WP/03/54

IMF Working Paper

Trade Costs, Market Integration, and Macroeconomic Volatility

Allan D. Brunner and Kanda Naknoi

INTERNATIONAL MONETARY FUND

 WP/03/54

IMF Working Paper

IMF Institute

Trade Costs, Market Integration, and Macroeconomic Volatility

Prepared by Allan D. Brunner and Kanda Naknoi[1]

Authorized for distribution by Sunil Sharma

March 2003

Abstract

This paper examines the effects of trade costs on macroeconomic volatility. We first construct a dynamic, two-country general equilibrium model, where the degree of market integration depends directly on trade costs (transport costs, tariffs, etc.). The model is a extension of Obstfeld and Rogoff (1995). Naturally, a reduction in trade costs leads to more market integration, as the relative price of foreign goods falls and households increase their consumption of imported goods. In addition, with more market integration, the model predicts that the variability of the real exchange rate should fall, while the variability of the trade balance should increase. Trade costs have ambiguous effects on the volatility of other macro variables, such as income and consumption. Finally, we present some empirical findings that provide mixed support for the model's predictions.

JEL Classification Numbers: E32, F12, F41, F42

Keywords: transport costs, tariffs, relative prices, globalization

Authors' E-Mail Addresses: abrunner@imf.org and kanda@standford.edu

[1] We are grateful to Andrew Feltenstein, Michael Kumhof, Eswar Prasad, Sunil Sharma, Francis Warnock, and seminar participants at the IMF Institute and the Center for Financial Studies for helpful comments on earlier versions of this paper. The views expressed in this paper are ours and should not be attributed to any organization or institution. We are responsible for any and all errors and omissions.

Contents | Page

Tables

Figures

I. INTRODUCTION

There has been a great deal of recent attention given to the benefits and costs of globalization. Much of this attention has focused on the effects of increased trade and capital flows on income and income inequality. This paper addresses an issue that has received far less attention – what are the effects of increased integration on macroeconomic volatility?

There have been two main approaches to studying international business cycles. The first approach – see Backus, Kehoe, and Kydland (1992, 1994), Stockman and Tesar (1995), and Baxter and Crucini (1993) – is to construct and parameterize a dynamic general equilibrium model. The model is then used to simulate unconditional moments for various macroeconomic variables, which can be compared with the corresponding moments of the actual data. The second approach – see Lastrapes (1992), Ahmed, Ickes, Wang, and Yoo (1993), Clarida and Gali (1994), Eichenbaum and Evans (1995), Lee and Chin (1998), Prasad (1999), and Lane (1999) – is to place identifying restrictions on a vector-autoregressive (VAR) model that are consistent with a general equilibrium model. The resulting structural model can be used to examine impulse responses to various shocks and to determine the importance of various shocks in explaining the variability observed in the data.

One drawback to both of these approaches, however, is that they assume that the degree of economic integration is constant across time. In contrast, there is ample evidence that markets for trading goods, capital, labor, currencies, and risk have become more integrated since the end of World War II and that markets today are probably more integrated than any other historical period – see, for example, Irwin (1996) and Feenstra (1998) for historical perspectives. In our view, the effects of economic openness on the international business cycle are an important and neglected issue.

In this paper, we construct a dynamic general equilibrium model to study the effects of goods market integration on the international transmission process. There are several ways to incorporate the degree of goods market integration in such a framework. First, cross-border trading frictions – such as tariffs, quotas, subsidies, or transport costs – drive a wedge between the domestic and international prices of traded goods. Krugman (1980) and Krugman and Venables (1995), for example, use an iceberg-cost setup – a certain portion of the good "melts" in transit – to examine the effects of globalization on trade patterns and wage inequality. A second approach is to introduce the existence of nontradables. Lane (1997) views increased openness as a shift in consumer preferences away from nontraded toward traded goods, while Hau (2000, 2002) models openness as the supply of traded goods relative to the overall supply of goods. Third, consumers may not be willing to substitute as freely between domestic and foreign goods as they are between various domestic goods. Warnock (forthcoming) models increased openness as an increase in the substitutability of foreign goods for home goods. Finally, firms may have some market powers that allow them to price discriminate between domestic and foreign markets – that is, engage in pricing-to-market (PTM) behavior. Dornbusch (1987), Krugman (1987), Betts and Devereux (1996, 2000), and Senay (1998) show that lowering this degree of market power leads to an increase in overall goods trade.

We adopt the first approach – modeling trade barriers and transport costs – because we see these factors as the primary mechanisms behind market integration over the last several decades – see Sachs and Warner (1995) for an insightful analysis of trade liberalization. We also view our approach as less ad hoc than the alternatives. Moreover, the importance of PTM is not well supported by empirical evidence (Obstfeld and Rogoff, 2000). Finally, Obstfeld and Rogoff (2001) emphasize the roles of transport costs in explaining major puzzles in international finance.

We are primarily interested in studying the effects of nominal shocks, since the international VAR evidence (cited above) suggests that nominal shocks play a significant role in explaining short-term fluctuations of real variables. Our model is an extension of Obstfeld and Rogoff's (1995) model, which has become the standard "workhorse" model for studying international policy transmission in the context of nominal rigidities and imperfect competition – see Lane (2001) for an excellent survey of the "new open economy macroeconomics". We extend the Obstfeld and Rogoff model in two ways. First, as noted above, we allow goods market integration to be less than perfect by incorporating trade costs proportional to the real volume of trade. These costs can be viewed as resulting from tariffs or transport costs. Second, following Sutherland (1996), we also incorporate multiperiod nominal contracts, as described by Calvo (1983a, 1983b), to allow for reasonably sluggish price adjustments.

We then parameterize the model and, using numerical simulations, examine the effects of various shocks – monetary, government spending, and labor supply – under various degrees of market integration and for various country sizes. The model yields some testable hypotheses. The clearest prediction is that large countries and countries with high trade costs should have a relatively stable trade balance and a relatively volatile real exchange rate compared with smaller countries and with countries with lower trade costs.

Unfortunately, the implications are less clear for consumption and output. For consumption, if, on one hand, domestic shocks are more important sources of variability compared with foreign shocks, then we would expect to see consumption become more volatile with increases in trade costs or country size. If, on the other hand, foreign shocks are more important – which seems unlikely for large, industrial countries – then consumption would be less volatile as trade costs and country size increase. For output, the implications depend entirely on how important domestic fiscal shocks are to a country compared with all other shocks. If they are relatively important (unimportant), then output will become more (less) volatile for larger countries and for higher trade costs. Similarly, if domestic and foreign fiscal shocks are important, relative output will become more volatile for larger countries and for higher trade costs.

Finally, we test the model's predictions using a panel data of Organization for Economic Cooperation and Development (OECD) countries. Overall, the empirical results are somewhat mixed.

The remainder of the paper is organized as follows. Section II presents the theoretical model. Sections III and IV examine, respectively, the effects of trade costs on the model's steady-state relative prices and on the model's dynamic responses to various shocks. Section V presents the results of an empirical study of the model's implications. Section VI concludes.

II. Model of Goods Market Integration

This section of the paper outlines the dynamic, two-country general equilibrium model. As discussed earlier, the model is an extension of Obstfeld and Rogoff (1995). Most importantly, we introduce trade costs, so that we can examine the effects of increased goods market integration (through lower tariff barriers or lower transport costs) on the international transmission process. We also incorporate Calvo-type nominal contracts, which results in more reasonable price behavior. The steady-state equilibrium and the dynamic properties of the model are examined in Sections III and IV, respectively.

A. Household Preferences and Behavior

The world is populated by a continuum of household-producers indexed by z, $z \in [0,1]$. These households are divided into two countries, home and foreign. Households located in the home country are indexed by $z \in [0,\alpha]$, and those in the foreign country are indexed by $z \in [\alpha,1]$, where $0<\alpha<1$. Each household also produces a single variety of a differentiated, tradable good. Thus, z also indexes a continuum of differentiated products in global goods market, with $z \in [0,\alpha]$ denoting home goods and $z \in [\alpha,1]$ representing foreign goods.

All households have identical preferences. The utility function of a typical household in the home country depends positively on a basket of consumption goods (C_t) and real balances (M_t/P_t) and depends negatively on total hours devoted to producing goods (N_t):

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{\sigma}{\sigma-1} C_s^{\frac{\sigma-1}{\sigma}} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\kappa_s}{\mu} N_s^{\mu} \right]$$

$$0<\beta<1, \ \ \mu>1, \ \ \sigma,\varepsilon>0$$

where κ_t is a (negative) labor supply shock. Consumers in the foreign country have an analogous utility function.

There is a perfectly integrated capital market, where both countries can trade a nominal bond, which is denominated in the home country's currency. The household's budget constraint for the home and foreign consumers, respectively, are:

$$P_t C_t + M_t + F_t + P_t T_t = w_t N_t + \Pi_t + M_{t-1} + (1+i_{t-1}) F_{t-1} \quad (1)$$

$$P_t^* C_t^* + M_t^* + F_t^* / \mathrm{E}_t + P_t^* T_t^* = w_t^* N_t^* + \Pi_t^* + M_{t-1}^* + (1+i_{t-1}) F_{t-1}^* / \mathrm{E}_t \qquad (2)$$

where T_t is the amount of real taxes paid by home residents to the government, w_t is the home nominal wage rate, Π_t are the home nominal profits from goods, i_t is the home country's nominal interest, F_t is the stock of bonds held by home residents between t and t+1, and E_t is the nominal exchange rate. For the bond market to clear, the following equilibrium condition must hold:

$$\alpha F_t + (1-\alpha) \mathrm{F}_t^* = 0 \qquad (3)$$

The first order conditions for utility maximization for home and foreign consumers are:

$$(C_{t+1} / C_t)^{1/\sigma} = \beta (1+i_t)(P_t / P_{t+1}) \qquad (4)$$

$$(C_{t+1}^* / C_t^*)^{1/\sigma} = \beta (1+i_t)(P_t^* / P_{t+1}^*)(E_t / E_{t+1}) \qquad (5)$$

$$(M_t / P_t)^{\varepsilon} = \chi C_t^{1/\sigma} \left[\frac{1+i_t}{i_t} \right] \qquad (6)$$

$$(M_t^* / P_t^*)^{\varepsilon} = \chi C_t^{*\,1/\sigma} \left[\frac{1+i_t}{i_t + 1 - E_{t+1} / E_t} \right] \qquad (7)$$

$$\kappa_t N_t^{\mu-1} = C_t^{-1/\sigma} \frac{w_t}{P_t} \qquad (8)$$

$$\kappa_t^* N_t^{*\,\mu-1} = C_t^{*\,-1/\sigma} \frac{w_t^*}{P_t^*} \qquad (9)$$

Equations (4)–(9) are the standard consumption Euler equations, money demand equations, and the labor supply equations for home and foreign consumers, respectively.

Trade between the home and foreign countries is not costless. In particular, we assume iceberg-type trade costs, where a fraction τ ($0 < \tau < 1$) of all shipped goods is lost ("melts") in transit. The law of one price (LOP) does not hold in this case. Let $p(z)$ denote the producer price of home goods, $z \in [0,\alpha]$, denominated in the home currency; and let $p^*(z)$ denote the producer price of foreign goods, $z \in [\alpha,1]$, denominated in foreign currency. Consumers in the home country will pay $p(z)$ for domestically produced goods, while foreign consumers will pay $p(z)/E(1-\tau)$ for a unit of the foreign good. Thus, unless $\tau = 0$, the LOP will not hold. Similarly, foreign consumers face a price of $p^*(z)$ for foreign-produced goods, while home residents will pay $Ep^*(z)/(1-\tau)$.

The composite good for home consumers is a CES consumption index over all good varieties:

$$C = \left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \qquad \theta > 1$$

where c(z) is the household's consumption of variety z, and θ is the elasticity of substitution between differentiated goods. It can be shown that the home consumer's demand for good z is:

$$c_t(z) = \begin{cases} \left[\dfrac{p_t(z)}{P_t} \right]^{-\theta} C_t & for \;\; z \in [0, \alpha] \\ \left[\dfrac{E_t p_t^*(z)}{(1-\tau)P_t} \right]^{-\theta} C_t & for \;\; z \in (\alpha, 1] \end{cases}$$

where the consumption price index is defined as:

$$P = \left\{ \int_0^\alpha p(z)^{1-\theta} dz + \int_\alpha^1 \left[Ep^*(z)/(1-\tau) \right]^{1-\theta} dz \right\}^{\frac{1}{1-\theta}} \tag{10}$$

Similarly, the foreign consumer price index can be defined as:

$$P^* = \left\{ \int_0^\alpha [p(z)/E(1-\tau)]^{1-\theta} dz + \int_\alpha^1 p^*(z)^{1-\theta} dz \right\}^{\frac{1}{1-\theta}} \tag{11}$$

Multiplying equation (11) by E yields:

$$EP^* = \left\{ \int_0^\alpha [p(z)/(1-\tau)]^{1-\theta} dz + \int_\alpha^1 [Ep^*(z)]^{1-\theta} dz \right\}^{\frac{1}{1-\theta}}$$

It is clear from this relationship that purchasing power parity (PPP) – which states that $P = EP^*$ – does not hold unless $\tau = 0$. This failure of the LOP and of PPP has several implications for both the steady-state and for the dynamics of the model. We will discuss this in sections III and IV.

B. Firm Technology and Production

Each domestic and foreign firm faces the following world demand for its product, respectively:

$$y_t(z) = \left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t + \left[\frac{p_t(z)/(1-\tau)E_t}{P_t^*}\right]^{-\theta} Q_t^*/(1-\tau) \tag{12}$$

$$y_t^*(z) = \left[\frac{E_t\, p_t^*(z)/(1-\tau)}{P_t}\right]^{-\theta} Q_t/(1-\tau) + \left[\frac{p_t^*(z)}{P_t^*}\right]^{-\theta} Q_t^* \tag{13}$$

where

$$Q_t = \alpha(C_t + G_t) \tag{14}$$

$$Q_t^* = (1-\alpha)(C_t^* + G_t^*) \tag{15}$$

All firms have the same production technology, where each unit of output requires one unit of labor:

$$y_t(z) = N_t(z) \tag{16}$$

$$y_t^*(z) = N_t^*(z) \tag{17}$$

Prices are sticky in our model, and we follow Calvo (1983a, 1983b) in deriving the optimal price-setting rule. Let γ represent the share of firms that cannot change their prices in a given period. For the (1- γ) domestic firms that can change their prices at time t, their profit maximization problem is:

$$V_t = \sum_{s=t}^{\infty} \gamma^{s-t} \beta^{s-t} \frac{\Pi_s(z)}{P_s}$$

where

$$\frac{\Pi_t(z)}{P_t} = \frac{p_t(z) - w_t}{P_t}\left[\left[\frac{p_t(z)}{P_t}\right]^{-\theta} Q_t + \left[\frac{p_t(z)/(1-\tau)E_t}{P_t^*}\right]^{-\theta} Q_t^*/(1-\tau)\right]$$

A similar problem exists for foreign firms.

The first order condition for the firm's problem yields the following price-setting rule for home and foreign firms, respectively:

$$\mathrm{p}_t(z) = \frac{\theta \sum_{s=t}^{\infty} \beta^{s-t}\gamma^{s-t} \; \frac{\mathrm{w}_s}{P_s}\left[\left(\frac{1}{P_s}\right)^{-\theta} Q_s + \left(\frac{1}{(1-\tau)E_s P_s^*}\right)^{-\theta} Q_s^*/(1-\tau) \right]}{(\theta-1) \sum_{s=t}^{\infty} \beta^{s-t}\gamma^{s-t} \; \frac{1}{P_s}\left[\left(\frac{1}{P_s}\right)^{-\theta} Q_s + \left(\frac{1}{(1-\tau)E_s P_s^*}\right)^{-\theta} Q_s^*/(1-\tau) \right]} \tag{18}$$

$$\mathrm{p}_t^*(z) = \frac{\theta \sum_{s=t}^{\infty} \beta^{s-t}\gamma^{s-t} \; \frac{\mathrm{w}_s^*}{P_s^*}\left[\left(\frac{1}{P_s^*}\right)^{-\theta} Q_s^* + \left(\frac{E_s}{(1-\tau)P_s}\right)^{-\theta} Q_s/(1-\tau) \right]}{(\theta-1) \sum_{s=t}^{\infty} \beta^{s-t}\gamma^{s-t} \; \frac{1}{P_s^*}\left[\left(\frac{1}{P_s^*}\right)^{-\theta} Q_s^* + \left(\frac{E_s}{(1-\tau)P_s}\right)^{-\theta} Q_s/(1-\tau) \right]} \tag{19}$$

Since all domestic firms have identical production technologies, all firms that can change their price at time t will choose the same price according to equation (10). Hence, we can drop the index z, and define p_t as the optimal price at time t. Furthermore, we define the weighted-average producer price (q_t) as:

$$\mathrm{q}_t = \left[(1\text{-}\gamma) \sum_{s=0}^{\infty} \gamma^s \, p_{t-s}{}^{1-\theta} \right]^{1/1-\theta} \tag{20}$$

$$\mathrm{q}_t^* = \left[(1\text{-}\gamma) \sum_{s=0}^{\infty} \gamma^s \, p_{t-s}^{*\;1-\theta} \right]^{1/1-\theta} \tag{21}$$

Recognizing that all consumers have identical preferences and that all domestic and foreign firms have the same technology and will have the same pricing rule, we can drop the z subscripts. Moreover, using the producer price indexes, we can rewrite the consumer price indexes – equations (10) and (11) – as

$$\mathrm{P}_t = \left[\alpha\, \mathrm{q}_t^{\,1-\theta} + (1-\alpha)(\mathrm{E}_t \mathrm{q}_t^*/(1-\tau))^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{10'}$$

$$\mathrm{P}_t^* = \left[\alpha(\mathrm{q}_t/\mathrm{E}_t(1-\tau))^{1-\theta} + (1-\alpha)\mathrm{q}_t^{*\;1-\theta} \right]^{\frac{1}{1-\theta}} \tag{11'}$$

and firm demand functions – equations (13) and (14) – as:

$$y_t = \left[\frac{q_t}{P_t}\right]^{-\theta} Q_t + \left[\frac{q_t}{(1-\tau)E_t P_t^*}\right]^{-\theta} Q_t^*/(1-\tau) \tag{12'}$$

$$y_t^* = \left[\frac{E_t q_t^*}{(1-\tau)P_t}\right]^{-\theta} Q_t/(1-\tau) + \left[\frac{q_t^*}{P_t^*}\right]^{-\theta} Q_t^* \tag{13'}$$

Finally, note that firm profits are:

$$\Pi_t = q_t y_t - w_t N_t \tag{22}$$

$$\Pi_t^* = q_t^* y_t^* - w_t^* N_t^* \tag{23}$$

C. Government

Governments finance their purchases by lump sum taxation and issuing new money. The home and foreign government budget constraints are:

$$P_t G_t = P_t T_t + M_t - M_{t-1} \tag{24}$$

$$P_t^* G_t^* = P_t^* T_t^* + M_t^* - M_{t-1}^* \tag{25}$$

D. Forcing Equations

There are six forcing equations:

$$M_t = \rho_M M_{t-1} \tag{26}$$

$$M_t^* = \rho_M M_{t-1}^* \tag{27}$$

$$G_t = \rho_G G_{t-1} \tag{28}$$

$$G_t^* = \rho_G G_{t-1}^* \tag{29}$$

$$\kappa_t = \rho_\kappa \kappa_{t-1} \tag{30}$$

$$\kappa_t^* = \rho_\kappa \kappa_{t-1}^* \tag{31}$$

E. Equilibrium

An equilibrium for our model is a sequence of prices and allocations that satisfy: (a) the conditions for optimal household behavior – equations (1) through (11), (b) the conditions for optimal firm behavior – equations (12) through (23), (c) the government budget constraints – equations (24) and (25), (d) the forcing equations – equations (26) through (31), and (e) initial values for the forcing variables and for foreign asset holdings at time 0.

The model solution is not analytically tractable. We use numerical methods to solve for the steady-state equilibrium. We then construct a log-linear approximation of the model (in the neighborhood of the steady-state values), which is also solved using numerical methods. Since the dynamic properties of the model depend on steady-state values, we discuss the steady-state equilibrium in some detail in the next section of the paper. We explore the dynamic properties of the model in section IV.

III. Relative Prices in the Steady State

The steady-state equilibrium is characterized by a set of non-linear equations, which are listed in Appendix I. In our model, trade costs play an important role in determining steady-state allocations through their effects on relative goods prices faced by households in both countries. These relative prices will also play an important role in the international transmission process, as we will discuss in the next section of the paper. In this section, we examine how relative prices are affected by trade costs and by country size.

Let ψ_{ij} denote the price of country *i*'s good relative to country *j*'s consumption basket. Hence,

$$\psi_{HH} = \frac{q}{P}, \quad \psi_{FH} = \frac{q^* E}{P(1-\tau)}, \quad \psi_{HF} = \frac{q}{E\,P^*(1-\tau)}, \quad \text{and} \quad \psi_{FF} = \frac{q^*}{P^*}.$$

The presence of trade costs has several distorting effects on the steady-state equilibrium. First, the relative price of imported goods will increase for both countries with an increase in τ. This will induce households to substitute away from imported goods toward domestically-produced goods. Second, there is a positive income effect for both countries associated with an increase in cost-of-trade earnings. Because of the way we model trade costs, this effect also shows up as an increase in demand for both domestic and foreign goods. Finally, unless goods are perfectly substitutable, trade costs tend to raise the overall price of consumption.

How distorting are trade costs? It is unfortunate that we cannot derive analytical solutions for steady-state variables. Nevertheless, we can gain some insight from the examining the steady-state relationship for the domestic consumer price level:

$$P = \left[\alpha q^{1-\theta} + (1-\alpha)\left(\frac{Eq^*}{(1-\tau)}\right)^{1-\theta} \right]^{1/(1-\theta)}$$

It is useful to normalize the price of the consumption basket as follows:

$$1 = \alpha\left(\frac{q}{P}\right)^{1-\theta} + (1-\alpha)\left(\frac{Eq^*}{(1-\tau)P}\right)^{1-\theta} = \alpha\psi_{HH}^{1-\theta} + (1-\alpha)\psi_{FH}^{1-\theta}$$

From this expression, we can see that an increase in the relative price of imported goods for home consumers must result in a fall in the relative price of domestically-produced goods. The magnitude of these changes depends importantly on both α (the home country's size) and θ (the elasticity of substitution between goods). If the home country is large (large α), imported goods have a small weight (1-α) in the overall consumption basket, and, as a result, an increase in trade costs will have a lesser effect on the consumption basket compared to a smaller country. In other words, we would expect to see the relative price of imported goods rise by more and the relative price of domestically-produced goods fall by less for a large country compared to a small country.[2]

In order to examine the effects of trade costs and country size on relative prices, we need to set a number of parameter values. Most of the values – the exceptions are τ (trade costs) and α (country size) – have been established elsewhere in the literature. These values are summarized in Table 1.

There are a number of factors that contribute to trade costs, including transport costs, tariff, and non-tariff barriers. In addition, as McCalum (1995) and Engel and Rogers (1996) have shown, even after accounting for these factors, there are substantial impediments to trade. For example, exchange rate volatility, lack of shipping ports, language and other information barriers, and differences in legal and payments systems likely add to the costs of trade.

A few studies have tried to quantify the magnitude of transport and tariff costs, and these studies are summarized in Table 2. Haskel and Slaughter (2000) examined U.S. Census data compiled by Feenstra (1996) and found that transport costs vary widely from industry to industry. For example, in 1974, transport costs varied from 0 to 32 percent, as a percentage of trade, while the average for that year was 6.7 percent. The data also showed a clear declining trend in transport costs in the past few decades. This declining trend has been confirmed by other studies using the same data source – see, for example, Hummels (1999) and Obstfeld and Rogoff (2000). Baier and Bergstrand (2001) examined transport costs data complied for OECD countries. They found comparable and declining rates – 8.2 percent in 1958-60 and 4.3 percent in 1986-88 – with individual country rates varying in 1986-88 from 1 percent (Switzerland) to 9 percent (Australia).

Similarly, studies find that tariff costs were significant but declining over the second half of the 20th century. Baier and Bergstrand – combining tariff rates from Prewo (1978) and Deardorff and Stern (1986, 1990) – found that effective tariff rates for OECD countries

---

[2] Although we do not focus on substitutability in this paper, if goods are highly substitutable, then an increase in trade costs will have a lesser effect on relative prices compared to goods that are less substitutable.

declined from 11.2 percent in 1958-60 to 2.1 percent in 1986-88. Haskell and Slaughter found similar rates. Finally, as Obstfeld and Rogoff show, there is still a fair amount of variation in tariff rates among OECD countries, from 3.5 in Japan to 8.9 percent in Canada.

Based on these studies and assuming that there are other trade costs that cannot be easily measured, we conclude that total trade costs could be as high as 30 percent of trade. As a consequence, we calibrate our model using values of τ ranging from 0 to 0.30. Finally, we calibrate the model with two values of α – 0.1 and 0.3. These are the approximate GDP shares (relative to the world) of the United Kingdom and the United States, respectively.[3]

Figures 1 and 2 present numerical calculations for steady-state values of ψ_{FH} and ψ_{HH}, respectively, for several parameterizations of the model. As discussed above, an increase in trade costs is not reflected one-for-one in the relative price of imported goods (Figure 1), since the overall price of consumption increases in the home country; likewise, the relative price of domestic goods falls (Figure 2). It is also clear that country size plays a significant role in determining the impact on relative prices. For example, for $\tau = 0.3$, the relative price of imported goods will be about 7 percent higher for $\alpha = 0.3$ (the relative size of the United States) compared to $\alpha = 0.1$ (the relative size of the United Kingdom). On the other hand, the relative price of domestically-produced goods will be about 25 percent less for $\alpha = 0.3$ compared to $\alpha = 0.1$.

IV. The Dynamic Properties of the Model

In this section, we examine the dynamic properties of the model presented in Section II. Since the model is highly nonlinear, we study the log-linearized version of the model, which is described in detail in Appendix II. We subject the model to a number of temporary shocks – monetary, demand, and supply shocks – and examine the impulse responses for a number of economic variables. We focus on temporary shocks, because they are likely the primary sources of short-run fluctuations. Although we focus on a home country with $\alpha = 0.3$, we also compare these results to a smaller country.[4]

We are particularly interested in the effects that trade costs have on economic variability in the home country. As we saw in the previous section, trade costs have a significant impact on relative prices and on the relative allocation of goods. Similarly, trade costs play an important role in determining how various shocks are transmitted to economic variables.

---

[3] Our view is that GDP shares are probably a better proxy for "country size" than population. However, since our empirical investigation focuses only on OECD countries, the distinction is relatively unimportant.

[4] Our results are broadly similar to Crucini (1997), who finds that supply shocks have less impact on consumption and the trade balance for larger countries relative to smaller countries.

We can see the role that trade costs have for the transmission process by considering the log-linearized version of equation (12'), the demand function for the home firms' products:

$$\hat{y}_t = \Lambda \left\{\hat{Q}_t - \theta(\hat{q}_t - \hat{P}_t)\right\} + (1-\Lambda) \left\{\hat{Q}^*_t - \theta\left(\hat{q}_t - \hat{P}^*_t - \hat{E}_t\right)\right\} \tag{32}$$

$$\Lambda = \alpha\psi_{\mathrm{HH}}^{1-\theta}$$

where $\hat{Q}_t = \hat{C}_t + \hat{G}_t$, and $\hat{X}_t$ denotes the percentage deviation of X_t from its steady-state value (dX_t/X).[5]

The relationship in (32) implies that we can decompose deviations in aggregate demand into two sources of macroeconomic disturbances – domestic and foreign. Clearly, the impact of both types of disturbances on aggregate demand in the home country will depend on the magnitude of Λ, which depends on α (country size) and ψ_{HH} (the relative price of home goods in the home country). As we saw in the previous section and in Figure 2, ψ_{HH} falls with an increase in either country size (α) or trade costs (τ). Therefore, the responsiveness of home aggregate demand to domestic disturbances (via $\hat{C}_t$, $\hat{G}_t$, $\hat{q}_t$, *and* $\hat{P}_t$) is increasing in both α and τ. The effects of trade costs on Λ are fairly dramatic. For a relatively large country (α = 0.3), aggregate demand is almost 3 times more responsive to domestic disturbances when trade costs are high (τ = 0.3) compared to when trade costs are zero. The influence of trade costs on smaller countries is even more dramatic. For α = 0.1, aggregate demand is about 6 times more responsive when trade costs are high rather than equal to zero.

By construction, the responsiveness of home aggregate demand to domestic and foreign disturbances must sum to one. Therefore, the responsiveness of home aggregate demand to foreign disturbances (via $\hat{C}^*_t$, $\hat{G}^*_t$, $\hat{q}^*_t$, $\hat{P}^*_t$ *and* $\hat{E}^*_t$) falls with an increase in either trade costs (τ) or in country size (α).

A. Effects of Fiscal Shocks

The effects of domestic and foreign fiscal shocks on the home country are shown in Figures 3 and 4, respectively. The direct effect of a domestic fiscal shock for the home country is through its effects on the demand for home goods, the first term on the right-hand side of equation (32). Likewise, the direct effect of a foreign fiscal shock for the home country is

[5] The exceptions are foreign liabilities and government expenditures, which have steady-state values of zero. Their deviations are expressed relative to steady-state consumption -- $\hat{X}_t = dX_t/C$.

through the second term on the right-hand side of equation (32). As discussed above, the impact of either shock on aggregate demand in the home country will depend on the magnitude of Λ. For very large countries or for countries with very large trade costs, the relative price of home goods will be relatively low, and there will be a steady-state bias toward consumption of home goods relative to foreign goods. Therefore, the responsiveness of home aggregate demand to home government spending shocks (Λ) for these countries will be fairly large compared to a smaller country or to a country with lower trade costs. Similarly, for very large countries or for countries with very large trade costs, the responsiveness of home aggregate demand to foreign fiscal shocks (1-Λ) will be fairly small compared to a smaller country or to a country with lower trade costs.

The overall impact of one-percentage-point changes in government spending on home output are shown in panel (b) of Figures 3 and 4. Both domestic and foreign fiscal shocks have a stimulatory effect on domestic output, although the overall effect is mitigated by an increase in relative prices. Importantly, as trade costs increase, the stimulatory effect of domestic shocks becomes larger, and the stimulatory effect of foreign shocks because smaller. In addition, an increase in government demand for home goods crowds out private consumption (panel (a)) and raises the real interest rate in the home country (panel (e)).

The effects of the fiscal expansions on the trade-to-GDP ratio are shown in panel (d). For the case of a domestic fiscal shock, the increase in domestic demand for goods initially exceeds the increase in the supply of goods, so the home country experiences a trade deficit and a real appreciation in the first four years following the fiscal shock. As trade costs increase and as the domestic fiscal shock has more of an effect on domestic output, the trade deficit response becomes smaller, since a substitution towards home goods becomes stronger. Similarly, with higher trade costs and with more responsive domestic output, domestic prices are pushed up more relative to foreign prices in response to the domestic fiscal shock. In other words, the real exchange rate (panel (f)) becomes more responsive as trade costs increase.

For the case of a foreign fiscal shock, the increase in foreign demand for goods initially exceeds the increase in the supply of goods, so the home country experiences a trade surplus and a real appreciation in the first four years after the foreign fiscal stimulus. As trade costs increase and as foreign output and prices become more responsive to the fiscal stimulus, the trade balance becomes less responsive and the real exchange more responsive to the foreign stimulus.

B. Effects of Monetary Shocks

The effects of domestic and foreign monetary shocks on the home country are shown in Figures 5 and 6, respectively. The direct effects of domestic monetary shocks are two-fold. First, increased liquidity causes the real interest rate to fall in the home country (panel (e)), which leads consumers to increase current consumption relative to future consumption (panel (a)). Second, the increased liquidity also leads to a real depreciation of the exchange rate (panel (f)), which increases the relative price of foreign goods. In turn, this encourages foreign demand and discourages domestic demand for the home country's products. As a result, the home country experiences a trade surplus (panel (d)). Moreover, the positive interest rate effect on domestic consumption is always greater than the offsetting expenditure switching effect. Consequently, the home country also sees an overall expansion in domestic output.

As with fiscal shocks, we can understand the role of trade costs in this transmission process by examining equation (32). The consequences of the domestic monetary expansion will show up in both an increase in domestic aggregate demand (an increase in $\hat{Q}_t$ and an increase in the nominal exchange rate. Recall that the responsiveness of home aggregate demand to an increase in $\hat{Q}_t$ (Λ) is increasing in both α and τ. However, this stimulatory response is offset by a decrease in responsiveness to changes in the nominal exchange rate ($1-\Lambda$). That is, it takes a much larger exchange rate change to achieve a given change in the trade balance. As a consequence, as trade costs increase, output and the trade balance becomes less responsive, while the nominal and real exchange rates become more responsive.

The effects of a foreign monetary shock on the home country (Figure 5) are nearly opposite to the effects of a domestic monetary shock. The exception is the response of consumption. With a foreign monetary expansion, there is a real appreciation of the exchange rate in the home country, which stimulates consumption of foreign goods. This effect is smaller as trade costs increase, as suggested by equation (32).

C. Effects of Supply Shocks

The effects of domestic and foreign supply shocks on the home country are shown in Figures 7 and 8, respectively. Consider first the effects of a domestic supply shock. An increase in the supply of domestic goods (panel (b)) leads to a fall in the relative price of domestic goods, which implies both a fall in the domestic real interest rate (panel (e)) and a real depreciation in the real exchange rate (panel (f)). Thus, both domestic and foreign demand for home goods will increase following the supply shock. That is, domestic consumption (panel (a)) and the trade balance (panel (d)) go up.

The degree to which the increase in supply is distributed to the home country relative to the foreign country depends importantly on trade costs. As seen in equation (32), as trade costs rise, Λ also increases. As a result, domestic aggregate demand becomes more responsive to domestic changes in consumption and relative prices. Expressed somewhat differently, with higher trade costs, it takes a larger real depreciation to attract a given increase in foreign demand for the home country's products. Consequently, we should expect to see a larger domestic consumption response and a smaller trade balance response to a domestic supply shocks, as trade costs increase. In addition, the responses of the real interest rate and the real exchange rate become larger with higher trade costs.

Now consider the effects of a foreign supply shock (Figure 8). The increase in supply of foreign goods induces a fall in the relative price of foreign goods. As a consequence, the home real interest rate falls, and the real exchange rate appreciates. The result is an increase in domestic consumption, along with a substitution away from consumption of home goods toward consumption of foreign goods. Therefore, the home country initially experiences a trade deficit following the foreign supply increase.

Again, we can see from equation (32) that how this shock is transmitted to the home country depends crucially on trade costs. As trade costs increase, and $1-\Lambda$ falls, the effects of the foreign supply shock is muted, as domestic demand becomes less responsive to changes in foreign demand and foreign goods prices. As a result, the domestic consumption response is smaller with higher trade costs, and there is a smaller change in the home real interest rate. In addition, the trade deficit is smaller. Finally, the real exchange rate response is larger, because, with higher trade costs, a larger change in relative prices is needed to induce domestic consumers to help absorb the foreign supply response.

D. Summary

In this section, we have demonstrated how trade costs and country size can alter the transmission process of domestic and foreign shocks to various macro variables. Essentially, the presence of trade costs change steady-state relative prices in both the home and foreign countries, which leads to a bias towards consumption of domestically-produced goods and a reduced sensitivity of domestic aggregate demand to foreign disturbances.

The results of this section are summarized in Table 3. The first two columns of the table list the macroeconomic variables (X) and the economic shocks (Y) that we have studied in this section of the paper. The last two columns show the effect on the variability of a given macro variable with respect to a specific shock, as either trade costs (τ) or country size (α) increase. It is interesting to note that the influences of country size on variability is nearly the same (qualitatively) as the influences of trade costs, since Λ in equation (32) is increasing in both τ and α.

The results in Table 3 can be summarized as follows. First, for a large country or for a country with high trade costs, the model predicts that consumption will be more responsive to domestic shocks and less responsive to foreign shocks compared to a small country or to a country with low trade costs. On the other hand, output is less sensitive to most shocks as trade costs and country size increase. The exception is that output is more sensitive to domestic fiscal shocks in large countries or in countries with high trade costs.

The trade balance is less sensitive to all shocks as trade costs and country size increase. Again, this is because large countries and countries with high trade costs are significantly less responsive to changes in the relative price of imported goods. Thus, the home country's demand for foreign goods is less sensitive to foreign shocks. Similarly, for the home country, the bulk of the economic adjustment to domestic shocks occurs domestically rather than externally.

The real exchange rate – which reflects changes in relative prices between the home and foreign countries – is more volatile as trade costs and country size increase. The real exchange rate has to be more responsive in these cases, precisely because aggregate demand is less responsive to relative price changes with increases in trade costs or country size. That is, relative price changes need to be larger in these circumstances to achieve a given level of external adjustment.

This last result is rather interesting for another reason. Most theoretical models of the real exchange rate rely on some form of price or wage stickiness to generate real exchange rate movements. However, the degree of persistence in these models is generally quite small relative to observed behavior. In our model, however, we see that price stickiness is not a sufficient condition for generating persistent real exchange rate movements. Indeed, as seen in Figures 3 through 8, there is no change in the real exchange rate in response to any economic shock when the goods markets are perfectly integrated (when trade costs are zero). Thus, trade costs <u>and</u> price stickiness are necessary to explain this type of observed behavior.[6]

The model yields some testable hypotheses. The clearest prediction of the model is that large countries and countries with high trade costs should have a relatively stable trade balance and a relatively volatile real exchange rate compared to smaller countries and to countries with lower trade costs. Unfortunately, the implications are less clear for consumption and output. For consumption, if domestic shocks are more important sources of variability compared to foreign shocks, then we would expect to see consumption become more volatile with increases in trade costs or country size. If on the other hand, foreign shocks are more important – which seems unlikely for large, industrial countries – then consumption would be less volatile as trade costs and country size increase. For output, the implications depend entirely on how important domestic fiscal shocks are to a country compared to all other shocks. If they are relatively important (unimportant), then output will become more (less) volatile for larger countries and for higher trade costs.[7] Similarly, if domestic and foreign fiscal shocks are important, relative output will become more volatile for larger countries and for higher trade costs.

V. Empirical Results

As discussed in the previous section, our model has several testable predictions regarding the effects of trade costs and economic size on macroeconomic volatility. In this

---

[6] Betts and Devereaux (1996, 2000) achieve a similar result by introducing pricing-to-market. Our results are consistent with Rogoff (1996), who stresses the role of trade frictions in the explaining the dynamic properties of the real exchange rate.

[7] Although several studies have examined the importance of relative shocks, we are not aware of any studies that have documented the importance of individual shocks for any countries.

section of the paper, we test those predictions using a panel data set of 23 OECD countries from 1950 to 1990.[8] Below, we provide a discussion of the data set and the empirical results.

A. Data Issues

With the exception of the measures of transport costs and tariff rates, the data were constructed using the Penn-World Tables. We constructed macroeconomic volatility measures for per capita income and consumption growth, real effective exchange rate changes (using 1987-89 trade weights), the trade-balance-to-GDP ratio, and relative per capital income by calculating the standard deviation of annual observations over ten-year intervals (1951-60, 1961-70, 1971-80, and 1981-90). Ten-year intervals are a reasonable compromise between using annual observations, which likely contain significant volatility that is not related to trade costs, and using a sample-wide interval, which assumes that trade costs are stationary over the 1950-90 period. In order to control for sources of volatility other than trade costs, we also included initial GDP per capita, the investment-to-GDP ratio, and the government-spending-to-GDP ratio as regressors. These variables were sampled in 1950, 1960, 1970, and 1980 in order to avoid endogeneity with the volatility measures.

It is well known that transport costs and tariff rates are poorly measured. Most countries in the world compile bilateral trade statistics for f.o.b.-valued exports and c.i.f.-valued imports. If these data are accurate, then a comparison of c.i.f. imports of country *X* from country *Y* to f.o.b. exports of country *Y* to country *X* would provide a reasonable measure of transport costs between *X* and *Y*. Moreover, this measure would be consistent with the one obtained by comparing c.i.f. imports of country *Y* from country *X* to f.o.b. exports of country *X* to country *Y*. Unfortunately, such calculations are sometimes inconsistent across countries or result in implausible values, and this suggests that the bilateral statistics are unreliable for calculating trade cost measures.

A fewer number of countries also provide multilateral estimates of both c.i.f.-valued imports and f.o.b.-valued imports, which are published in the International Monetary Fund's *International Financial Statistics* (*IFS*). It is plausible that these estimates are more reliable than the bilateral data, since, for example, the multilateral statistics would be unaffected by imports from country Y being mistakenly attributed to those from country Z. Nevertheless, estimates of transport costs based on the multilateral data are not strictly comparable over time, unless transport costs are strictly proportional to distance and the structure of imports for the sample countries is unchanging over time.

Data on tariff rates are also poorly measured. The most widely available measure of trade protection is the average effective tariff rate, which is simply the amount of collected import duties relative to total imports. This measure can be quite misleading. For example, suppose that the tariff rate on a particular product is so high that imports of that product are

---

[8] We chose to limit our analysis to OECD countries both because the model, which is based on monopolistic competition, seems more appropriate for developed countries and because the data is probably better quality for developed countries than for emerging markets.

zero. In this case, the effective tariff rate is measured as zero, suggesting that the product is unprotected.

Despite these data problems, we constructed decade-average measures of transport costs and tariff rates using the above mentioned data, available from the *IFS*. In addition, we constructed a measure of economic remoteness (for each country in each decade) that provides an alternative to the trade cost measure. The index was calculated as follows:

$$R_{it} = \sum_{j \neq i} D_{ij} \bar{Y}_{jt} / \bar{Y}_{-it}$$

where R_{it} is the measure of economic remoteness for country i in decade t, D_{ij} is the distance between the capitals of country *i* and country *j*, $\bar{Y}_{jt}$ is the initial level of GDP of country *j* for decade *t*, and $\bar{Y}_{-it}$ is the initial level of world GDP (excluding country *i*) for decade *t*. While this index avoids mismeasurement of multilateral trade, it still does not directly address problems related to the relationship between trade costs and distance and to the structure of imports over time.

B. Regression Results

The empirical results are summarized in Tables 4 through 8. Each table corresponds to a different measure of macroeconomic volatility – income, consumption, real exchange rate, trade balance, and relative income variability. For each volatility measure, we examined three regression specifications. Each specification regressed the volatility measure on a constant, decadal dummies, initial GDP per capita, initial investment-to-GDP ratio, initial government-spending-to-GDP ratio, relative economic size, and one of three trade cost measures (transport costs, remoteness index, or tariff rates). The adjusted R^2 and the number of observations in each regression are reported at the bottom of the tables.

The control variables have some explanatory power for the volatility measures. First, countries with higher initial GDP per capita generally have lower macro volatility. Second, in contrast, economies with higher investment ratios are generally more volatile than those with lower ratios. An increase in the I/Y ratio raises the variability of the trade balance and relative income. There is only weak evidence that the investment ratio is positively associated with income and consumption variability, and there is no discernible effect on the real exchange rate. Finally, there is some evidence that a high government spending ratio lowers real exchange rate variability, while raising the volatility of the trade balance. The initial level of government spending does not appear to affect the variability of the other volatility measures.

We now address the central question of this section – what are the effects of higher trade costs and economic size on economic variability? Remarkably, the estimated effects of trade on economic volatility are consistent across our three measures of trade costs – transport costs, remoteness, and tariff rates. That is, the estimates generally have the same sign and similar levels of significance with regard to a particular measure of volatility. Unfortunately, however, the results provide only mixed support for our model's predictions.

The effects of trade costs and economic size on the variability of the trade balance (as a percent of GDP) are shown in Table 4. Recall from the previous section that our model predicts that the trade balance should become less volatile with an increase in either trade costs or country size. The empirical results indicate that country size is negatively correlated with trade balance variability. The results, however, indicate that higher trade costs lead to a more volatile trade balance rather than a more stable balance, although these estimates are significantly different from zero when tariffs are used as a measure of trade costs.

By way of comparison, consider the cases of Japan and the United Kingdom Japan was roughly twice the size of the United Kingdom in the 1980s, and by all measures it was had significantly higher trade costs. The standard deviations of the trade balance ratio for Japan and the United Kingdom, respectively were 1.4 and 1.8 percent. The empirical results indicate that Japan's trade balance ratio should vary by 0.75 to 1.0 percentage points less than the United Kingdom based on its relative size. On the other hand, because of Japan's higher trade costs, all things being equal, its trade balance should vary about 0.2 percentage points more than the United Kingdom.

The effects of trade costs and economic size on real exchange rate variability are shown in Table 5. Our model predicts that the real exchange rate should be more volatile with an increase in either trade costs or country size. The empirical results indicate that, indeed, higher real exchange rate volatility is associated with higher trade costs and larger countries, although the results are only convincing when tariffs are used as the measure of trade costs.[9]

`The effects of trade costs and economic size on the volatility of income and relative income are shown in Tables 6 and 7, respectively. The model predicts that the variability of these variables (with respect to trade costs and country size) depends on the importance of fiscal shocks. If domestic fiscal shocks are relatively important, then output will become more volatile for larger countries and for higher trade costs. If domestic and foreign fiscal shocks are relatively important, then relative output will become more volatile for larger countries and for higher trade costs. Unfortunately, the empirical results are contradictory: higher trade costs are associated with more variability, which would imply that fiscal disturbances are relatively more important than other shocks. On the other hand, larger countries are associated with less income variability, which would implies that fiscal shocks are relatively less important.

Income appears to be relatively more responsive to differences in trade costs and about as responsive to differences in country size compared to the trade balance. To put this in perspective, consider again the cases of Japan and the United Kingdom The standard deviations of income in the 1980s for Japan and the United Kingdom, respectively were 1.2

[9] This result is consistent with Hau (2002), who finds that real exchange variability is negatively related to the level of trade.

and 2.2 percent. The empirical results indicate Japan's income should vary by 0.9 percentage points less than the United Kingdom based on its relative size. On the other hand, because of Japan's higher trade costs, all things being equal, its income should vary about 0.3 to 0.4 percentage points more than the United Kingdom

Finally, the effects of trade costs and economic size on consumption variability are shown in Tables 8. The model predicts that the variability of consumption depends on the importance of domestic shocks relative to foreign shocks. If domestic shocks are relatively important, then consumption will become more volatile for larger countries and for higher trade costs. If foreign shocks are relatively important, then consumption will become less volatile for larger countries and for higher trade costs. The empirical results are conflicting: higher trade costs are associated with more variability, which would imply that domestic shocks are more important than foreign shocks. On the other hand, larger countries are associated with less consumption variability, which would imply that foreign shocks are more important than domestic shocks.

Consumption appears to be relatively more responsive to differences in both trade costs and country size compared to the trade balance and to income. The standard deviations of consumption in the 1980s for Japan and the United Kingdom, respectively were 0.8 and 2.6 percent. The empirical results indicate Japan's consumption should vary by 0.6 to 1.8 percentage points less than the United Kingdom based on its relative size. On the other hand, because of Japan's higher trade costs, all things being equal, its consumption should vary about 0.4 to 0.6 percentage points more than the United Kingdom

Overall, the results are somewhat mixed relative to the predictions of our model. Our model correctly predicts that higher trade costs raise real exchange rate variability. Our model is also consistent with empirical evidence that larger countries have more real exchange rate volatility and less trade balance variability. On the other hand, the empirical evidence is counter to the model's prediction that high trade costs should also be associated with less trade balance variability. In addition, the evidence is contradictory with respect to its predictions of income and consumption volatility.

What are the possible reasons for our model's inconsistency with the data? It cannot be argued that it's because of endogeneity between volatility and our trade cost measures. It's likely that high variability might lead countries to raise tariff barriers, but our transport cost and remoteness measures are unlikely to be endogenous, and the empirical results are very similar for all trade cost measures.

A more likely possibility is that changes in trade costs have other, indirect effects on macroeconomic variability. First, although we included government spending as an additional regressor, it is very likely that governments change other policy variables in response to changes in trade costs and changes in the macro environment. For example, Romer (1993) and Lane (1997) argue that open economies are typically associated with lower inflation, because their central banks have less incentives to use monetary policy to stimulate aggregate demand. Second, lower trade costs and more trade openness might change the degree of diversification in the economy, as the country moves toward its comparative advantages in production. These possibilities seems worth exploring in the future.

VI. Conclusion

In this paper, we constructed a dynamic general equilibrium model to study the effects of goods market integration on the international transmission process. Our model is an extension of Obstfeld and Rogoff's (1995) model, which has become the standard "workhorse" model for studying international policy transmission in the context of nominal rigidities and imperfect competition. We extended the Obstfeld and Rogoff model in two ways. First, we allowed goods market integration to be less than perfect by incorporating trade costs proportional to the real volume of trade. These costs can be viewed as resulting from tariffs or transport costs. Second, we also incorporated multiperiod nominal contracts, as described by Calvo (1983a, 1983b), to allow for reasonably sluggish price adjustments.

The model clearly demonstrates how trade costs and country size have important effects on the transmission process of domestic and foreign shocks to various macroeconomic variables. Essentially, the presence of trade costs changes steady-state relative prices in both the home and foreign countries, which leads to a bias toward consumption of domestically-produced goods and a reduced sensitivity of domestic aggregate demand to foreign disturbances.

Finally, we tested the model's predictions using a panel data of OECD countries. Overall, the empirical results are somewhat mixed. As discussed in the previous section, changes in trade costs can have other, indirect effects on macroeconomic variability. Government officials are likely to change key policies in conjunction with more trade openness, and the economic structure of the economy is also likely to change with greater goods market integration. We hope to explore these possibilities in future research.

APPENDIX I
STEADY-STATE EQUILIBRIUM

This appendix describes the initial steady-state equilibrium of our model – assuming that initial foreign assets (F_0) and government expenditures (G_0) are equal to zero – which is characterized by the following relationships:

$$i = (1-\beta)/\beta$$

$$(M/P)^{\varepsilon} = \chi\, C^{1/\sigma}\ (1+i/i)$$

$$(M^*/P^*)^{\varepsilon} = \chi\, C^{*\,1/\sigma}\ (1+i/i)$$

$$\kappa\, y^{\mu-1} = C^{-1/\sigma}\ \frac{w}{P}$$

$$\kappa^*\, y^{*\mu-1} = C^{*-1/\sigma}\ \frac{w^*}{P^*}$$

$$P\,C = q\,y$$

$$P^*\,C^* = q^*\,y^*$$

$$w/q = w^*/q^* = (\theta-1)/\theta$$

$$y = \left[\frac{q}{P}\right]^{-\theta} \alpha C + \left[\frac{q}{(1-\tau)EP^*}\right]^{-\theta} (1-\alpha)C^*/(1-\tau)$$

$$y^* = \left[\frac{Eq^*}{(1-\tau)P}\right]^{-\theta} \alpha C/(1-\tau) + \left[\frac{q^*}{P^*}\right]^{-\theta} (1-\alpha)C^*$$

$$P = \left[\ \alpha q^{1-\theta} + (1-\alpha)\left(\frac{Eq^*}{(1-\tau)}\right)^{1-\theta}\right]^{1/(1-\theta)}$$

$$P^* = \left[\ \alpha\left(\frac{q/E}{(1-\tau)}\right)^{1-\theta} + (1-\alpha)q^{*\ 1-\theta}\right]^{1/(1-\theta)}$$

There are 13 steady-state variables and 14 equations. Following Walras' law, one equation is redundant and can be deleted from the system.

Appendix II
Log-Linearized Version of the Model

This appendix presents the log-linearized version of the model presented in Section II of the paper. For any variable X_t, let $\hat{X}_t$ denote the percentage deviation from its initial steady state level; in other words, $\hat{X}_t = \frac{dX_t}{X}$. $\hat{F}_t$ and $\hat{G}_t$ are two exceptions. Their steady state values are zero by construction. We defined their deviations from steady state values relative to steady state consumption, i.e. $\hat{F}_t = \frac{dF_t}{C}$ and $\hat{G}_t = \frac{dG_t}{C}$. The corresponding foreign variables are defined in a similar fashion. For simplicity, we have used equations (22) through (25) to eliminate firm profits and government taxes from the system of equations. Each equation below corresponds directly to an equation in Section II; for example, equation (A1) corresponds to equation (1) in the main text.

A. Household Preferences and Behavior

The log-linearized household budget constraints for home and foreign consumers in (1) and (2) are:

$$\hat{C}_t + \hat{P}_t + \hat{F}_t + \hat{G}_t = \hat{y}_t + \hat{q}_t + \frac{\hat{F}_{t-1}}{\beta} \tag{A1}$$

$$\hat{C}_t^* + \hat{P}_t^* + \hat{F}_t^* + \hat{G}_t^* = \hat{y}_t^* + \hat{q}_t^* + \frac{\hat{F}_{t-1}^*}{\beta} \tag{A2}$$

The bond-market clearing condition in (3) is:

$$\alpha C\hat{F}_t + (1\text{-}\alpha)C^* \hat{F}_t^* = 0 \tag{A3}$$

The households' first-order conditions in (4) through (9) are:

$$(\hat{C}_{t+1} - \hat{C}_t) = \sigma(1-\beta)\hat{i}_t + \sigma(\hat{P}_t - \hat{P}_{t+1}) \tag{A4}$$

$$(\hat{C}_{t+1}^* - \hat{C}_t^*) = \sigma(1-\beta)\hat{i}_t + \sigma(\hat{P}_t^* - \hat{P}_{t+1}^* + \hat{E}_t - \hat{E}_{t+1}) \tag{A5}$$

$$\hat{M}_t - \hat{P}_t = \frac{1}{\sigma\varepsilon}\hat{C}_t - \frac{\beta}{\varepsilon}\hat{i}_t \tag{A6}$$

$$\hat{M}_t^* - \hat{P}_t^* = \frac{1}{\sigma\varepsilon}\hat{C}_t^* - \frac{\beta}{\varepsilon}\hat{i}_t + \frac{\beta}{(1-\beta)\varepsilon}(\hat{E}_{t+1} - \hat{E}_t) \tag{A7}$$

$$\hat{N}_t = \frac{1}{\mu - 1}(\hat{w}_t - \hat{P}_t - \frac{1}{1-\sigma}\hat{C}_t - \hat{\kappa}_t) \quad \text{(A8)}$$

$$\hat{N}^*_t = \frac{1}{\mu - 1}(\hat{w}^*_t - \hat{P}^*_t - \frac{1}{1-\sigma}\hat{C}^*_t - \hat{\kappa}^*_t) \quad \text{(A9)}$$

The consumption price indices in (10') and (11') are

$$\hat{P}_t = \alpha \psi_{HH}^{1-\theta} \hat{q}_t + (1-\alpha)\psi_{FH}^{1-\theta}(\hat{E}_t + \hat{q}^*_t) \quad \text{(A10)}$$

$$\hat{P}^*_t = \alpha \psi_{HF}^{1-\theta}(\hat{q}_t - \hat{E}_t) + (1-\alpha)\psi_{FF}^{1-\theta}\hat{q}^*_t \quad \text{(A11)}$$

B. Firm Technology and Production

Log-linearizing the firm's demand function (12') and (13') yields,

$$\begin{aligned}\hat{y}_t &= \alpha\psi_{HH}^{1-\theta}\left\{\hat{Q}_t - \theta(\hat{q}_t - \hat{P}_t)\right\} \\ &+ (1-\alpha)\psi_{HF}^{-\theta}\psi_{HH}\frac{C*}{(1-\tau)C}\left\{\hat{Q}^*_t - \theta\left(\hat{q}_t - \hat{P}^*_t - \hat{E}_t\right)\right\}\end{aligned} \quad \text{(A12)}$$

$$\begin{aligned}\hat{y}^*_t &= (1-\alpha)\psi_{FF}^{1-\theta}\left\{\hat{Q}^*_t - \theta(\hat{q}^*_t - \hat{P}^*_t)\right\} \\ &+ \alpha\psi_{FH}^{-\theta}\psi_{FF}\frac{C}{(1-\tau)C*}\left\{\hat{Q}_t - \theta\left(\hat{q}^*_t - \hat{P}_t + \hat{E}_t)\right)\right\}\end{aligned} \quad \text{(A13)}$$

Aggregate demand from (14) and (15) are:

$$\hat{Q}_t = \hat{C}_t + \hat{G}_t \quad \text{(A14)}$$

$$\hat{Q}^*_t = \hat{C}^*_t + \hat{G}^*_t \quad \text{(A15)}$$

The log-linearized production functions are:

$$\hat{y}_t = \hat{N}_t \quad \text{(A16)}$$

$$\hat{y}^*_t = \hat{N}^*_t \quad \text{(A17)}$$

The firm's pricing rules in (18) and (19) are:

$$\hat{p}_t - \beta\gamma\,\hat{p}_{t+1} = (1-\beta\gamma)\,\hat{w}_t \tag{A18}$$

$$\hat{p}_t^* - \beta\gamma\,\hat{p}_{t+1}^* = (1-\beta\gamma)\,\hat{w}_t^* \tag{A19}$$

The producer price equations in (20) and (21) become

$$\hat{q}_t - \gamma\hat{q}_{t-1} = (1-\gamma)\hat{p}_t \tag{A20}$$

$$\hat{q}_t^* - \gamma\hat{q}_{t-1}^* = (1-\gamma)\hat{p}_t^* \tag{A21}$$

For simplicity, we set initial net foreign assets and government purchases as zero. There are 20 endogenous variables and 21 equations. Following Walras's law, one equation can be dropped from the system. We used the computational method suggested by Uhlig (1999) to analyze the dynamic properties of the model.

Table 1. Model Parameter Values

Parameter Description	Parameter	Parameter Value
Discount rate	β	0.95
Intertemporal elasticity of substitution	σ	0.75
Elasticity of substitution between goods	θ	6
Inverse of consumption elasticity of money demand	ε	9
Elasticity of disutility from labor	μ	1.4
Persistence of shocks	ρ_i	0.5
Country size	α	0.1 and 0.3
Trade costs	τ	0.0 to 0.3
Fraction of firms changing prices	γ	0.5

Table 2. Summary of Trade Cost Measures

Study	Data Source	Year(s)	Estimate
	Transport Costs (as a percentage of trade)		
Haskel and Slaughter (2000)	U.S. Census data	1974	6.7
		1979	6.2
		1988	5.0
Hummels (1999)	U.S. Census data	1994	3.8
Obstfeld and Rogoff (2000)	U.S. Census data	1995	3.6
		1996	3.3
		1997	3.3
Baier and Bergstrand (2001)	IMF	1958–60	8.2[1]
		1986–88	4.3[1]
	Tariff Rates (as a percentage of trade)		
Baier and Bergstrand (2001)	Prewo (1978)	1958–60	11.2[2]
	Deardorff and Stern (1986,1990)	1986–88	2.1[2]
Haskel and Slaughter (2000)	Magee (1988)	1974	7.8
		1979	6.8
		1988	4.1
Obstfeld and Rogoff (2000)	OECD	1993	4.9 (US)
			7.7 (EU)
			3.5 (Japan)
			8.9 (Canada)

[1] Average of 16 OECD countries.
[2] Average of 18 OECD countries.

Table 3. Predicted Effects of Trade Costs and Economic Size

X (for Home Country)	*Y* (Shock)		Effect on the Variability of *X* with respect to *Y* given an increase in: Trade Costs (τ)	Country Size (α)
Output	Domestic	Money	-	-
		Fiscal	+	+
		Supply	-	-
	Foreign	Money	-	-
		Fiscal	-	-
		Supply	-	-
Consumption	Domestic	Money	+	+
		Fiscal	+	+
		Supply	+	+
	Foreign	Money	-	-
		Fiscal	-	-
		Supply	-	-
Real exchange rate	Domestic	Money	+	+
		Fiscal	+	+
		Supply	+	+
	Foreign	Money	+	+
		Fiscal	+	+
		Supply	+	+
Trade-balance-to-GDP ratio	Domestic	Money	-	-
		Fiscal	-	-
		Supply	-	-
	Foreign	Money	-	-
		Fiscal	-	-
		Supply	-	-
Relative output	Domestic	Money	-	+
		Fiscal	+	+
		Supply	-	+
	Foreign	Money	-	?
		Fiscal	+	+
		Supply	-	?

Table 4. Effects of Trade Costs on Trade Balance Variability

(LHS variable = standard deviation of trade balance relative to GDP)

	(1)		(2)		(3)	
RHS Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	0.557	0.30	-1.224	-0.37	-1.483	-0.34
1960s	-0.092	-0.37	-0.094	-0.42	---	
1970s	0.389	1.12	0.302	0.99	**1.095**	**3.96**
1980s	0.677	1.89	**0.623**	**1.95**	**1.631**	**4.83**
Initial GDP per capita	-0.065	-0.26	-0.100	-0.62	-0.259	-0.57
Initial *I/Y* Ratio	0.038	1.88	**0.049**	**2.75**	**0.081**	**284**
Initial *G/Y* Ratio	0.023	0.97	0.022	1.07	**0.125**	**2.98**
Transport costs	0.012	0.38	---		---	
Remoteness index	---		0.225	0.70	---	
Tariff rate	---		---		**0.107**	**2.44**
Relative size	**-0.027**	**-3.03**	**-0.028**	**-3.49**	-0.016	-1.46
Adjusted *R*-squared	0.130		0.156		0.217	
Number of observations	87		92		48	

Note: Numbers in bold indicate "significantly different from zero at the 5 percent confidence level."

Table 5. Effects of Trade Costs on Real Effective Exchange Rate Variability
(LHS variable = standard deviation of real effective exchange rate growth)

	(1)		(2)		(3)	
RHS Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	**14.397**	**2.03**	9.355	0.92	-0.683	-0.01
1960s	-1.284	-1.12	-1.256	-1.19	---	
1970s	1.794	1.52	1.505	1.41	**3.399**	**3.58**
1980s	1.951	1.53	1.792	1.59	**3.708**	**4.10**
Initial GDP per capita	-0.868	-1.04	**-1.642**	**-2.33**	0.023	0.04
Initial *I/Y* Ratio	-0.059	-1.25	-0.016	-0.35	0.020	0.30
Initial *G/Y* Ratio	**-0.185**	**-2.35**	-0.133	-1.76	-0.031	-0.51
Transport costs	0.145	1.75	---		---	
Remoteness index	---		1.271	1.28	---	
Tariff rate	---		---		**0.235**	**3.71**
Relative size	0.001	0.17	-0.030	-0.80	0.092	1.86
Adjusted *R*-squared	0.086		0.055		0.358	
Number of observations	87		92		48	

Note: Numbers in bold indicate "significantly different from zero at the 5 percent confidence level."

Table 6. Effects of Trade Costs on Income Variability
(LHS variable = standard deviation of real GDP per capita growth)

	(1)		(2)		(3)	
RHS Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	6.031	1.25	**8.897**	**2.03**	**-4.885**	**-0.51**
1960s	**-0.945**	**-2.87**	**-0.820**	**-2.76**	---	
1970s	0.524	1.19	0.620	1.52	**1.955**	**3.52**
1980s	-0.033	-0.07	0.147	0.31	**1.632**	**2.27**
Initial GDP per capita	-0.396	-0.75	**-0.986**	**-2.69**	0.307	0.35
Initial *I/Y* Ratio	0.019	0.76	0.030	1.28	0.069	1.35
Initial *G/Y* Ratio	-0.025	-0.57	-0.010	-0.24	0.073	0.79
Transport costs	**0.119**	**2.04**	---		---	
Remoteness index	---		0.291	0.75	---	
Tariff rate	---		---		**0.254**	**2.11**
Relative size	-0.025	-1.68	-0.015	-1.44	-0.016	-1.14
Adjusted *R*-squared	0.150		0.089		0.272	
Number of observations	87		92		48	

Note: Numbers in bold indicate "significantly different from zero at the 5 percent confidence level."

Table 7. Effects of Trade Costs on Relative Income Variability
(LHS variable = standard deviation of real GDP growth relative to OECD)

	(1)		(2)		(3)	
RHS Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	2.826	1.05	-0.258	0.47	**8.594**	**2.11**
1960s	**-1.033**	**-2.91**	**-1.047**	**-2.97**	---	
1970s	**-0.887**	**-2.11**	**-1.139**	**-2.70**	**1.048**	**3.19**
1980s	**-0.980**	**-1.96**	**-1.137**	**-2.42**	**1.244**	**3.11**
Initial GDP per capita	0.004	0.01	-0.440	-1.35	**-1.035**	**-2.04**
Initial *I/Y* Ratio	0.023	0.97	**0.061**	**2.22**	0.031	1.17
Initial *G/Y* Ratio	-0.052	-1.40	-0.036	-0.97	0.058	1.29
Transport costs	**0.098**	**3.13**	---		---	
Remoteness index	---		0.753	1.80	---	
Tariff rate	---		---		**0.105**	**5.78**
Relative size	**-0.047**	**-3.99**	**-0.042**	**-3.77**	-0.023	-1.91
Adjusted *R*-squared	0.304		0.299		0.410	
Number of observations	87		92		48	

Note: Numbers in bold indicate "significantly different from zero at the 5 percent confidence level."

Table 8. Effects of Trade Costs on Consumption Variability
(LHS variable = standard deviation of real consumption per capita growth)

	(1)		(2)		(3)	
RHS Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Constant	6.642	1.19	6.150	0.92	-0.017	-0.00
1960s	-0.821	-1.76	-0.622	-1.48	---	
1970s	0.555	0.95	0.790	1.48	**2.225**	**4.69**
1980s	0.083	0.13	0.345	0.54	**2.128**	**2.75**
Initial GDP per capita	-0.487	-0.80	**-1.344**	**-2.94**	-0.399	-0.37
Initial *I/Y* Ratio	0.015	0.53	0.021	0.80	0.083	1.41
Initial *G/Y* Ratio	-0.033	-0.79	0.003	0.08	0.117	1.20
Transport costs	**0.156**	**2.32**	---		---	
Remoteness index	---		0.938	1.61	---	
Tariff rate	---		---		**0.262**	**2.03**
Relative size	**-0.038**	**-2.18**	-0.026	-1.84	-0.020	-1.37
Adjusted *R*-squared	0.172		0.109		0.270	
Number of observations	87		92		48	

Note: Numbers in bold indicate "significantly different from zero at the 5 percent confidence level."

Figure 1. Relative Price of Imported Goods in the Home Country (ψ_{FH})

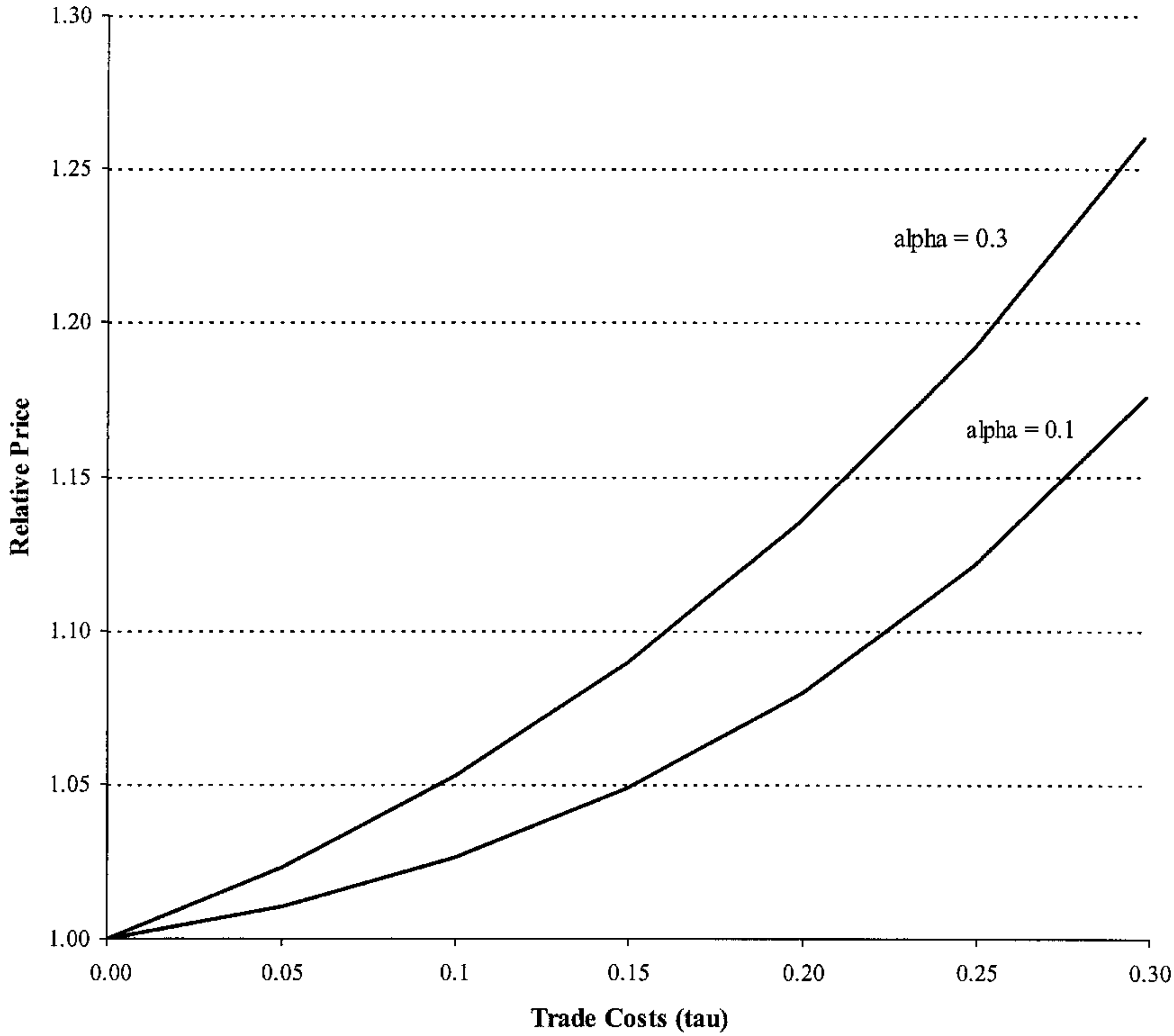


Figure 2. Relative Price of Home Goods in the Home Country (ψ_{HH})

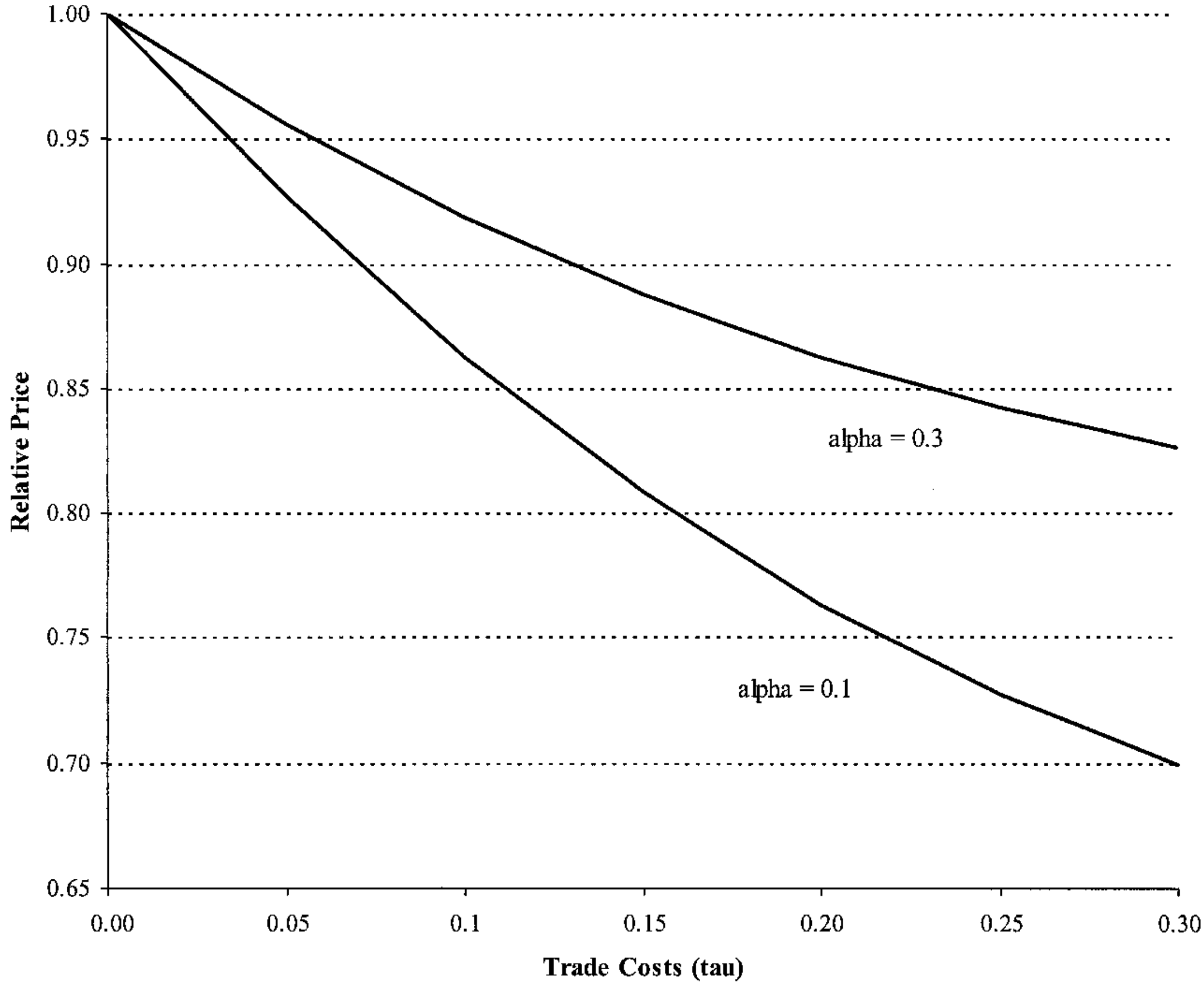


Figure 3. The Effects of a Home Fiscal Shock (α = 0.3)

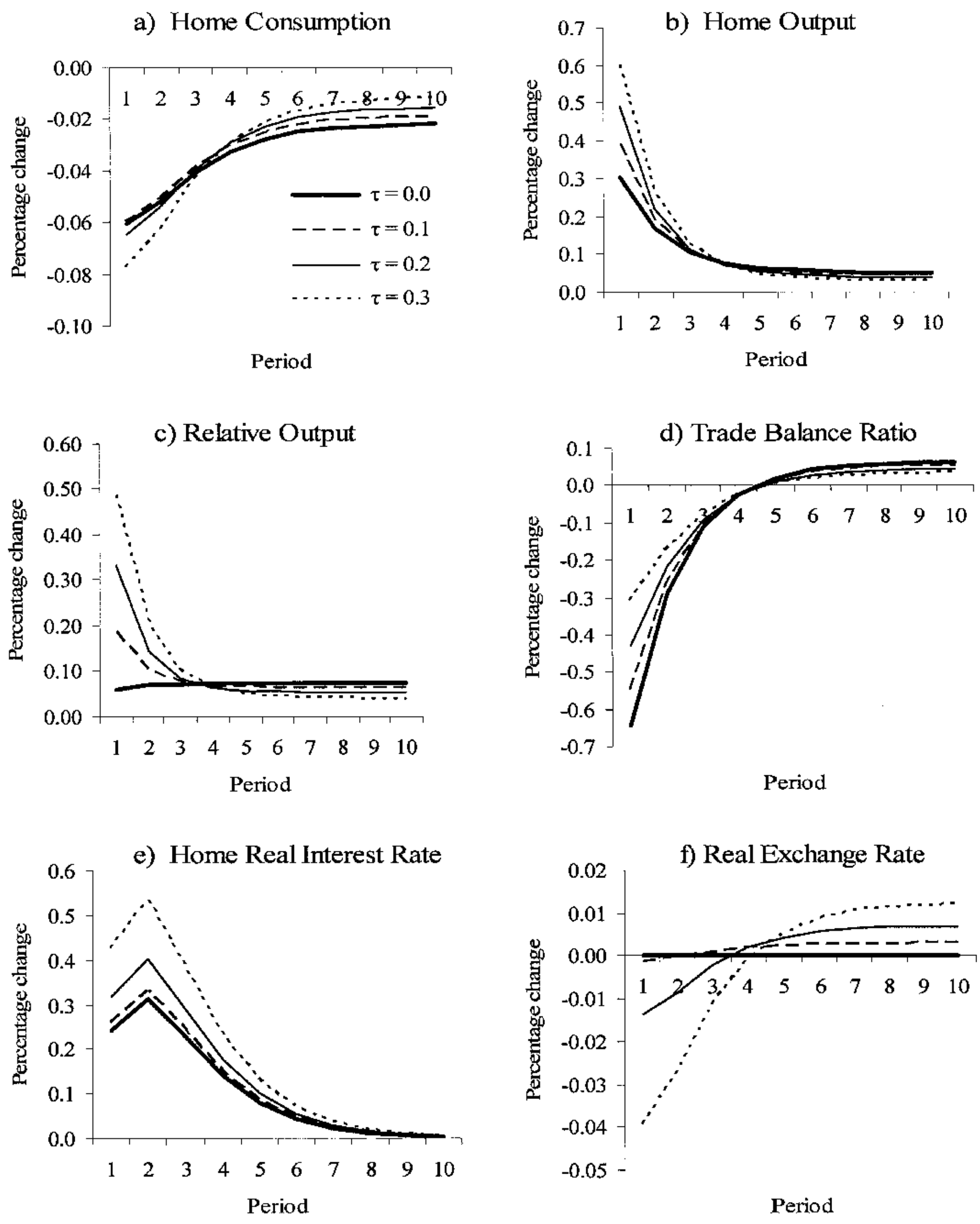


Figure 4. The Effects of a Foreign Fiscal Shock (α = 0.3)

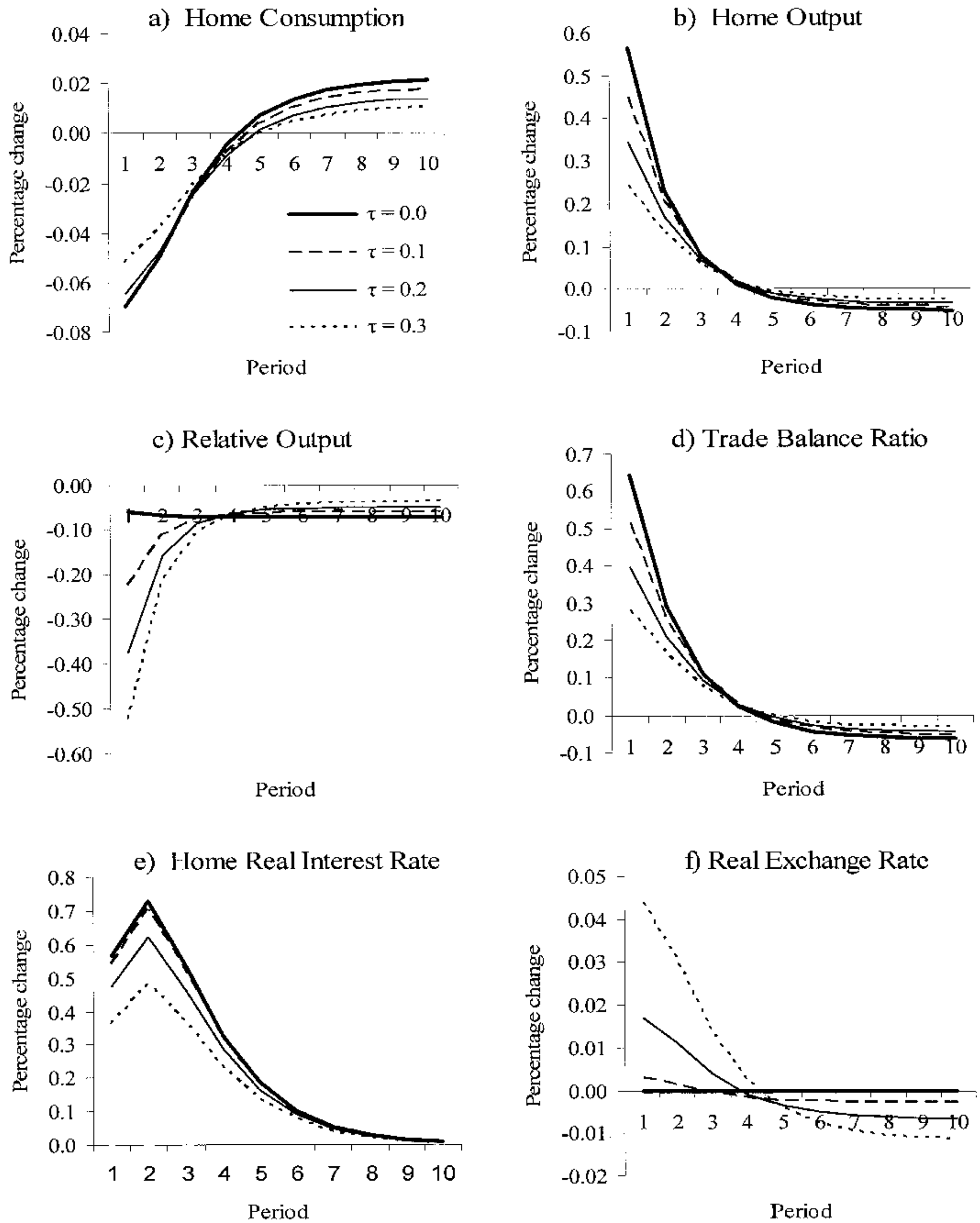


Figure 5. The Effects of a Home Monetary Shock ($\alpha = 0.3$)

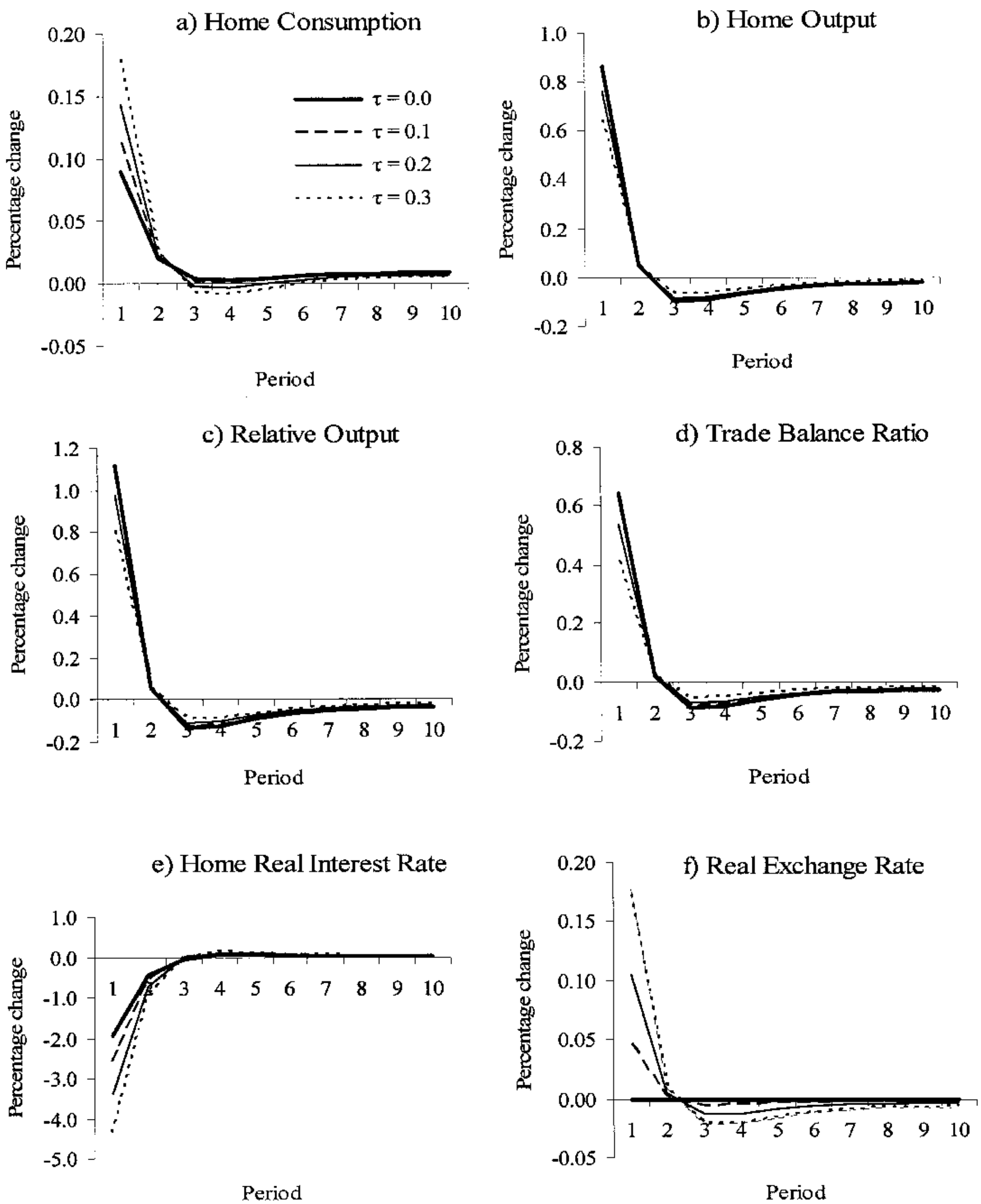


Figure 6. The Effects of a Foreign Monetary Shock (α = 0.3)

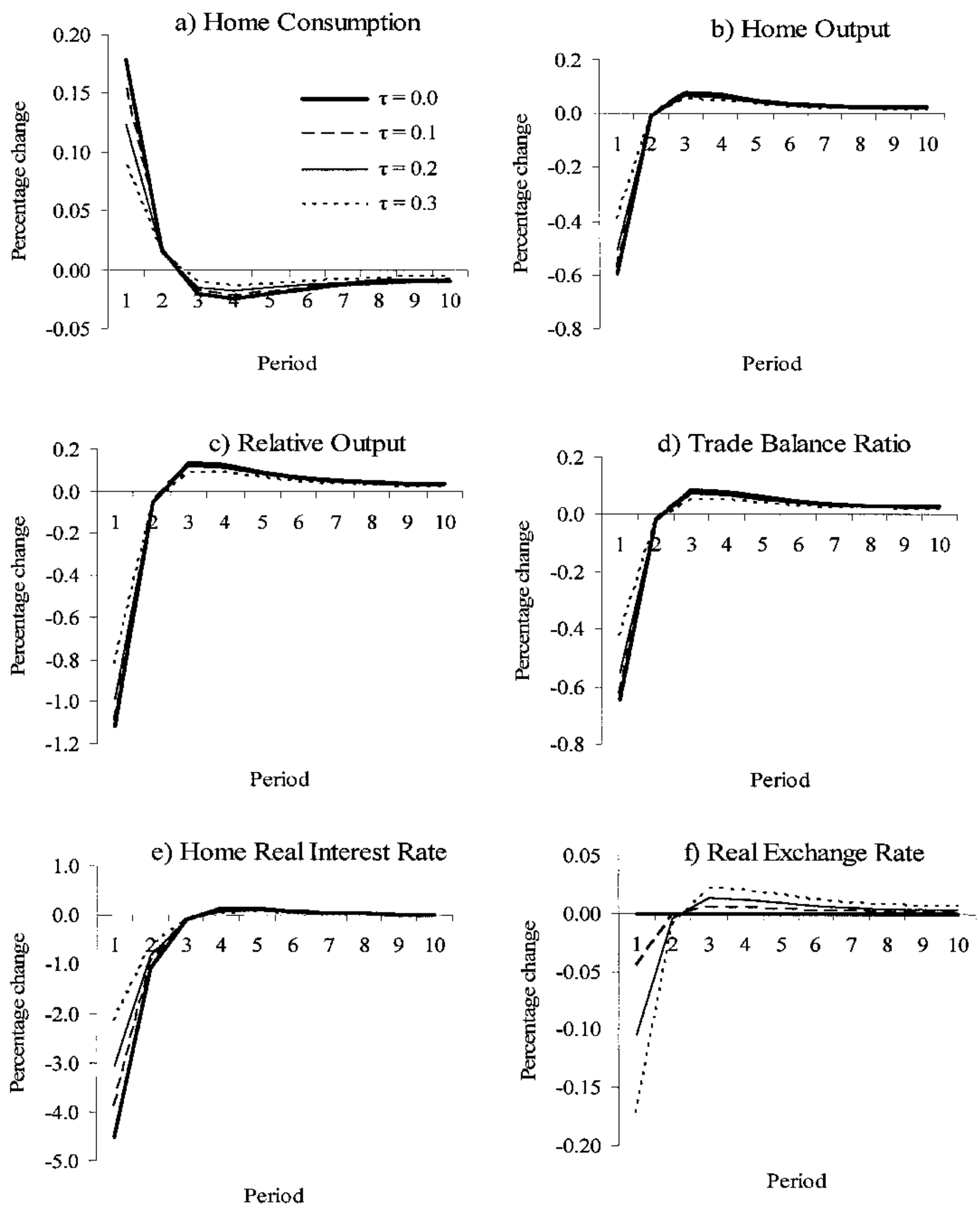


Figure 7. The Effects of a Home Supply Shock (α = 0.3)

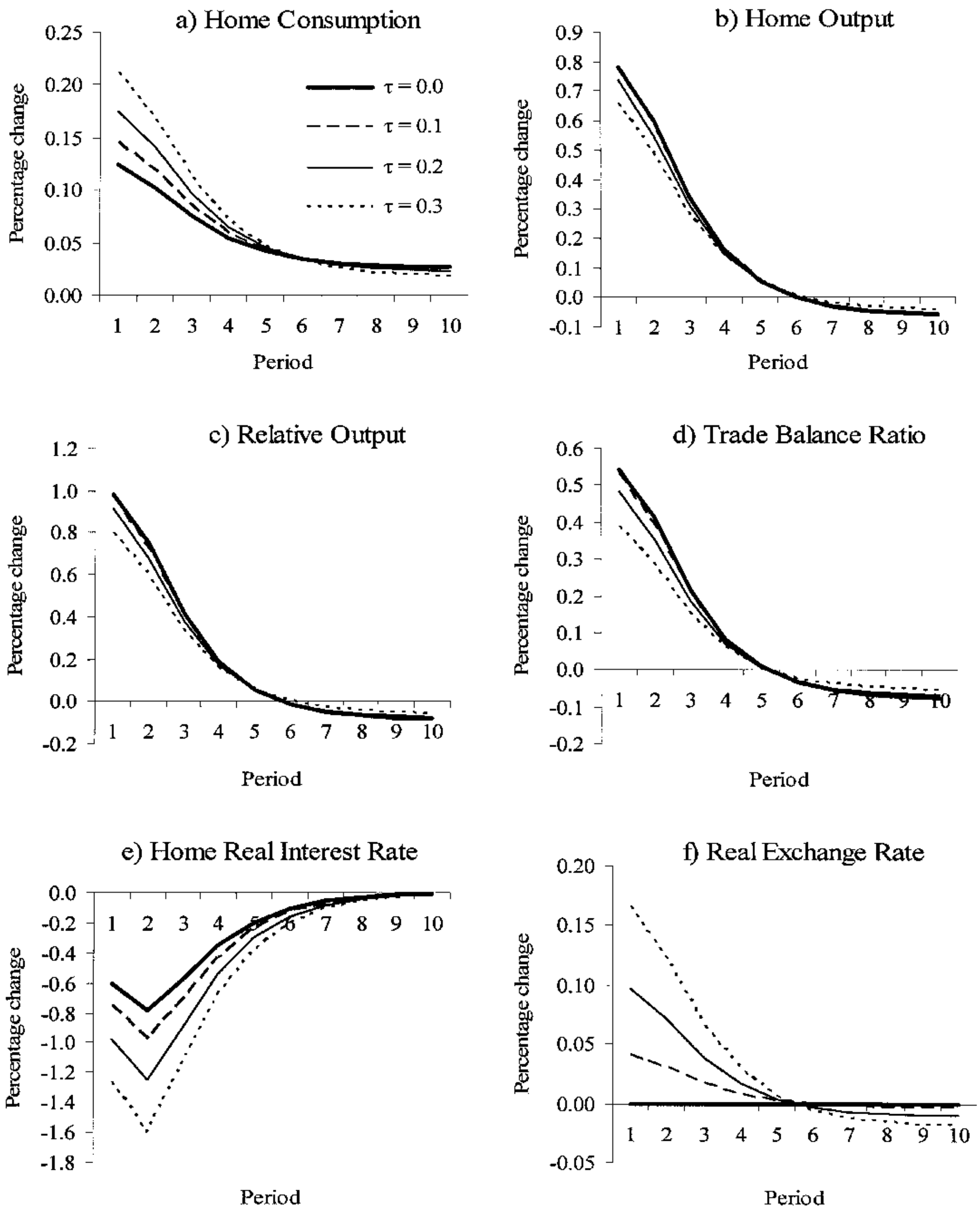
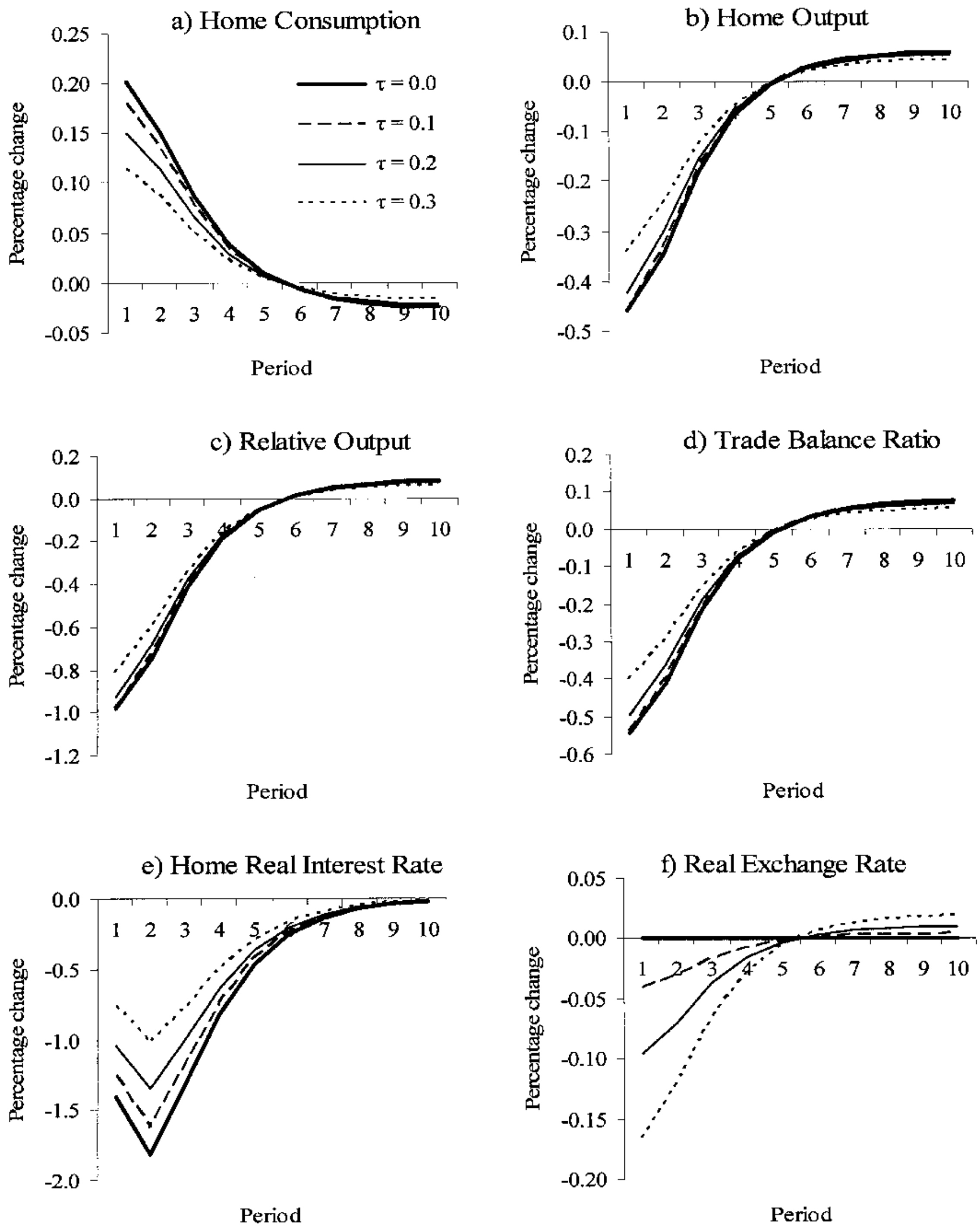


Figure 8. The Effects of a Foreign Supply Shock (α = 0.3)



References

Ahmed, Shagil, Barry Ickes, Ping Wang, and Byung Sam Yoo, 1993, "International Business Cycles," *American Economic Review*, Vol. 83, pp. 335–59.

Backus, David K., Patrick Kehoe, and Finn E. Kydland, 1992, "International Real Business Cycles," *Journal of Political Economy*, Vol. 100, pp. 745–75.

———, 1994, "Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?" *American Economic Review*, Vol. 84, pp. 84–103.

Baier, Scott L. and Jeffery H. Bergstrand, 2001, "The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity," *Journal of International Economics*, Vol. 53, pp. 1–27.

Baxter, Marianne, and Mario Crucini, 1993, "Explaining Saving-Investment Correlations," *American Economic Review*, Vol. 36, pp. 416–36.

Betts, Caroline, and Michael B. Devereux, 1996, "The Exchange Rate in a Model of Pricing-to-Market," *European Economic Review*, Vol. 40, pp. 1007–21.

———, 2000, "Exchange Rate Dynamics in a Model of Pricing-to-Market," *Journal of International Economics*, Vol. 50, pp. 215–244.

Calvo, Guillermo A., 1983a, "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics*, Vol. 12, pp. 383–98.

———, 1983b, "Staggered Contracts and Exchange Rate Policy," in *Exchange Rates and International Macroeconomics*, ed. by Jakob A. Frenkel (Chicago: University of Chicago Press).

Clarida, Richard, and Jordi Gali, 1994, "Sources of Real Exchange-Rate Fluctuations: How Important are Nominal Shocks?" Carnegie-Rochester Conference Series on Public Policy, Vol. 41, (Amsterdam: North-Holland), pp. 1–56.

Crucini, Mario J., 1997, "Country Size and Economic Fluctuations," *Review of International Economics*, Vol. 5, pp. 204–20.

Deardorff, Alan V., and Robert M. Stern, 1986, *The Michigan Model of World Production and Trade* (Cambridge, Massachusetts: MIT Press).

———, 1990, *Computational Analysis of Global Trading Arrangements* (Ann Arbor, Michigan: University of Michigan Press).

Dornbusch, Rudiger, 1987, "Exchange Rates and Prices," *American Economic Review*, Vol. 77, pp. 93–106.

Eichenbaum, Martin, and Charles L. Evans, 1995, "Some Empirical Evidence of the Effects of Shocks to Monetary Policy on Exchange Rates." *Quarterly Journal of Economics*, Vol. 110, pp. 975–1009.

Engel, Charles, and John H. Rogers, 1996, "How Wide is the Border?" *American Economic Review*, Vol. 86, pp. 1112–25.

Feenstra, Robert C., 1996, "U.S. Imports, 1972-1994: Data and Concordances," NBER Working Paper # 5515 (Cambridge, Massachusetts: National Bureau of Economic Research).

———, 1998, "Integration of Trade and Disintegration of Production in the Global Economy," *Journal of Economic Perspectives*, Vol. 12, pp. 31–50.

Haskel, Jonathan E. and Slaughter, Matthew J., 2000, "Have Falling Tariffs and Transportation Costs Raised U.S. Wage Inequality?" NBER Working Paper # 7539 (Cambridge, Massachusetts: National Bureau of Economic Research).

Hau, Herald, 2000, "Exchange Rate Determination: The Role of Factor Price Rigidities and Nontradables," *Journal of International Economics*, Vol. 50, pp. 421–447.

———, 2002, "Real Exchange Rate Volatility: Theory and Evidence," *Journal of Money, Credit, and Banking*, Vol. 34, pp. 611–30.

Hummels, David, 1999, "Have International Transportation Costs Declined?" (unpublished).

Irwin, Douglas A., 1996, "The United States in a New Global Economy? A Century's Perspective," *American Economic Review,* Vol. 86, pp. 41–46.

Krugman, Paul, 1980, "Scale Economies, Product Differentiation, and the Pattern of Trade," *American Economic Review*, Vol. 70, pp. 950–59.

———, 1987, "Pricing to Market When the Exchange Rate Changes," in S.W. Arndt and J.D. Richardson (eds.), *Real-Financial Linkages among Open Economies* (Cambridge, Massachusetts: MIT Press).

———, and Anthony J. Venables, 1995, "Globalization and the Inequality of Nations," *Quarterly Journal of Economics*, Vol. 110, pp. 857–80.

Lane, Philip R., 1997, "Inflation in Open Economies," *Journal of International Economics*, Vol. 42, pp. 327–47.

———, 1999, "Money Shocks and the Current Account," (unpublished).

———, 2001, "The New Open Economy Macroeconomics: A Survey," *Journal of International Economics*, Vol. 54, pp. 235–66.

Lastrapes, William, 1992, "Sources of Fluctuations in Real and Nominal Exchange Rates," *Review of Economics and Statistics*, Vol. 74, pp. 530–39.

Lee, Jaewoo, and Menzie D. Chinn, 1998, "The Current Account and the Real Exchange Rate: a Structural VAR Analysis of Major Currencies," NBER Working Paper # 6495 (Cambridge, Massachusetts: National Bureau of Economic Research).

McCalum, John C. P., 1995, "National Borders Matter: Canada-U.S. Regional Trade Patterns," *American Economic Review*, Vol. 85, pp. 615–23.

Obstfeld, Maurice, and Kenneth Rogoff, 1995, "Exchange Rate Dynamics Redux," *Journal of Political Economy*, Vol. 103, pp. 624–60.

———, 2000, "New Directions for Stochastic Open Economy Models," *Journal of International Economics*, Vol. 50, pp. 117–53.

———, 2001, "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" in *NBER Macroeconomics Annual 2000*, edited by Ben S. Bernanke and Kenneth Rogoff, pp. 339–412.

Prasad, Eswar S., 1999, "International Trade and the Business Cycle," *Economic Journal*, Vol. 109, pp. 588–606.

Prewo, Wilfried, 1978, "Determinants of the Trade Pattern among OECD Countries from 1958 to 1974," *Jahrbucher fur Nationalekonomie und Statistick,* Vol. 193, pp. 341–58.

Rogoff, Kenneth, 1996, "The Purchasing Power Parity Puzzle," *Journal of Economic Literature*, Vol. 34, pp. 647–68.

Romer, David, 1993, "Openness and Inflation: Theory and Evidence," *Quarterly Journal of Economics*, Vol. 108, pp. 870–903.

Sachs, Jeffrey D. and Andrew Warner, 1995, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity,* Vol. 1, pp. 1-118.

Senay, Ozge, 1998, "The Effects of Goods and Financial Market Integration on Macroeconomic Volatility," *The Manchester School Supplement*, pp. 39–61.

Stockman, Alan C., and Linda L. Tesar, 1995, "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements," *American Economic Review,* Vol. 85, pp. 168–85.

Sutherland, Alan, 1996, "Financial Market Integration and Macroeconomic Volatility," *Scandinavian Journal of Economics*, Vol. 98, pp. 521–39.

Uhlig, Harald, 1999, "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily," in *Computational Methods for the Study of Dynamic Economies*, edited by Ramon Marimon and Andrew Scott (Oxford University Press).

Warnock, Francis E., forthcoming, "Exchange Rate Dynamics and the Welfare Effects of Monetary Policy in a Two-Country Model with Home Product Bias," *Journal of International Money and Finance.*