effect of the U.S. capital formation in good $j$'s industry, while $\alpha_j$ is its wealth effect.

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[12] Note that our external adjustment mechanism quietly differs from the standard view in which an increase in government spending raises the interest rate and thus appreciates the nominal and real exchange rate at home. See Branson(1985) and Feldstein (1986) for detailed discussions of the standard view.

Again, the relative exchange rate does not change when the world elasticities of excess demand for both goods are infinite. If country B's export good faces a relatively elastic demand and $\lambda_3^a > \alpha_3$, a factor augmentaion in the U.S. raises production of good 3 more than it does good 3's demand, thus driving down good 3's price. It, in turn, appreciates the relative exchange rate between country B and C. In the other case where the elasticity of world excess demand for good 3 is relatively elastic and $\lambda_2^a > \alpha_2$, the relative exchange rate of country B's currency would depreciate. In general, the effect on the relative exchange rate of the U.S. capital formation is ambiguous, depending on the relative magnitudes of its production and wealth effects, and the world excess demand elasticities of goods for each country.

### 3. Production-Agumenting Technology Change

Suppose that technology changes occur specific to the production of an export good (good 1) in the U.S. The new production function for good 1 ($x_1^a$) and total revenue are as follows:

$$\begin{aligned} x_1^a &= Q_1^a f_1^a(v^1) : x_j^a = f_j^a(v^j) \quad \text{for } j \neq 1 \\ R^a &= p_1^a x_1^a + p_2^a x_2^a + p_3^a x_3^a \\ &= p_1^a \; Q_1^a f_1^a + p_2^a f_2^a + p_3^a f_3^a \end{aligned} \tag{17}$$

where $v^j$ and $f_j^a$ are an input used in producing good $j$ and its production function, which is homothetic, concave and twice differentiable. $Q_1^a$ is a technology factor specific to the production of good 1 in the U.S. An increase in $Q_1^a$ means a correspondingly higher production value for given factor inputs. Obviously, then, a 1 percent change in $Q_1^a$ has the same effect on revenue as a 1 percent change in $p_1^a$. Following Dixit and Norman(1980, p. 138), we obtain the revenue change due to technology change:

$$Q_1^a \frac{dR^a}{dQ_1^a} = p_1^a \frac{dR^a}{dp_1^a} \tag{18}$$

Differentiating both sides in (18) with respect to good's prices, we get:

$$R_{Q_1 p_j}^a = \delta_{1j}(R_{p_j}^a) + p_1^a R_{p_1 p_j}^a \tag{19}$$

where $\delta_{1j}$ is a Kronecker delta where $\delta_{1j} = 1$ for $j = 1$ and O otherwise. An initial $Q_1^a$ is assumed to equal one. Reworking the system with (17) and (19), we obtain the third-country effect of the U.S. technology change on the relative exchange rate.

$$\hat{S}_b - \hat{S}_c = \frac{\frac{\eta^*_{22}\gamma_3}{T^c q^c_3}(\varepsilon^a_{13} - \alpha_3) - \frac{\eta^*_{33}\beta_2}{T^b q^b_2}(\varepsilon^a_{12} - \alpha_2)}{\eta^*_{22}\eta^*_{33}} p^a_1 x^a_1 \, d\, Q^a \tag{20}$$

where $\varepsilon^a_{1j}$ is a cross-price elasticity of supply for good 1 with respect to good j's price, which is negative. Technological progress in the U.S. affects the relative exchange rate through the wealth effect and the substitution effect of production. The substitution effect of production is brought about by substituting production of a relatively higher priced good (good 1) with that of lower priced ones. This effect is captured in $\varepsilon^a_{1j}$. Thus, technological progress specific to the production of good 1 reduces production of goods 2 and 3 in the U.S. Combined with the wealth effect, the substitution effect of technology change tends to increase the relative prices of goods 2 and 3.

An actual relative exchange rate change depends on the elasticities of world excess demand for goods. If country B's export good faces a relatively elastic demand, then the U.S. technological progress specific to producing good 1 at home tend to depreciate the relative exchange rate of country B's currency against country C's currency.[13] When the elasticities of world demand for both goods are infinite, the U.S. technology change would not affect the relative exchange rate between the other countries.

The model can be further extended to consider the third-country effects of other real shocks originating from the U.S. on the relative exchange rate of the other countries, such as tariff change and preference changes.

## 4. Capital Flows and the Relative Exchange Rate

To see the correlation of the exchange rate and capital flows in the three-country version, we start by pinning down the U.S. overall capital constraint (trade balance) to a given level. The U.S. overall capital inflow (trade deficit) is financed by bilateral capital outflows from country B and C to the United States as shown in the equation (13). With the U.S. overall capital constraint held constant,[14] a rise in country B's bilateral capital outflow to the U.S. implies a fall in that of country C. The ratio of country B's to country C's bilateral capital

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[13] See Stockman and Svensson (1987) for the effect of productivity shock on the exchange rate in an economy without investment.

[14] In our model, the world wealth is assumed to be fixed in the economy without investment and money as in Helpman and Razin (1982).

outflow to the U.S. is defined as the relative capital (out)flow, $T^b / T^c$ with $T^a$ held constant. By totally differentiating equation (13), we get,

$$\hat{T}^b / \hat{T}^c = \lambda(\text{RID}), \text{ where RID} = (dr^b - dr^c) \tag{21}$$

where RID represents a change in the real interest rate differential between country B and C given the U.S. interest rate. A change in the relative capital flow of country B against country C depends on RID as well as on $\lambda$. Given $\lambda$ and $T^a$, an increase in RID leads to a relatively lower capital outflow in country B to the United States, compared to that of country C.

Consider the case where the relative capital outflow of country B against country C falls because of a rise in RID. Given $\lambda$ and $T^a$, country B's capital constraint expands and its real expenditure increases, while that of country C falls. A rise in country B's real expenditure puts upward pressure on its domestic goods prices, while country C's goods demand tends to fall. Each country's demand change causes relative prices to adjust internationally in the large-country model. Relative price changes may reinforce or counteract an initial wealth change by capital flows. The exchange rates move in such a way that these seven price movements maintain the law of one price as well as a fixed price level in each country. Equation (22) shows how the relative exchange rate between country B and C would respond to a change in the relative capital flow.

$$\hat{S}_b - \hat{S}_c = \frac{\frac{t^c}{q_2^b}\eta_{33}^*\beta_2^2 + \frac{t^b}{q_3^b}\eta_{22}^*\gamma_3^2}{\eta_{22}^*\eta_{33}^*}(\hat{T}^b - \hat{T}^c) \tag{22}$$

where $t^i$ is a share of country $i$'s bilateral capital flow among the U.S. overall capital constraint, $T^i / T^a$. Change in the relative exchange rate depends mainly on the world excess demand elasticities for country B's and C's export goods.

As long as country B's and C's export goods face a finite $\eta_{jj}^*$ (large-country case), the bilateral capital outflow of country B with the United States relative to that of country C is associated with its relative exchange rate depreciation. In the case of infinite $\eta_{jj}^*$'s, however, the relative exchange rate between country B and C is insensitive to changes in their relative capital flows. These results represent a three-dimensional extension of the traditional transfer problem.[15] Even in the three-country version, our result could validate the traditional proposition that

[15] The main issue of a transfer problem is how the transfer affects national income,TOT, the exchange rate and the current account for both the transferor and transferee (Jones (1970) and Johnson(1961)).

the exchange rate depreciation is associated with capital outflow in the large-country case.[16]

## Ⅳ. EVIDENCE

According to theory, a traditional proposition concerning the exchange rate and capital flows would hold even in a three-country version under the large country assumption. That is, the real depreciation of the relative exchange rate is associated with the relative capital outflow in a large country case. It has also been demonstrated that third-country effects on the relative exchange rates of U. S. policy variables depend mainly on the sources of disturbances and the elasticities of the world excess demand for goods.

Although many studies have estimated a long-run relationship between real variables and the real exchange rate, few empirical studies have been conducted on the third-country effects of domestic real variables on the exchange rates for other countries. In an empirical work, Calvo, Leiderman and Reinhart (1993) found that U.S. variables contributed sizably to the variation in the real exchange rates in the Latin American countries. However, their work lacks any structural model to explain the third country effect of real shocks in a large country.

This chapter is devoted to providing support for our theoretical results using simple illustrations of the G-7 country cases. Quarterly data based on the year 1985 are used to estimate the third-country effects of the U.S. domestic shocks over the period 1978 Q1 to 1993 Q2. When quarterly data series were not available, the annual series were converted into quarterly data using the methods developed by de Boor (1981).[17] The estimation of (23) is constructed to test the following joint hypotheses: 1) $\alpha_1$ is positive and significantly different from zero and 2) $\alpha_2$ through $\alpha_4$ are jointly significant in determining the relative exchange rate. The first hypothesis tests whether a traditional relationship between exchange rate and capital flows holds even in the three-country version, given international capital mobility ($\lambda$).[18] The second proposition tests whether U.S. policies have sig-

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16 Using the two-country model where capital flows alter the level and location of world wealth, Stockman and Svensson (1987) have shown that the relationship between the two external variables is ambiguous and depends on the degree of risk aversion and the magnitude and sign of international debt.

17 The method developed by de Boor(1981) fits cubic spline curves to the nonmissing values of variables to form continuous-time approximations. To get consistent quarterly data, we put a restriction on the data conversion, the sum of the 4 quarterly values for the year.

18 International capital mobility ($\lambda$) between G-7 countries was estimated by the Cochrane-Orcutt technique (Johnston(1984, p. 323)). The estimation results are summarized in table A2. The results indicate that $\lambda$ is significantly non-zero and negative in most cases. The range of magnitudes of an absolute value of $\lambda$ is 1 through 6. Note that the relative overall current account of countries B and C was used a proxy for capital flows between countries B and C.

nificant impacts on the exchange rates of the G-7 countries, which seem to be independent of those policies.

$$(LNS_b - LNS_c)_t = \alpha_0 + \alpha_1 (LNCA^b - LNCA^c)_t + \alpha_2 LNUSG_t + \alpha_3 LNUSK_t + \alpha_4 USY_t + \eta_t \tag{23}$$

where $(LNS_b - LNS_c)$ in the left-hand side of (23) represents the relative exchange rate between country B and C and $LNS_i$ is a natural logarithm of the bilateral real exchange rate (PPP version) of country $i$'s currency per U.S. dollar. A rise in $(LNS_b - LNS_c)$ implies a real depreciation of the country B's currency against that of country C. $(LNCA^b - LNCA^c)$ is a natural logarithm of the ratio of the bilateral current account (CA) of country B with the United States, relative to that of country C, representing the relative capital flow between country b and C.[19]

A rise in $(LNCA^b - LNCA^c)$ implies a higher current account surplus in country B relative to that country C and, thus, a higher capital outflow. Note that we treated negative quantities of CA by using absolute values of CA in logarithms and placing the signs of CA in front of the logarithm values.[20] According to theory, the coefficient $\alpha_1$ is expected to be positive under the large-country assumption. This indicates that a real depreciation of the relative exchange rate between country B and C is associated with the relative capital outflow (current account surplus) of country B.

$LNUSG_t$ and $LNUSK_t$ are the natural logarithms of U.S. real government consumption(USG) and real gross fixed capital formation(USK). *LNUSK* measures change in the factor endowment of capital. Technogical progress in the United States was proxied by the growth rate of U.S. per capita GDP (USY). This type of proxy has been used in a number of empirical investigations dealing with the Ricardo-Balassa effect (Edwards (1989)). The nominal value of the exchange rate, government consumption and the WPI were obtained from International Monetary Fund (IMF), *International Financial Statistics (IFS)*. The U.S. per capita GDP and gross fixed capital formation were obtained from O.E.C.D., *National Accounts*. The bilateral current accounts of G-7 countries with the United States were from the U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*. Nominal values are divided by the price index (WPI) to get real values.

A generalized two-stage least squares (G2SLS) technique was used to estimate

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[19] We use the bilateral trade balance as a proxy of the bilateral current account for France, Italy and Germany.

[20] Although this treatment of negative quantities of CA is not valid in cases of near zero values of CA, the values of CA over the G-7 countries are large enough in absolute values.

equation (23) for two reasons: one, the contemporaneous values of the capital flows are plausibly endogenous, and two, the exchange rate series generally show serial correlation in its error terms.[21] The first stage is to estimate (23) using a 2SLS procedure to obtain the consistent estimators for each parameter.[22] The residuals from the 2SLS estimation were used to estimate the coefficients of the first-order autocorrelated error terms.[23] Then the latter were used to transform all variables in (23). A 2SLS procedure was implemented again using the transformed variables. All variables in the estimation except a growth rate of per-capita GDP are given in logarithmic terms, so that all coefficients represent the elasticity of the relative real exchange rate with respect to explanatory variables.

Table 1 summarizes the results obtained from the G2SLS using centered independent variables.[24] The relative real exchange rate of country B currency against that of country C is expressed by the country code in the first column of table 1. For example, CA-UK represents the relative exchange rate between Canada and the U.K. A rise in the relative exchange rate between Canada and the U.K. implies that the real value of the Canadian *dollar* against the British *pound* falls. The country code is provided in table A1. The main entries are parameter estimates and underneath, in parentheses, are the t-values of the parameter estimates. The F-statistic, the adjusted $R^2$ and mean square error (MSE) are given in columns 7 through 9 of tabel 1. The p-values of the F-statistics are given in parentheses under the F-statistics.

As expected, $\alpha_1$ is positive in most cases but statistically insignificant at the standard levels. This indicates that the traditional relationship between the exchange rate and capital flows is quite weak in the three-country version even though the sign of $\alpha_1$ is correct.[25] This result could arises from various empirical aspects. One of them is that the exchange rates might more often be influenced by overall rather than bilateral capital flows. Using quarterly data for the overall capital flow over the sample period, the Granger-Causality tests have shown that the overall capital flows have strong impacts on the real exchange rates in the G-7 countries. The test results are provided in table A3.

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[21] The Durbin-Watson tests for the 2SLS estimation of (23) indicate that there exist serially correlated error terms in (23).

[22] Instrumental variables used in the estimation are real interest rate differential, current and lagged values of the other variables in the right-hand side of (23).

[23] Here we assume the AR(1) process for the error terms in equation (23).

[24] Centering variables makes all independent variables orthogonal to significant intercept terms and, hence, removes any collinearity involving the intercept column (Belsley (1984)).

[25] As shown in the theory, the third-country effects of the U.S. real shocks on the relative exchange rate of G-7 countries depend on the economic conditions, the bilateral trade share of each country with the U.S. and the world elasticities of excess demand for each goods. Thus, the exact estimation of equation (23) would require the predeterminated value of each parameter. However, the pre-estimation of the coefficients is out of the scope of this paper.

**[Table 1]** G2SLS Estimations of Relative Real Exchange Rates in the G-7 Countries

| Code* | const. | $CA^b/CA^c$ | USG | USK | USY | F | Adj. $R^2$ | MSE | F1 |
|---|---|---|---|---|---|---|---|---|---|
| FR-UK | 1.0997 | 0.0045 | −0.5058 | 0.1497 | 2.0155 | 3.968 | 0.172 | 0.010 | 5.163 |
| | (71.96) | (0.49) | (−1.32) | (0.27) | (1.50) | (0.007) | | | (0.003) |
| GE-UK | 0.3189 | 0.0027 | −0.4877 | 0.0874 | 1.4947 | 4.549 | 0.199 | 0.003 | 6.019 |
| | (36.96) | (0.78) | (−1.98) | (0.27) | (1.96) | (0.003) | | | (0.001) |
| IT-UK | 1.8729 | 0.0240 | −5.0955 | 4.7726 | 4.2722 | 5.158 | 0.226 | 0.128 | 6.611 |
| | (35.83) | (1.05) | (−3.27) | (2.28) | (0.87) | (0.001) | | | (0.000) |
| CA-UK | 0.2504 | 0.0074 | 0.1681 | −0.0266 | 1.1896 | 1.400 | 0.027 | 0.005 | 1.184 |
| | (24.22) | (2.13) | (6.68) | (−0.08) | (1.63) | (0.246) | | | (0.324) |
| JA-UK | 2.0489 | 0.0241 | −2.1106 | 2.4600 | 4.7704 | 4.036 | 0.233 | 0.071 | 4.922 |
| | (52.06) | (1.17) | (−2.07) | (1.94) | (1.20) | (0.006) | | | (0.004) |
| GE-FR | −0.3227 | 0.0042 | 0.8686 | −0.7494 | 0.2807 | 5.230 | 0.229 | 0.003 | 6.761 |
| | (−36.64) | (0.50) | (4.31) | (−2.16) | (0.40) | (0.001) | | | (0.000) |
| IT-FR | 1.6733 | −0.0049 | −3.5884 | 4.1745 | −0.5724 | 4.481 | 0.192 | 0.072 | 5.418 |
| | (42.40) | (−0.13) | (−3.98) | (3.03) | (−0.18) | (0.004) | | | (0.002) |
| CA-FR | −0.1865 | −0.0011 | 1.9233 | −0.6037 | −0.6035 | 6.564 | 0.281 | 0.005 | 8.675 |
| | (−17.52) | (−0.39) | (4.58) | (−1.34) | (−1.02) | (0.000) | | | (0.000) |
| JA-FR | 1.4945 | 0.0001 | −1.3361 | 1.6385 | 0.0939 | 2.696 | 0.159 | 0.028 | 3.271 |
| | (52.32) | (0.001) | (−2.98) | (1.86) | (0.05) | (0.043) | | | (0.028) |
| IT-GE | 1.9271 | 0.0087 | −4.6015 | 5.0476 | −0.4172 | 4.632 | 0.203 | 0.104 | 6.162 |
| | (39.07) | (1.16) | (−4.12) | (2.84) | (−0.15) | (0.002) | | | (0.001) |
| CA-GE | −0.1478 | −0.0011 | 0.3565 | 0.1279 | −0.7099 | 2.821 | 0.176 | 0.003 | 3.651 |
| | (−16.70) | (−0.28) | (1.62) | (0.38) | (−1.29) | (0.033) | | | (0.018) |
| JA-GE | 0.6239 | 0.0167 | −4.1911 | 2.8733 | −1.0416 | 4.521 | 0.198 | 0.037 | 5.769 |
| | (22.03) | (0.49) | (−4.14) | (2.43) | (−0.65) | (0.003) | | | (0.001) |
| CA-IT | −1.2227 | 0.0073 | 6.6146 | −5.2544 | 0.0078 | 5.745 | 0.250 | 0.093 | 7.547 |
| | (−27.33) | (0.34) | (4.64) | (−2.87) | (0.003) | (0.000) | | | (0.000) |
| JA-IT | −0.3160 | 0.0091 | 2.0040 | −1.6801 | 0.0091 | 4.637 | 0.203 | 0.010 | 5.930 |
| | (−19.60) | (0.25) | (4.00) | (−1.91) | (0.01) | (0.002) | | | (0.001) |
| JA-CA | 1.3200 | 0.0017 | −3.6859 | 3.3329 | 0.1286 | 5.244 | 0.229 | 0.053 | 6.889 |
| | (39.35) | (0.11) | (−4.31) | (2.56) | (0.06) | (0.001) | | | (0.000) |

* Code represents the relative exchange rates between countries of which codes are provided in table A1.

**[Table 2]** Third-Country Effects of U.S. Variables on the Relative Exchange Rates of the G-7 Countries

| | USG | USK | USY |
|---|---|---|---|
| U.K. | + | − | insignificant |
| France | ? | ? | 〃 |
| Japan | − | + | 〃 |
| Germany | ? | − | 〃 |
| Italy | − | + | 〃 |
| Canada | + | − | 〃 |

Note : that + and − denote depreciation and appreciation of the relative exchange rate of each country. ? denotes the ambiguous effect of U.S. variables on the relative exchange rate.

Values (F1) of the F-statistics for the joint hypothesis tests of the second proposition are given in the last column of table 1. It is shown that $\alpha_2$ through $\alpha_4$ are jointly significant at standard levels in all regressions. This shows that real shocks originating from the United States have significant third-country effects on the relative exchange rates of the G-7 countries, although their impacts differ across countries. The third-country effects on the G-7 countries' exchange rates of each U.S. variable are summarized in table 2. A few policy implications can be drawn as follows.

The U.S. government consumption significantly affects the relative exchange rates of G-7 countries. In general, the relative exchange rates of the U.K and Canada against the other countries depreciate by a rise in U.S. government spending, while the rates in Japen and Italy tend to appreciate. The impacts of the U.S. government spending on the relative exchange rate of Germany against the other countries are ambiguous. The U.S. fixed capital formation also has significant impact on the relative exchange rates in most cases. The relative real exchange rates tend to depreciate for Japan and Italy but to appreciate for the U.K., Germany, Canada with a rise in U.S. capital formation. Change in the rate for France is ambiguous.

Note in general that the third-country effect of the U.S. capital formation appears to be in the opposite sign to that effect of the U.S. government spending on the relative exchange rate of each country. According to theory (equation (15) and (16)), this is the case where if the production effect of change in factor endowment of capital is *nil*, then the third-country effect of the U.S. capital formation on the relative exchange rate of country B and C tends to show the opposite sign to that effect of change in the U.S. government spending.

The U.S. technological progress does not appear to affect the G-7 countries' exchange rates. This insignificance of U.S. technological progress could possibly be because the sample period is not long enough to capture the effects of U.S. technological progress. The common finding in the above analysis is 1) that the U.S. real disturbances have significant impacts on the real exchange rates of the G-7 countries, although the magnitudes of these impacts on each country's exchange rate differ across countries, and 2) that a traditional proposition concerning the capital flows and the exchange rates generally holds in the three-country version, although its significance is relatively weak.

## V. CONCLUSION

Using the three-country exchange rate model, our study indicates that third-country effects of the U.S. policy changes is not trivial, depending on the world elasticities of excess demand for other countries' export goods as well as on their economic structure. Using the same framework, we have shown that the traditional relationship between the exchange rate and capital flows holds even in the three-country version under the large-country assumption. Using quarterly data for the G-7 countries over the period 1978 Q1 to 1993 Q2, an evidence generally supports the model.

## APPENDIX

**[Table A1]** Country Codes

| Country | Country Code |
|---|---|
| Canada | CA |
| Japan | JA |
| France | FR |
| United Kingdom | UK |
| Italy | IT |
| Germany | GE |

**[Table A2]** Cochrane-Orcutt Estimations of International Capital Mobility

| $LNCA^b - LNCA^c = \lambda(RID)^*$ | |
|---|---|
| RTB | $\lambda^{**}$ |
| FR-UK | −1.89 (−1.19) |
| GE-UK | −2.52 (−2.65) |
| IT-UK | −1.77 (−2.10) |
| CA-UK | −0.51 (−0.41) |
| JA-UK | −2.88 (−3.32) |
| GE-FR | −3.22 (−2.91) |
| IT-FR | 0.21 (0.04) |
| CA-FR | 1.68 (1.17) |
| JA-FR | −3.73 (−3.25) |
| IT-GE | −1.81 (−3.58) |
| CA-GE | −3.00 (−3.15) |
| JA-GE | −5.83 (−3.43) |
| CA-IT | −0.62 (−0.60) |
| JA-IT | −2.47 (−5.27) |
| JA-CA | −3.70 (−3.84) |

* ($LNCA^b - LNCA^c$) and RID represent the relative current account and a real interest rate differential between countries B and C respectively. The relative current account between countries B and C is expressed by country code given in table A1. For instance, CA-UK is the relative current account between Canada and the U.K. The overall current account was actually used as a proxy because the capital mobility is more vulnerable to overall capital flows than to bilateral capital flows. A real interest rate is calculated by a three-month discount rate less the inflation rate over the same period. $\lambda$ represents the international capital mobility. The interest rate were obtained from *IFS*.

** A main entry is a parameter estimate of $\lambda$. Values in parentheses beside the parameter estimates are the t-statistics.

**[Table A3]** Granger-Causality Test from the Overall Current Account to the Trade Weighted Real Exchange Rate Indexes for the G-7 Countries

| Country | 1 lag | 3 lags | 5 lags | 7 lags | FPE |
|---|---|---|---|---|---|
| United States | 9.7677* | 2.8300** | 1.4959 | 2.2379** | [1 1] 9.3411* |
| United Kingdom | 0.0773 | 0.3066 | 0.9281 | 0.7932 | [1 1] 0.0789 |
| France | 5.8755* | 2.4472 | 1.5980 | 1.3371 | [1 1] 6.3984** |
| Germany | 0.1160 | 1.0720 | 2.8749** | 2.0098 | [3 5] 3.4345* |
| Italy | 31.5963* | 9.8312* | 5.4011* | 3.6475* | [1 1] 36.0100* |
| Canada | 0.5475 | 1.2554 | 0.6713 | 2.2242** | [4 1] 5.9357** |
| Japan | 25.2202* | 5.9058* | 2.2234 | 0.7214 | [1 2] 17.5133* |

FPE is a final prediction error and the values in the blocked brackets are the optimal lag lengths for each country. * and ** denote significance at the 1% and 5% levels. See Akaike (1970) for the FPE criterion.

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