What Happened to the Good Old Days? the Role of Expenditure Switching in the Global Imbalance Adjustment

Wei Dong*

Bank of Canada

August 19, 2009

Abstract

In this paper, we use a structural general-equilibrium approach to study whether the expenditure-switching role of exchange rates has changed in the G7 countries in the current episode of significant global imbalances. We develop a multi-sector two-country model for the United States and the G6 countries with the rest of the world captured by exogenous price and demand shocks, and estimate the model over two sub-samples, which covers the periods before and after the early 1990s. Our results indicate that both U.S. imports and exports have become much less responsive to exchange rate movements in recent years. This may suggest that the unwinding of the same amount of U.S. trade deficit would require a larger move in exchange rates now than in the 1970s and 1980s. Structural estimation reveals that the decline in the responsiveness of trade to exchange rates is due to changes both in the variances of structural shocks and in firms' pricing behavior, as well as the increased size of distribution margins.

JEL Classification: F3, F4
Bank Classification: Exchange Rates; Inflation and Prices; International Topics

---

*I thank Ali Dib, Philipp Maier, Larry Schembri, and numerous seminar participants for helpful comments. Contact:*wdong@bank-banque-canada.ca*.

1 Introduction

Global current account imbalances have received enormous attention in recent years. In particular, the U.S. current account deficit has widened substantially in the last decade. Many factors are linked to the evolution of the global imbalances, including low saving rates in the United States (Obstfeld and Rogoff, 2005), "savings glut" in the rest of the world (Bernanke, 2005, Gruber and Kamin, 2007), the U.S. fiscal deficit (Chinn, 2005, Erceg et al., 2005), the *de facto* exchange rate pegs in emerging Asia (Taylor, 2006, Chinn and Wei, 2008), productivity differentials (Engel and Rogers, 2006), and the increasing role of the valuation component in net foreign asset positions (Lane, Milesi-Ferretti, 2005, Gourinchas and Rey, 2006, Devereux and Sutherland, 2008). So far there is little consensus about the relative importance of each potential explanation. Additionally, is the present U.S. current account deficit sustainable? Economists hold various opinions about the answer. Few would doubt, though, that the deficit will adjust at some point, because countries cannot borrow forever, and will not want to lend forever, either.

According to the flexible exchange rate theory, a larger-than-expected trade deficit will lead to the depreciation of the domestic currency, thus lowering the relative price of domestic goods versus imported goods. Consequently, agents will switch expenditure towards domestic-produced goods in order to reestablish a sustainable current account balance. This is called expenditure-switching effect. The evolvement of the U.S. trade balance and exchange rate in the 1980s seems to be consistent with the theory (Figure 1). However, the U.S. current account deficit since the early 1990s only keeps widening rather than shrinking, even with the sizable U.S. dollar depreciation since 2002.

The above observations lead us to ask the following questions: Has the expenditure-switching role of exchange rates changed in the U.S. in the current episode of significant global imbalances? If so, what are the underlying reasons for the changes and what are the macroeconomic implications?

In this paper, we adopt a structural general-equilibrium approach of developing a multi-sector two-country sticky-price model for the United States and the G6 countries with the rest of the world captured by exogenous price and demand shocks. We assume that the non-tradable sector in each country provides distribution services to facilitate the sale of foreign-produced imports. Also, in light of the practical difference of choice of invoice currency,[1] we assume that firms exporting to the United States set their prices in the local market currency, and the U.S. firms exporting abroad price their goods in producer's currency. In other words, the U.S. dollar is the currency of invoice for both U.S. exports and imports. We estimate the model with Bayesian approach over two sub-samples, which covers the periods before and after the early 1990s. Our results suggest that a larger move in exchange rates might be required to rebalance the same amount of U.S. trade deficit now than two decades ago, because both U.S. exports and imports have become much less responsive to exchange rate movements in recent years. We find that the decline in the responsiveness of U.S. trade to exchange rates is due

[1] Goldberg and Tille (2005) report the U.S. dollar share in export invoicing and import invoicing for 24 countries. In particular, for the U.S., with confidential data from the Bureau of Economic Analysis, they show that the dollar share in the invoicing of exports and imports is 99.8% and 92.8% respectively in 2003.

to changes both in the variances of structural shocks and in firms' pricing behavior, as well as the increased size of distribution margins.

This paper is also related to the literature on the evolution of exchange rate pass-through. Particularly, recent studies have debated whether exchange rate pass-through into import prices may have declined in recent years in industrialized countries. For the United States, Marazzi and Sheets (2007) estimate a significant step down in the pass-through coefficient around the year of 1997 with a reduced-form approach. However, as suggested by Bouakez and Rebei (2008), the reduced-form methodology has important drawbacks in terms of overlooking the joint determination of exchange rates and prices and treating pass-through as an unconditional phenomenon. Bouakez and Rebei (2008) address the question of declining pass-through for Canada within a dynamic stochastic general equilibrium framework and conclude that the pass-through to Canadian import prices has been rather stable.

The remainder of this paper is organized as follows: Section 2 presents the theoretical model. Section 3 describes the data and the methodology. The empirical results are stated in Section 4. Finally, Section 5 concludes the paper.

2 The Model

We develop a two-country model with the rest of the world captured by exogenous price and demand shocks. The two countries are denoted by home and foreign respectively. Each country is characterized by : (1) a continuum of infinitely lived households; (2) competitive final good producers; (3) a continuum of intermediate tradable good producers; (4) intermediate tradable good importers; (5) a continuum of non-tradable good producers; and (6) government and the monetary authority. Households provide capital and labor services to intermediate tradable good producers and non-tradable good producers. Each household acts as a price setter for a particular type of labor services. Domestic-produced intermediate goods are then combined with imports to produce final goods for consumption and investment. Non-tradable goods are used for making foreign-produced intermediate goods available to the domestic final good producers. In what follows, the model setup is described focusing on the home country, with the understanding that similar expressions also characterize the foreign country. Foreign variables are marked with an asterisk, or where necessary with an "F" subscript.

2.1 Households

Households maximize expected utility discounted at the rate of time preference. Households are indexed by $i \in (0, 1)$. The lifetime utility is a function of consumption and labor supply.

$$U_t = E_t \Sigma_{t=0}^{\infty} \beta^t a_{\beta,t} U(C_t^i, L_t^i),$$

$a_{\beta,t}$ represents a preference shock that follows an AR(1) stochastic process. U is the instantaneous utility function, and is assumed to take the form

$$U = \ln(C_t^i) - \vartheta \ln L_t^i.$$

Utility is assumed to positively depend on the consumption of goods, and negatively depend on labor supply.

The full consumption basket, C_t, is defined by the CES aggregate of consumption of tradable goods, $C_{T,t}$, and non-tradable goods, $C_{N,t}$, at the elasticity of substitution ς,

$$C_t = \left[\alpha_T^{\frac{1}{\varsigma}} C_{T,t}^{1-\frac{1}{\varsigma}} + (1-\alpha_T)^{\frac{1}{\varsigma}} C_{N,t}^{1-\frac{1}{\varsigma}} \right]^{\frac{\varsigma}{\varsigma-1}}. \tag{2.1}$$

The price index for the consumption bundle and the demand for tradable and non-tradable goods are given by

$$\begin{aligned}
P_t &= \left[\alpha_T P_{T,t}^{1-\varsigma} + (1-\alpha_T) P_{N,t}^{1-\varsigma} \right]^{\frac{1}{1-\varsigma}} \\
C_{T,t} &= \alpha_T \left(\frac{P_{T,t}}{P_t} \right)^{-\varsigma} C_t \\
C_{N,t} &= (1-\alpha_T) \left(\frac{P_{N,t}}{P_t} \right)^{-\varsigma} C_t.
\end{aligned}$$

Capital is assumed to be sector specific. $K_{T,t}$ denotes capital stock in the tradable sector, which is assumed to be owned by households and rented to intermediate firms at the rate $r_{T,t}$. $K_{N,t}$ denotes capital stock in the non-tradable sector, and the rental rate is $r_{N,t}$. Investment in new capital is assumed to involve quadratic adjustment costs given by

$$\begin{aligned}
AC_{T,t} &= \frac{\chi}{2} \frac{(K_{T,t} - K_{T,t-1})^2}{K_{T,t-1}} \\
AC_{N,t} &= \frac{\chi}{2} \frac{(K_{N,t} - K_{N,t-1})^2}{K_{N,t-1}},
\end{aligned}$$

and $K_{T,t}$ and $K_{N,t}$ evolves following the law of motion

$$\begin{aligned}
K_{T,t} &= (1-\delta) K_{T,t-1} + I_{T,t} \\
K_{N,t} &= (1-\delta) K_{N,t-1} + I_{N,t}.
\end{aligned}$$

Households can provide labor service, $L_{N,t}$, to non-tradable good producers, and $L_{T,t}$ to intermediate tradable good producers, at the wage rate W_t. They receive dividends D_t from the firms and a lump sum transfer τ_t from the government. Households can purchase the domestic bond $B_{H,t}$ and foreign bond $B_{F,t}$. All bonds are denominated in the issuing country's currency, and there is a quadratic adjustment cost on bond holdings to ensure the stationarity in the net foreign asset position. The representative household's budget constraint can then be expressed as

$$C_t + \frac{P_{T,t}I_{T,t}}{P_t} + \frac{P_{N,t}I_{N,t}}{P_t} + \frac{P_{T,t}AC_{T,t}}{P_t} + \frac{P_{N,t}AC_{N,t}}{P_t} + \frac{S_tB_{F,t}}{P_tR_t^*} + \frac{B_{H,t}}{P_tR_t} + \frac{1}{2}\mu(\frac{S_tB_{F,t}^2}{P_tY_t} - \frac{SB_F^2}{PY})$$
$$= \frac{D_t}{P_t} + \tau_t + \frac{r_{T,t}P_{T,t}K_{T,t-1}}{P_t} + \frac{r_{N,t}P_{N,t}K_{N,t-1}}{P_t} + \frac{W_tL_{T,t}}{P_t} + \frac{W_tL_{N,t}}{P_t} + \frac{S_tB_{F,t-1}}{P_{t-1}\pi_t} + \frac{B_{H,t-1}}{P_t},$$

where π_t is the gross consumption inflation rate, and S_t is the nominal exchange rate, which is defined as the price of foreign currency in terms of domestic currency.

Household's maximization implies the following optimality conditions.

$$\frac{1}{P_tR_t} = E_t\Lambda_{t,t+1}\frac{1}{P_{t+1}}$$

$$\frac{S_t}{P_tR_t^*} + \frac{\mu S_tB_{F,t}}{P_tY_t} = E_t\Lambda_{t,t+1}\frac{S_{t+1}}{P_{t+1}}$$

$$\frac{P_{T,t}}{P_t}\left[\frac{\chi(K_{T,t} - K_{T,t-1})}{K_{T,t-1}} + 1\right] = E_t\Lambda_{t,t+1}\frac{P_{T,t+1}}{P_{t+1}}\left[\frac{\chi(K_{T,t+1}^2 - K_{T,t}^2)}{2K_{T,t}^2} + 1 - \delta + r_{T,t+1}\right]$$

$$\frac{P_{N,t}}{P_t}\left[\frac{\chi(K_{N,t} - K_{N,t-1})}{K_{N,t-1}} + 1\right] = E_t\Lambda_{t,t+1}\frac{P_{N,t+1}}{P_{t+1}}\left[\frac{\chi(K_{N,t+1}^2 - K_{N,t}^2)}{2K_{N,t}^2} + 1 - \delta + r_{N,t+1}\right],$$

where $\Lambda_{t,t+1} = \frac{E_t\beta a_{\beta,t+1}C_{t+1}^{-1}}{a_{\beta,t}C_t^{-1}}$. It is well documented that the uncovered interest rate parity (UIP) is rejected by the data. However, our first order approximation of the UIP condition abstracts from the the existence of time-varying risk premiums. Therefore, we introduce a risk premium shock φ_t to household's first order condition, that may be interpreted as the bias of market expectations. The optimality condition then become

$$\varphi_t\left(\frac{S_t}{P_tR_t^*} + \frac{\mu S_tB_{F,t}}{P_tY_t}\right) = E_t\Lambda_{t,t+1}\frac{S_{t+1}}{P_{t+1}}$$

The shock φ_t that plays the role of an uncovered interest rate parity shock enters the bond holding condition symmetrically in the foreign country.

In the labor market, households act as price-setters and meet the demand for their particular type of labor service. Wage rates are assumed to be set in a staggered fashion, following Calvo (1983). In each period, only those households who receive random signals can optimally adjust their nominal wages. The probability that households receive such a signal in each period is $1 - \psi_w$. For those households who do not receive such a signal to reoptimize, they simply index last period's wage rate by lagged inflation up to the degree of τ_w. Let ϖ_t^i be the new wage rate for labor service of type i at time t. The optimal value of ϖ_t^i is set according to

$$\varpi_t^i = \frac{E_t \Sigma_{j=0}^{\infty} (\psi_w \beta)^j a_{\beta,t+j} \vartheta \gamma}{E_t \Sigma_{j=0}^{\infty} (\psi_w \beta)^j a_{\beta,t+j} (\gamma - 1)(\varpi_t^i)^{-\gamma} C_{t+j}^{-1} P_{t+j}^{-1} W_{t+j}^{\gamma} L_{t+j}},$$

where γ is the elasticity of substitution among varieties of labor types. The wage index W_t is given by

$$W_t = \left\{ \psi_w \left[W_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\tau_w} \right]^{1-\gamma} + (1 - \psi_w) \varpi_t^{1-\gamma} \right\}^{\frac{1}{1-\gamma}} \tag{2.2}$$

2.2 Tradable Sector

2.2.1 Final Good Producers

Competitive final good producers combine domestically produced intermediate tradable goods with imports to produce final goods for consumption and investment. The technology is given by a CES production function

$$Y_{T,t} = \left[\alpha_H^{\frac{1}{\sigma}} Y_{H,t}^{1-\frac{1}{\sigma}} + (1 - \alpha_H)^{\frac{1}{\sigma}} Y_{IM,t}^{1-\frac{1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{2.3}$$

where $Y_{H,t}$ and $Y_{IM,t}$ denote, respectively, the amount of home-produced and imported intermediate goods used in domestic final good production. The elasticity of substitution between domestic and import intermediate goods is assumed to be σ. Furthermore, the home imports of intermediate goods are translated into a demand for the foreign country's exports via the following relationship

$$Y_{IM,t} = \left[\alpha_M^{\frac{1}{\sigma_m}} Y_{F,t}^{1-\frac{1}{\sigma_m}} + (1 - \alpha_M)^{\frac{1}{\sigma_m}} Y_{ROW,t}^{1-\frac{1}{\sigma_m}} \right]^{\frac{\sigma_m}{\sigma_m-1}}, \tag{2.4}$$

with $Y_{F,t}$ representing the imports from the foreign country, and $Y_{ROW,t}$ representing the home country's imports from the rest of the world.

Profit maximization by final good producers entail

$$Y_{H,t} = \alpha_H \left(\frac{P_{H,t}}{P_{T,t}} \right)^{-\sigma} Y_{T,t}$$

$$Y_{IM,t} = (1 - \alpha_H) \left(\frac{P_{IM,t}}{P_{T,t}} \right)^{-\sigma} Y_{T,t}$$

$$P_{T,t} = \left[\alpha_H P_{H,t}^{1-\sigma} + (1 - \alpha_H) P_{IM,t}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

$$Y_{F,t} = \alpha_M \left(\frac{\tilde{P}_{F,t}}{P_{IM,t}} \right)^{-\sigma_m} Y_{IM,t}$$

$$Y_{ROW,t} = (1 - \alpha_M) \left(\frac{P_{ROW,t}}{P_{IM,t}} \right)^{-\sigma_m} Y_{IM,t}$$

$$P_{IM,t} = \left[\alpha_M \tilde{P}_{F,t}^{1-\sigma_m} + (1-\alpha_M) P_{ROW,t}^{1-\sigma_m}\right]^{\frac{1}{1-\sigma_m}}.$$

$\tilde{P}_{F,t}$ denotes the retail price of imported intermediate goods from the foreign country. $P_{ROW,t}$ denotes the import price for goods produced in the rest of the world. $P_{ROW,t}$ is unobservable and assumed to follow a first-order AR process. Let $p_{ROW,t} = \frac{P_{ROW,t}}{P_t}$, we assume $\ln p_{ROW,t} = (1-\rho_p)\ln p_{ROW} + \rho_p \ln p_{ROW,t-1} + \epsilon_{p,t}$, with the error term $\epsilon_{p,t}$ normally distributed with zero mean and variance σ_p^2. Final goods are used for consumption and investment by households and the government, as well as paying adjustment costs of holding capital and bonds.

$$Y_{T,t} = C_{T,t} + I_{T,t} + G_{T,t} + AC_{T,t} + BAC_t. \tag{2.5}$$

2.2.2 Intermediate Good Producers

Each intermediate good producer produces its differentiated good with capital and labor according to the Cobb Douglas technology

$$Z_{T,t}(s) = (A_t L_{T,t}(s))^{1-\eta} K_{T,t-1}(s)^{\eta} \tag{2.6}$$

where $Z_{T,t}$ denotes the intermediate tradable output, $L_{T,t}$ is the aggregate labor input into the tradable good production, and A_t captures the technology shock. Let $f_t = \frac{A_t}{A_{t-1}}$, we assume that the technology growth follows a stochastic process

$$\ln f_t = (1-\rho_f)\ln f + \rho_f \ln f_{t-1} + \epsilon_{f,t},$$

where $\epsilon_{f,t}$ is normally distributed with zero mean and variance σ_f^2.

Intermediate goods produced in the home country can be used domestically for the final good production, exported to the foreign country, or exported to the rest of the world. The demand for home-produced intermediate goods from the rest of the world is assumed to be exogenously given.

$$Z_{T,t}(s) = Y_{H,t}(s) + Y_{H,t}^*(s) + D_{ROW,t}$$
$$\ln d_{ROW,t} = (1-\rho_d)\ln d_{ROW} + \rho_d \ln d_{ROW,t-1} + \epsilon_{d,t}.$$

Intermediate good prices are sticky. We assume the probability that intermediate production firms change prices in each period is $1-\psi_d$. Each intermediate firm acts as a monopolistic competitor in its price setting. Observed incomplete exchange rate pass-through has lead to different specifications for the currency of invoice in trade: producer currency pricing versus local currency pricing. Particularly for the home country U.S., in light of the dominant role of U.S. dollar, there is important asymmetry between home exporters and foreign exporters in their price setting behavior. Goldberg and Tille (2005) report the U.S. dollar share in export invoicing and import invoicing for the U.S., computed from confidential data from the Bureau of Economic Analysis. They show that the dollar share in the invoicing of both U.S. exports and imports is over 90%. Therefore, in this paper, we assume U.S. (home) exporters price their goods in producer's currency (U.S. dollar), while foreign exporters set their export prices in the local market currency (U.S. dollar).

Consider a home intermediate good producer using producer currency pricing, who is randomly selected to set new prices at time t. Let $X_{H,t}(s)$ and $X^{p}_{H,t}(s)$ denote the prices chosen by the firm in the home market and the foreign market, respectively. ε captures the elasticity of substitution between varieties of intermediate goods produced within one country. The firm maximizes the present discounted value of profits and sets the prices according to

$$\begin{aligned}
X_{H,t}(s) &= \frac{E_t\Sigma_{j=0}^{\infty}\psi_d^j\Gamma_{t,t+j}\varepsilon P^{\varepsilon}_{ht+j}Y_{ht+j}MC_{T,t+j}(P_{t+j-1}/P_{t-1})^{-\tau_d\varepsilon}}{E_t\Sigma_{j=0}^{\infty}\psi_d^j\Gamma_{t,t+j}(\varepsilon-1)P^{\varepsilon}_{ht+j}Y_{ht+j}(P_{t+j-1}/P_{t-1})^{-\tau_d(\varepsilon-1)}}\\
X^{p}_{H,t}(s) &= \frac{E_t\Sigma_{j=0}^{\infty}\psi_d^j\Gamma_{t,t+j}\varepsilon(P^{*}_{ht+j}S_{t+j})^{\varepsilon}(Y^{*}_{ht+j}+D_{ROW,t+j})MC_{T,t+j}(P_{t+j-1}/P_{t-1})^{-\tau_d\varepsilon}}{E_t\Sigma_{j=0}^{\infty}\psi_d^j\Gamma_{t,t+j}(\varepsilon-1)(P^{*}_{ht+j}S_{t+j})^{\varepsilon}(Y^{*}_{ht+j}+D_{ROW,t+j})(P_{t+j-1}/P_{t-1})^{-\tau_d(\varepsilon-1)}}\\
MC_{T,t+j} &= \frac{(1-\eta)^{\eta-1}(r_{T,t+j}P_{T,t+j})^{\eta}}{\eta^{\eta}W^{\eta-1}_{t+j}A_{T,t+j}}\\
\Gamma_{t,t+j} &= \beta^j\frac{U_{c,t+j}/P_{t+j}}{U_{c,t}/P_t}.
\end{aligned}$$

For the home country, the domestic price index for intermediate goods, $P_{H,t}$, and the export price index, $P^{*}_{H,t}$, can then be expressed as

$$P_{H,t} = \left\{\psi_d\left[P_{H,t-1}\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\tau_d}\right]^{1-\varepsilon} + (1-\psi_d)X^{1-\varepsilon}_{H,t}\right\}^{\frac{1}{1-\varepsilon}}$$

$$P^{*}_{H,t} = \left\{\psi_d\left[P^{*}_{H,t-1}\left(\frac{P^{*}_{t-1}}{P^{*}_{t-2}}\right)^{\tau_d}\right]^{1-\varepsilon} + (1-\psi_d)\left(\frac{X^{p}_{H,t}}{S_t}\right)^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}}.$$

Now for a foreign intermediate good producer using local currency pricing that is randomly selected to set new prices at time t, let $X^{*}_{F,t}(s)$ and $X^{l}_{F,t}(s)$ denote the price chosen by the firm in the foreign and home country's market respectively. The optimal price setting rules are given by

$$\begin{aligned}
X^{*}_{F,t}(s) &= \frac{E_t\Sigma_{j=0}^{\infty}(\psi^{*}_d)^j\Gamma^{*}_{t,t+j}\varepsilon(P^{*}_{ft+j})^{\varepsilon}Y^{*}_{ft+j}MC^{*}_{T,t+j}(P^{*}_{t+j-1}/P^{*}_{t-1})^{-\tau^{*}_d\varepsilon}}{E_t\Sigma_{j=0}^{\infty}(\psi^{*}_d)^j\Gamma^{*}_{t,t+j}(\varepsilon-1)(P^{*}_{ft+j})^{\varepsilon}Y^{*}_{ft+j}(P^{*}_{t+j-1}/P^{*}_{t-1})^{-\tau^{*}_d(\varepsilon-1)}}\\
X^{l}_{F,t}(s) &= \frac{E_t\Sigma_{j=0}^{\infty}(\psi^{*}_d)^j\Gamma^{*}_{t,t+j}\varepsilon(P_{ft+j})^{\varepsilon}(Y_{ft+j}+D^{*}_{ROW,t+j})MC^{*}_{T,t+j}S_{t+j}(P_{t+j-1}/P_{t-1})^{-\tau_d\varepsilon}}{E_t\Sigma_{j=0}^{\infty}(\psi^{*}_d)^j\Gamma^{*}_{t,t+j}(\varepsilon-1)(P_{ft+j})^{\varepsilon}(Y_{ft+j}+D^{*}_{ROW,t+j})(P_{t+j-1}/P_{t-1})^{-\tau_d(\varepsilon-1)}}.
\end{aligned}$$

For the foreign country, the domestic price index for intermediate goods, $P^{*}_{F,t}$, and the export price index, $P_{F,t}$, can then be expressed as

$$P^*_{F,t} = \left\{ \psi^*_d \left[P^*_{F,t-1} \left(\frac{P^*_{t-1}}{P^*_{t-2}} \right)^{\tau^*_d} \right]^{1-\varepsilon} + (1-\psi^*_d)(X^*_{F,t})^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}}$$

$$P_{F,t} = \left\{ \psi^*_d \left[P_{F,t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\tau^*_d} \right]^{1-\varepsilon} + (1-\psi^*_d) \left(X^l_{F,t} \right)^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}}.$$

2.2.3 Intermediate Good Importers

Intermediate good importers bring intermediate inputs produced in the foreign country and in the rest of the world to the domestic market. Similar to Burstein, Neves and Rebelo (2001) and Corsetti, Dedola and Leduc (2005), we assume that importing one unit of the intermediate good requires λ units of a basket of the differentiated non-tradable goods,

$$\lambda = \left[\int_0^1 \lambda(n)^{1-\frac{1}{\nu}} di \right]^{\frac{\nu}{\nu-1}},$$

where $n \in [0,1]$ is the index of non-tradable good varieties, and ν is the elasticity of substitution among varieties of non-tradable goods. With a competitive distribution sector, the retail price index for foreign-produced intermediate goods in the home market, $\tilde{P}_{F,t}$, is given by

$$\tilde{P}_{F,t}(s) = P_{F,t}(s) + \lambda P_{N,t}. \tag{2.7}$$

In the trade block, the balance of payment condition is given by

$$S_t P^*_{H,t}(Y^*_{H,t} + D_{ROW,t}) - P_{IM,t} Y_{IM,t} + B_{H,t-1} - \frac{B_{H,t}}{R_t} + S_t B_{F,t-1} - \frac{S_t B_{F,t}}{R^*_t} = 0.$$

2.3 Non-tradable Sector

The non-tradable goods are produced using capital and labor as inputs,

$$Y_{N,t}(n) = (A_t L_{N,t}(n))^{1-\theta} K_{N,t-1}(n)^{\theta}. \tag{2.8}$$

Taking wages and capital rental rates as given, non-tradable good producers solve the profit maximization problem and set prices.[2] The optimal price firm n chooses if it is selected to reset its price at time t, $X_{N,t}(n)$, and the non-tradable good price index are given by

[2]For simplicity, we assume the probability that non-tradable good producers reoptimize in each period is also $1 - \psi_d$.

$$X_{N,t}(n) = \frac{E_t \Sigma_{j=0}^{\infty} \psi_d^j \Gamma_{t,t+j} \nu P_{N,t+j}^{\nu} Y_{N,t+j} MC_{N,t+j} (P_{t+j-1}/P_{t-1})^{-\tau_d \varepsilon}}{E_t \Sigma_{j=0}^{\infty} \psi_d^j \Gamma_{t,t+j} (\nu - 1) P_{N,t+j}^{\nu} Y_{N,t+j} (P_{t+j-1}/P_{t-1})^{-\tau_d (\varepsilon - 1)}}$$

$$MC_{N,t+j} = \frac{(1-\theta)^{\theta-1} (r_{N,t+j} P_{N,t+j})^{\theta}}{\theta^{\theta} W_{t+j}^{\theta-1} A_{N,t+j}}$$

$$P_{N,t} = \left\{ \psi_d \left[P_{N,t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\tau_d} \right]^{1-\nu} + (1-\psi_d) X_{N,t}^{1-\nu} \right\}^{\frac{1}{1-\nu}}.$$

The market clearing condition implies that

$$Y_{N,t} = C_{N,t} + I_{N,t} + G_{N,t} + AC_{N,t} + \lambda(Y_{F,t} + Y_{ROW,t}). \tag{2.9}$$

2.4 Government and Monetary Authority

The government adjusts the lump sum transfer in each period to balance its budget constraint. Government spending, G_t, is assumed to be an exogenous process, reflecting a combination of tradable and non-tradable goods. The weights are assumed to be the same as consumer's behavior.

$$P_t G_t + P_t \tau_t + B_{H,t-1} + B_{H,t-1}^{*} = \frac{B_{H,t}}{R_t} + \frac{B_{H,t}^{*}}{R_t}.$$

The monetary policy authority uses interest rate as an instrument to respond to inflation deviation and output.

$$\ln(R_t/R) = \rho_r \ln(R_{t-1}/R) + (1-\rho_r)[\alpha_\pi \ln(\pi_t/\pi) + \alpha_y \ln(Y_t/Y)] + \epsilon_{r,t}.$$

where ρ_r is a parameter that captures interest-rate smoothing, and $\epsilon_{r,t}$ is a monetary policy shock, which is assumed to be i.i.d. normal with zero mean and variance σ_r^2.

2.5 Linearized Relations

The non-stationary technology shock induces a common stochastic trend in the real variables of the model. We use the following transformations to achieve stationarity.

$$\begin{array}{llllll}
p_{T,t} = \frac{P_{T,t}}{P_t} & p_{N,t} = \frac{P_{N,t}}{P_t} & p_{H,t} = \frac{P_{H,t}}{P_t} & p_{F,t} = \frac{P_{F,t}}{P_t} & \tilde{p}_{F,t} = \frac{\tilde{P}_{F,t}}{P_t} & p^*_{H,t} = \frac{P^*_{H,t}}{P^*_t} \\
p^*_{T,t} = \frac{P^*_{T,t}}{P^*_t} & p^*_{N,t} = \frac{P^*_{N,t}}{P^*_t} & p^*_{F,t} = \frac{P^*_{F,t}}{P^*_t} & \tilde{p}^*_{H,t} = \frac{\tilde{P}^*_{H,t}}{P^*_t} & x_{H,t} = \frac{X_{H,t}}{P_t} & x^p_{H,t} = \frac{X^p_{H,t}}{P_t} \\
x^l_{H,t} = \frac{X^l_{H,t}}{P^*_t} & x_{N,t} = \frac{X_{N,t}}{P_t} & x^*_{F,t} = \frac{X^*_{F,t}}{P^*_t} & x^p_{F,t} = \frac{X^p_{F,t}}{P^*_t} & x^l_{F,t} = \frac{X^l_{F,t}}{P_t} & x^*_{N,t} = \frac{X^*_{N,t}}{P^*_t} \\
w_t = \frac{W_t}{P_t A_t} & \omega_t = \frac{\varpi_t}{P_t A_t} & w^*_t = \frac{W^*_t}{P^*_t A_t} & \omega^*_t = \frac{\varpi^*_t}{P^*_t A_t} & q_t = \frac{S_t P^*_t}{P_t} & \pi_t = \frac{P_t}{P_{t-1}} \\
\pi^*_t = \frac{P^*_t}{P^*_{t-1}} & b_{H,t} = \frac{B_{H,t}}{P_t A_t} & b^*_{H,t} = \frac{B^*_{H,t}}{P_t A_t} & b^*_{F,t} = \frac{B^*_{F,t}}{P^*_t A_t} & b_{F,t} = \frac{B_{F,t}}{P^*_t A_t} &
\end{array}$$

In addition, all quantity variables are transformed according to $h_t = \frac{H_t}{A_t}$. The model is then log-linearized around a nonstochastic steady state of the transformed variables. The log-linearization yields a system of equations that are linear in log deviations, and can be solved using standard methods. The linearized equation system is described in Appendix A.

3 Empirical Approach

3.1 Bayesian Method and Priors

The model is estimated with a Bayesian approach, similar to Smets and Wouters (2003), Lubik and Schorfheide (2005). Bayesian inferences start from prior distributions capturing information outside of the data set used in the estimation, for example, results from past studies. The time series data is subsequently brought in to update researchers' beliefs about the parameter values and generate posterior estimates.

Generally, for prior densities, Beta distributions are chosen for parameters that are constrained in the unit interval; Gamma distributions are set for parameters defined to be non-negative; and inverse Gamma distributions are selected for standard deviations of shocks. The prior distributions are set to be the same for the two sub-samples. Specifically, the priors for Calvo adjustment parameters are set at 0.75, which suggests that firms and households re-optimize once every 4 quarters. The degree of partial indexation is given a prior of 0.5. Recall that we assume an asymmetry between home and foreign country here in terms of currency of invoicing. In particular, we emphasize the dominant role U.S. dollar in its trade by assuming that both U.S. firms and foreign firms set their export prices in U.S. dollars.

The prior means for the elasticity of substitution between domestic goods and imports σ and σ^* are set at 0.5, with a standard deviation of 0.15.[3] Priors on the policy coefficients are chosen to match

[3] It is well known that there is micro and macro discrepancy regarding the estimated value of this intratemporal elasticity of substitution. Specifically, micro literature suggests that this elasticity is larger than 1 and similar in nature to the elasticity of substitution between individual goods; while marco estimates, particularly from DSGE models (e.g. Lubik and Schorfheide, 2005), tend to find this elasticity to be quite small. In practice, the estimates of the elasticity term

values generally associated with the Taylor rule. The distribution margin ϱ measures the share of distribution costs in import prices. A prior mean of 0.4 is specified for both ϱ and ϱ^*, with a standard deviation of 0.15. Finally, for the parameters of the shocks, relatively loose priors are specified, since there is little guidance provided by the literature.

In addition to the parameters estimated, we choose to calibrate a number of parameters in light of the computational intensity. Precisely, the subjective discount factor β is given a value of 0.99, which implies an annual real interest rate of 4% in the steady state. The elasticity of substitution between tradables and non-tradables — ς and ς^*, both take a value of 0.6, based on the available estimates.[4] The elasticity of substitution among different types of labor services γ and γ^* are assumed to be 6, consistent with micro estimates. The quarterly capital depreciation rate is set to 0.025 for both home and foreign country.

The share of capital in tradable good production, η, is set to 0.36, which implies that the steady state share of labor income in tradable output is 64%. The share of capital in non-tradable good production, θ, is set to 0.32. These are consistent with Valentinyi and Herrendorf (2007)'s average measures on the U.S. income shares of capital and labor across sectors. The fraction of labor effort in the tradable good sector is inferred from the data on the distribution of civilian employment by economic sector for several industrialized countries.[5] In the pre-1992 sub-sample, this share is approximately 0.32 for the U.S., and 0.42 for the G6 countries; in the post-1992 period, it is 0.24 for the U.S. and 0.32 for the G6 countries. Other calibrated parameters can be related to the steady state values of the observed variables in the model, and are therefore calibrated so as to match their sample mean. For example, we notice that the parameter $\bar{\alpha}_H$ that captures U.S. households' preference over domestic goods and imports is smaller in the post-1992 sample than in the pre-1992 sample. This suggests that the U.S. households have shifted their preferences over domestic goods to imported goods in recent years.

3.2 Data

To estimate the model, we use seasonally adjusted quarterly G7 countries' data over two sub-samples, 1970:1–1991:4 and 1992:1–2008:1, to match the following variables: output growth, interest rates, inflation rates, real wage rates, terms of trade and exports to the rest of the World. These variables capture both the important macro aspects of the domestic economy and the external trade, particularly the link with the rest of the World from the home and foreign country.

The foreign output series is constructed as a geometric weighted average of the G6 countries, with the time-varying weights based on each country's trade share. The foreign price index used to compute the foreign inflation and real wage rate is computed in a similar manner. Likewise, we gathered short-term interest rates, treasury bill rates, or equivalent rates, for the G6 countries and averaged them

out of a structural model is very dependent on the starting values; while models assuming low elasticity of substitution marginally outperforms models assuming high elasticity of substitution (Smets, Walque and Wouters, 2005).

[4] Stockman and Tesar (1995) estimate the elasticity to be 0.44 for an "average" industrialized country out of the G7 countries. Mendoza (1991) estimates it to be 0.74.

[5] The time series data covering 1960-2007 is from the *Bureau of Labour Statistics* website.

using the same trade weighting scheme to compute the foreign interest rate. Since we assume the non-stationary technology shock generates a common stochastic trend across countries, we choose to match the log-linearized first differences of home and foreign variables, except for inflation and interest rates.

4 Empirical Results

4.1 Model Assessment

We estimate the model for the pre-1992 sample and the post-1992 sample. The joint posterior distribution of all estimated parameters is obtained in two steps. First, the posterior mode and covariance matrix are obtained from directly maximizing the log of the posterior distributions, given the priors and the likelihood based on the data. Second, the posterior distribution is subsequently explored by generating draws using the Monte Carlo Metropolis-Hastings algorithm. It is subject to 1,000,000 draws, and the first 500,000 draws are dropped.

To assess the conformity of the model to the data, unconditional second moments are computed and reported in Table 1-2. The first two columns in Table 1 report the standard errors and first order autocorrelations of the data, and the next two columns present the mean counterparts along with the 90% confidence intervals derived from simulations of the model out of 1000 random draws from the posterior distributions. Generally, in both two sub-samples, the volatility of all variables are reasonably matched by the estimated model. Precisely, in most cases, the data values lie in the confidence bands suggested by model simulations. In particular, the high volatilities of exports to the rest of the World are well captured by the model, though at the cost of generating excessive volatilities for terms of trade variables than what actually presents in the data. As for persistence, since most variables are in first differences, the first order autocorrelations are in general small and insignificant. The exceptions are interest rates, which are quite persistent in the data and well matched by the model.

Turning to the cross correlations between variables, Table 2 displays the values from the data as well as the model simulation for the pre-1992 sample in the left panel and the post-1992 sample in the right panel. The model is able to match the strong positive cross-country correlation of inflation, but fails in the sense of generating too much negative correlation between output growth. Since we have always assumed in the estimation that all shocks are orthogonal, allowing for a correlation structure in the innovations may help to correct this. Or alternatively, a more developed financial structure may be the solution by allowing for more risk sharing. The model is also able to generate the same magnitude of observed correlations between terms of trade and output or inflation. It seems though the estimated model does a better job matching moments in the first sub-sample than the second one. Similar messages come along when we examine the correlations of exports to the rest of World with other variables. In most cases, the model simulation confidence bands contain the corresponding data values.

There are several important issues to keep in mind when we assess how good the model is in fitting the data. First, we assume the fundamental structure of our economies haven't changed across samples, but only the size of structural parameters may have shifted. Therefore any possible regime shifts or structural breaks that may contribute in generating the observed differences across samples will not be captured with our current framework. Second, we estimate the structural model with the actual data without detrending. Thus we are matching the actual levels or differences of data series without any filtering. Third, the role of commodities is missing in the current set-up. The presence of oil imports and oil price shocks may bring more dynamics for trade particularly in the second sub-sample, and allow for another channel of common shocks across countries. In summary, adding more features to the model or complicating the shock specifications may improve the performance of the model in terms of reproducing the features of the data, but the current model does a reasonably good job for us to proceed with the analysis on the structural estimation.

4.2 Parameter Estimates

Two sets of posterior estimates are reported in Table 3-4 for two sub-samples. Each table presents an overview of the prior distributions specified for the parameters along with the estimated posterior mode and the corresponding standard errors computed from the inverse Hessian. In addition, it also reports the mean and the 90% confidence interval of the posterior distributions.

The estimation results suggest the following:

(i) The nominal price rigidity parameter is estimated ranging from 0.7 to 0.9 for home and foreign country in two samples. They are of plausible magnitude, and within the range of values in previous empirical studies and calibrated general-equilibrium models.[6] Comparing between home and foreign countries, it seems that there is more rigidity of home price setting than that of foreign in both pre-1992 and post-1992 samples. Since the degree of price indexation is estimated to be a lot larger for the foreign country than for home, it suggests that inflation would be more persistent in the foreign country in both sub-samples. If we compare estimates across time periods, however, the estimation results reveal that foreign prices are more sluggish in the post-1992 sample than in the pre-1992 sample. Since foreign firms employ local currency pricing to set prices in the U.S. market, the more sticky import prices are, the smaller the degree of exchange rate pass-through and expenditure switching is in the U.S. market. Wages are revised in similar frequency to prices.[7]

(ii) The estimate of the elasticity of substitution between domestic and foreign varieties, σ, is close to 0.47 in the pre-1992 sample, and 0.45 in the post-1992 sample. The foreign counterpart σ^* is estimated to be 0.51 and 0.46 respectively. These estimation results are in the lower half of the range of macro estimates. However, the estimation outcome depends very much on starting values assigned to the elasticity term. This characteristic of the two-country DSGE model has been reflected in other studies as well; models assuming low elasticity of substitution marginally

[6] For example, Lubik and Schorfheide (2006) report estimates of the price stickiness parameter ranging from 0.74 to 0.78 in their two-country structural model.

[7] Allowing for wage stickiness plays an important role in the structural estimation, as it allows the model to generate reasonable price stickiness.

outperforms models assuming high elasticity of substitution (Smets, Walque and Wouters, 2005). On the reconciliation of macro and micro estimates of the trade elasticity of substitution, Ruhl (2008) relates trade liberalization with increasing extensive margin, and Drozd and Nosal (2008) attributes the short and long run discrepancy of the price elasticity of trade flows to the market share sluggishness. The size of the expenditure-switching effect depends on the elasticity of substitution between domestic and import goods, in addition to the responses of prices to exchange rate movements. In light of the nature of the estimation of this particular parameter, what we can infer from the estimates of σ and σ^*, if any, is that the magnitude of the expenditure switching effect in both the home and foreign market would be marginally smaller in the second sub-sample, as both σ and σ^* are estimated to be smaller in the post-1992 sample.

(iii) The distribution margins ϱ and ϱ^* measure the fraction of the import prices accounted for by distribution costs in the home and foreign market respectively. The estimation results indicate that ϱ is approximately 0.25 in the first period, and 0.32 in the second period; while ϱ^* is around 0.26 in the pre-1992 sample and 0.44 in the post-1992 sample. We can derive the following relationship from the log-linearized equation system such that

$$\begin{aligned}
\hat{y}_{H,t} - \hat{y}_{F,t} &= \sigma(\hat{\hat{p}}_{F,t} - \hat{p}_{H,t}) \\
&= \sigma[(1-\varrho)\hat{p}_{F,t} + \varrho\hat{p}_{N,t} - \hat{p}_{H,t}] \\
\hat{y}^*_{F,t} - \hat{y}^*_{H,t} &= \sigma^*(\hat{\hat{p}}^*_{H,t} - \hat{p}^*_{F,t}) \\
&= \sigma^*[(1-\varrho^*)\hat{p}^*_{H,t} + \varrho^*\hat{p}^*_{N,t} - \hat{p}^*_{F,t}],
\end{aligned}$$

As implied by the equations, to what extent exchange rate movements affect the relative demands for home- to foreign-produced goods is determined both by the magnitude of the impact of exchange rate movements on the relative price, and by the degree of substitutability between domestic and foreign goods. The size of the impact on the relative price of an exchange rate movement further depends, among other things, on currency of invoice for trade, price stickiness, and size of the distribution margin. The larger the distribution margin is, the smaller the effect of exchange rate movements on the relative quantities. The estimates on ϱ and ϱ^* suggest that in the post-1992 period, the distribution margin is about 30% larger in the U.S. market and 70% larger in the foreign market. Now that distribution costs account for a much larger share of import prices in both markets, the pass-through of exchange rates to retail import prices ought to be much smaller in recent years compared to in the 1970s and 1980s, since an increasing share of non-tradable content has insulated the prices from exchange rate fluctuations.

(iv) The posterior mode of the persistence parameter in the unit-root technology process is estimated to be 0.24 in the first period, and 0.22 in the second period. The other stationary shocks are all estimated to be quite persistent. The standard deviations of innovations to exogenous processes vary widely in magnitude, though same prior distributions are given at the start of the estimation. They range from 0.1750 in the case of foreign monetary policy shock to 7.3810 in the case of import price shock from the rest of the world. The volatility of import price and export demand shocks from the rest of the world is generally large in both periods, suggesting the importance of the rest of world shocks in explaining for business cycle fluctuations. Comparing between samples, the standard deviations of almost all the shocks are estimated to be smaller in the second sub-sample than in the first.[8] This most likely driven by the substantial decline in macroeconomic volatilities since the late-1980s.

Finally, it is worth noting that, at an aggregate level, abstracting from various import and export categories, changes in the degree of pass-through can be attributed to factors like aggregate price stickiness, prevalence of PCP and LCP, and distribution margin etc.; while shifts in these aggregate factors may reflect either corresponding shifts at the level of disaggregated products, or changes in the underlying composition of products in a country's import or export bundle.[9]

4.3 Role of Expenditure-Switching

In the previous section, we analyze the structural estimation results over two sub-samples and examine the implications for changes in the expenditure-switching role of exchange rates. In this section, we investigate whether the responsiveness of trade to exchange rate fluctuations has decreased from one sub-sample to the other by plotting the unconditional pass-through of exchange rates to U.S. imports and exports. Because the pass-through measures are conditional on the horizon, our model can be used to study expenditure switching both in the short and long run.

In the international macroeconomic literature, many studies have examined exchange rate pass-through to import and consumption prices. Traditionally, the exchange rate pass-through is defined as the percentage change in local currency import prices resulting from a one percent change in the exchange rate. A typical pass-through regression estimates how import prices respond to exchange rate fluctuations (e.g. Campa and Goldberg, 2005). But since exchange rate changes also have feedback effects on domestic prices through marginal cost adjustment, some pass-though studies estimate an equation in which the relative price is a function of the exchange rate, cost factors, et al (e.g. Corsetti, Dedola and Leduc, 2005). In this case, costs, and thus errors in cost measurements, will influence the ratio only when there is a difference in the demand elasticity of the two markets.[10] While these studies are useful for policy analysis, they are subject to criticism due to the partial-equilibrium reduced-form approach. As suggested by Bouakez and Rebei (2008), these studies overlook the joint determination of exchange rates and prices. Also they ignore that the degree of pass-through may differ depending on what type of shocks impinging on the economy.

We adopt the general equilibrium approach to study the expenditure-switching role of exchange rates. Specifically, we examine the aggregate pass-through of exchange rates to imports and exports.

[8] The only exception is foreign government consumption shocks, in which case it is estimated to be slightly larger in the post-1992 sample.

[9] Specifically, Campa and Goldberg (2005) examine the underlying drivers causing changes in the pass-through of exchange rates to import prices using disaggregated data, and find that the pass-through to disaggregated import prices are highly stable in their estimation period and shifts in the composition of country import bundles are far more important for the overall pass-through rates.

[10] For extended surveys of the theory of exchange rate pass-through, see Goldberg and Knetter (1997).

First we generate impulse responses showing percentage changes of nominal exchange rates, U.S. imports and exports to a one-unit increase in the exogenous shock.[11] Then, similar to Bouakez and Rebei (2008), conditional pass-through is computed as the ratio of the impulse responses of the variable of interest (imports or exports) and nominal exchange rates to a given shock. Unconditional pass-through, or aggregate pass-through, is expressed as a weighted sum of conditional pass-through rates, where the weights reflect the contribution of various shocks in accounting for exchange rate variation.[12] A change in aggregate pass-through therefore can either result from changes in the degree of conditional pass-through or be related to differences in the relative importance of shocks in accounting for nominal exchange rate movements.

Figure 1 presents the unconditional pass-through of exchange rates to U.S. imports and exports. At the aggregate level, exchange rate pass-through to U.S. exports is much lower by around 0.37 in the medium to long run in the post-1992 period, while there is only a minor change in the unconditional pass-through to $\hat{y}^*_{H,t}$ in the short run. The unconditional pass-through of nominal exchange rates to U.S. imports, $\hat{y}_{IM,t}$, is much smaller in general than aggregate pass-through to U.S. exports, which is consistent with our assumption that U.S. firms all set export prices in PCP while foreign firms all price their export goods in LCP. Comparing across the two sub-samples, in the pre-1992 sample, the pass-through of nominal exchange rates to U.S. imports is always negative, reflecting that U.S. dollar depreciation is associated with decline in its imports; in the post-1992 sample, the U.S. imports sensitivity to exchange rate movements decreases to almost zero after 8 quarters upon impact, and turn to positive values afterwards. Imports may increase when domestic currency depreciates, because currency depreciation stimulates a country's exports and production of import-competing goods. The income effects of currency depreciation may drive the demand for imports to increase.

As analyzed in the previous section, the foreign prices being more sticky in the post-1992 period may contribute to the dropped pass-through to imports in the short run. In addition, both domestic and foreign distribution margins increasing in the post-1992 sample may induces the pass-through to U.S. imports and exports to decline in the long run. Additionally, the generally lower volatility of shocks in the post-1992 episode can also account for the dropped pass-through of exchange rates to trade, as the volatility of output and inflation has decreased substantially while the volatility of exchange rate has remained relative stable over this period.

4.4 Counterfactual Analysis

To identify which factors contribute to the muted responsiveness of U.S. imports and exports to exchange rate movements in the second sub-sample and to what extent they matter, we carry out some counterfactual experiments in this section. Particularly, we study the role of four factors: price adjustment sluggishness, distribution margin, the variance and persistence of structural shocks. In each

[11]The impulse responses are calculated from a random selection of 1,000 parameters out of the 500,000 draws from the posterior distributions.

[12]For more details on the relationship between the aggregate and conditional measures of pass-through, see Bouakez and Rebei (2008).

counterfactual experiment, we vary one factor while keeping all other parameters constant. We then compare aggregate pass-through to U.S. imports and exports computed from the counterfactual simulations with those from the benchmark case.

Figure 2 displays results on exchange rate pass-through to U.S. exports from counterfactual analysis. The two graphs in the top panel show impact on the degree of pass-through to exports from structural shifts (price adjustment and distribution margin); the two plots in the second row present impacts from changes of shocks (variance and persistence). As we can see from these plots, all four factors can provide potential explanations for the decline of U.S. exports responsiveness to exchange rate movements, although the contribution of changes in shock persistence is almost negligible. As stated before, the distribution margin in the foreign market has increased in the post-1992 period, which translates into a lower degree of aggregate pass-through to U.S. exports. Estimation results in Table 3 and 4 reveal that almost all structural shocks become less volatile in the second sub-sample. Relatively speaking, preference shocks and monetary policy shocks may gain more weights in the computation of aggregate pass-through. Simulation results show that they can partially explain the dropped responsiveness of U.S. exports to nominal exchange rates.

The counterfactual experiment results on pass-through to U.S. imports are illustrated in Figure 3. Here, changes in price adjustment, distribution margin and variances of shocks all are responsible for the observed drop in pass-through. However, the analysis seems to preclude persistence of shocks as a potential explanation, as it leads to slightly increased pass-through to imports in the long run. Overall, changes in shock variances and structural shifts in price adjustment mainly account for the decline in rate of pass-through to U.S. imports; while changes in distribution margins play a less important role.

5 Conclusion

We adopt a structural general-equilibrium approach to study whether the expenditure-switching role of exchange rates has changed in the G7 countries in the current episode of significant global imbalances. Our approach consist of developing a multi-sector two-country model for the United States and the G6 countries with the rest of the world captured by exogenous price and demand shocks, and estimating the model over two sub-samples, which covers the periods before and after the early 1990s. We find that both U.S. imports and exports have become much less responsive to exchange rate movements, mainly due to changes both in the variances of structural shocks and in firms' pricing behavior, as well as the increased size of distribution margins. This may suggest that closing the same amount of U.S. trade deficit now would require a larger move in exchange rates than in the 1970s and 1980s.

Our results certainly have to be qualified with respect to the structural model employed, as the estimation results are model dependent. One issue is that trade in commodities, particularly petroleum, is not explicitly modeled. Although the non-petroleum trade balance of the United States traces the dynamics of the overall trade balance fairly closely up until early 2000, the non-petroleum trade deficit has been much smaller since then. We choose to match U.S. and foreign countries' exports to the rest of the World, instead of overall trade balance. That way, we minimize the impact out of this specification, since commodities trade modifies trade balance mainly through imports.[13]

The second issue of concern may be related to the break date of splitting the time series data. Although it is widely agreed that the episode of global current account imbalance starts in the early 1990s (Obstfeld and Rogoff, 2000), there is no strong reason to believe that the global imbalance starts exactly at the beginning of the year of 1992. In fact, there is no strong reason to believe that the global imbalance starts at any time exactly. Even the concept of global imbalance was first greeted with skepticism before it became conventional wisdom. When at that time Federal Reserve Chairman Alan Greenspan gave a speech in 2003, the conventional view was still that the U.S. current account would most likely resolve itself in quite a benign manner. Therefore, on one hand, there's plenty sensitivity analysis from perturbation of break dates; while on the other hand, there's no robustness check on this issue necessary at all. We could move the break date around 1992 Q1; but given the persistence of the macro economy around that time and the nature of structural estimation, it is probably safe to expect structural estimation results to remain largely unchanged if the new break date is close to the old one. Alternatively, we could split the sample at some point when U.S. deficit became more apparent part of the imbalance, for example in 2002. The practical problem it brings to estimation is that we will be left with too few observations in the global imbalance sub-sample to generate convincing results out of structural estimation approach.

[13] An alternative is to use trade data excluding commodities for estimation. The data is readily available for the U.S., but not for all the other G6 countries.

A The Linearized Equation System

A.1 Prices and Wages

$$0 = \bar{\alpha}_T \hat{p}_{T,t} + (1-\bar{\alpha}_T)\hat{p}_{N,t} \qquad 0 = \bar{\alpha}^*_T \hat{p}^*_{T,t} + (1-\bar{\alpha}^*_T)\hat{p}^*_{N,t}$$
$$\hat{p}_{T,t} = \bar{\alpha}_H \hat{p}_{H,t} + (1-\bar{\alpha}_H)\hat{p}_{IM,t} \qquad \hat{p}^*_{T,t} = \bar{\alpha}^*_H \hat{p}^*_{F,t} + (1-\bar{\alpha}^*_H)\hat{p}^*_{IM,t}$$
$$\hat{p}_{IM,t} = \bar{\alpha}_M \hat{\tilde{p}}_{F,t} + (1-\bar{\alpha}_M)\hat{p}_{ROW,t} \qquad \hat{p}^*_{IM,t} = \bar{\alpha}^*_M \hat{\tilde{p}}^*_{H,t} + (1-\bar{\alpha}^*_M)\hat{p}^*_{ROW,t}$$

$$\hat{x}_{H,t} = \psi_d \beta E_t \hat{x}_{H,t+1} + \psi_d \beta \hat{\pi}_{t+1} - \psi_d \beta \tau_d \hat{\pi}_t + (1-\psi_d\beta)[(1-\eta)\hat{w}_t + \eta \hat{r}_{T,t}]$$
$$\hat{x}^*_{F,t} = \psi^*_d \beta E_t \hat{x}^*_{F,t+1} + \psi^*_d \beta \hat{\pi}^*_{t+1} - \psi^*_d \beta \tau^*_d \hat{\pi}^*_t + (1-\psi^*_d\beta)[(1-\eta^*)\hat{w}^*_t + \eta^* \hat{r}^*_{T,t}]$$
$$\hat{x}^p_{H,t} = \hat{x}_{H,t} \qquad \hat{x}^p_{F,t} = \hat{x}^*_{F,t}$$
$$\hat{x}^l_{H,t} = \psi_d \beta E_t \hat{x}^l_{H,t+1} + \psi_d \beta \hat{\pi}^*_{t+1} - \psi_d \beta \tau_d \hat{\pi}^*_t + (1-\psi_d\beta)[(1-\eta)\hat{w}_t - \hat{q}_t + \eta \hat{r}_{T,t}]$$
$$\hat{x}^l_{F,t} = \psi^*_d \beta E_t \hat{x}^{*l}_{F,t+1} + \psi^*_d \beta \hat{\pi}_{t+1} - \psi^*_d \beta \tau^*_d \hat{\pi}_t + (1-\psi^*_d\beta)[(1-\eta^*)\hat{w}^*_t + \hat{q}_t + \eta^* \hat{r}^*_{T,t}]$$
$$\hat{x}_{N,t} = \psi_d \beta E_t \hat{x}_{N,t+1} + \psi_d \beta \hat{\pi}_{t+1} - \psi_d \beta \tau_d \hat{\pi}_t + (1-\psi_d\beta)[(1-\theta)\hat{w}_t + \theta \hat{r}_{N,t}]$$
$$\hat{x}^*_{N,t} = \psi^*_d \beta E_t \hat{x}^*_{N,t+1} + \psi^*_d \beta \hat{\pi}^*_{t+1} - \psi^*_d \beta \tau^*_d \hat{\pi}^*_t + (1-\psi^*_d\beta)[(1-\theta^*)\hat{w}^*_t + \theta^* \hat{r}^*_{N,t}]$$
$$\hat{p}_{H,t} = \psi_d \hat{p}_{H,t-1} - \psi_d \hat{\pi}_t + \psi_d \tau_d \hat{\pi}_{t-1} + (1-\psi_d)\hat{x}_{H,t}$$
$$\hat{p}^*_{F,t} = \psi^*_d \hat{p}^*_{F,t-1} - \psi^*_d \hat{\pi}^*_t + \psi^*_d \tau^*_d \hat{\pi}^*_{t-1} + (1-\psi^*_d)\hat{x}^*_{F,t}$$
$$\hat{p}_{N,t} = \psi_d \hat{p}_{N,t-1} - \psi_d \hat{\pi}_t + \psi_d \tau_d \hat{\pi}_{t-1} + (1-\psi_d)\hat{x}_{N,t}$$
$$\hat{p}^*_{N,t} = \psi^*_d \hat{p}^*_{N,t-1} - \psi^*_d \hat{\pi}^*_t + \psi^*_d \tau^*_d \hat{\pi}^*_{t-1} + (1-\psi^*_d)\hat{x}^*_{N,t}$$
$$\hat{p}^*_{H,t} = \psi_d \hat{p}^*_{H,t-1} - \psi_d \hat{\pi}^*_t + \psi_d \tau_d \hat{\pi}^*_{t-1} + (1-\psi_d)[\phi \hat{x}^l_{H,t} + (1-\phi)(\hat{x}^p_{H,t} - \hat{q}_t)]$$
$$\hat{p}_{F,t} = \psi^*_d \hat{p}_{F,t-1} - \psi^*_d \hat{\pi}_t + \psi^*_d \tau^*_d \hat{\pi}_{t-1} + (1-\psi^*_d)[\phi^* \hat{x}^l_{F,t} + (1-\phi^*)(\hat{x}^p_{F,t} + \hat{q}_t)]$$
$$\hat{\tilde{p}}_{F,t} = \frac{P_F}{\tilde{P}_F}\hat{p}_{F,t} + \frac{\lambda P_N}{\tilde{P}_F}\hat{p}_{N,t} \qquad \hat{\tilde{p}}^*_{H,t} = \frac{P^*_H}{\tilde{P}^*_H}\hat{p}^*_{H,t} + \frac{\lambda^* P^*_N}{\tilde{P}^*_H}\hat{p}^*_{N,t}$$

$$\hat{\omega}_t = \psi_w \beta E_t \hat{\omega}_{t+1} + \psi_w \beta \hat{\pi}_{t+1} + \psi_w \beta \hat{f}_{t+1} - \psi_w \beta \tau_w \hat{\pi}_t + \frac{1-\psi_w\beta}{\gamma-1}(\gamma \hat{w}_t + \hat{l}_t - \hat{c}_t)$$
$$\hat{\omega}^*_t = \psi^*_w \beta E_t \hat{\omega}^*_{t+1} + \psi^*_w \beta \hat{\pi}^*_{t+1} + \psi^*_w \beta \hat{f}_{t+1} - \psi^*_w \beta \tau^*_w \hat{\pi}^*_t + \frac{1-\psi^*_w\beta}{\gamma^*-1}(\gamma^* \hat{w}^*_t + \hat{l}^*_t - \hat{c}^*_t)$$
$$\hat{w}_t = \psi_w \hat{w}_{t-1} - \psi_w \hat{\pi}_t + \psi_w \tau_w \hat{\pi}_{t-1} + (1-\psi_w)\hat{\omega}_t - \psi_w \hat{f}_t$$
$$\hat{w}^*_t = \psi^*_w \hat{w}^*_{t-1} - \psi^*_w \hat{\pi}^*_t + \psi^*_w \tau^*_w \hat{\pi}^*_{t-1} + (1-\psi^*_w)\hat{\omega}^*_t - \psi_w \hat{f}_t$$

A.2 Output, Capital and Employment

Output

$$\hat{y}_{H,t} = \hat{y}_{T,t} - \sigma(\hat{p}_{H,t} - \hat{p}_{T,t}) \qquad \hat{y}_{IM,t} = \hat{y}_{T,t} - \sigma(\hat{p}_{IM,t} - \hat{p}_{T,t})$$
$$\hat{y}_{F,t} = \hat{y}_{IM,t} - \sigma_m(\hat{\tilde{p}}_{F,t} - \hat{p}_{IM,t}) \qquad \hat{y}_{ROW,t} = \hat{y}_{IM,t} - \sigma_m(\hat{p}_{ROW,t} - \hat{p}_{IM,t})$$

$$\hat{y}^*_{F,t} = \hat{y}^*_{T,t} - \sigma^*(\hat{p}^*_{F,t} - \hat{p}^*_{T,t}) \qquad \hat{y}^*_{IM,t} = \hat{y}^*_{T,t} - \sigma^*(\hat{p}^*_{IM,t} - \hat{p}^*_{T,t})$$
$$\hat{y}^*_{H,t} = \hat{y}^*_{IM,t} - \sigma^*_m(\hat{\tilde{p}}^*_{H,t} - \hat{p}^*_{IM,t}) \quad \hat{y}^*_{ROW,t} = \hat{y}^*_{IM,t} - \sigma^*_m(\hat{p}^*_{ROW,t} - \hat{p}^*_{IM,t})$$

$$\begin{aligned}
\hat{z}_t &= \frac{Y_H}{Z}\hat{y}_{H,t} + \frac{Y^*_H}{Z}\hat{y}^*_{H,t} + \frac{D_{ROW}}{Z}\hat{d}_{ROW,t} \\
\hat{z}^*_t &= \frac{Y^*_F}{Z^*}\hat{y}^*_{F,t} + \frac{Y_F}{Z^*}\hat{y}_{F,t} + \frac{D^*_{ROW}}{Z^*}\hat{d}^*_{ROW,t} \\
\hat{y}_t &= \frac{P_T Y_T}{PY}(\hat{p}_{T,t} + \hat{y}_{T,t}) + \frac{P_N Y_N}{PY}(\hat{p}_{N,t} + \hat{y}_{N,t}) \\
\hat{y}^*_t &= \frac{P^*_T Y^*_T}{P^* Y^*}(\hat{p}^*_{T,t} + \hat{y}^*_{T,t}) + \frac{P^*_N Y^*_N}{P^* Y^*}(\hat{p}^*_{N,t} + \hat{y}^*_{N,t}) \\
\hat{y}_{T,t} &= \frac{C_T}{Y_T}\hat{c}_{T,t} + \frac{G_T}{Y_T}\hat{g}_{T,t} + \frac{I_T}{Y_T}\hat{i}_{T,t} \\
\hat{y}_{N,t} &= \frac{C_N}{Y_N}\hat{c}_{N,t} + \frac{G_N}{Y_N}\hat{g}_{N,t} + \frac{I_N}{Y_N}\hat{i}_{N,t} + \frac{\lambda Y_F}{Y_N}\hat{y}_{F,t} + \frac{\lambda Y_{ROW}}{Y_N}\hat{y}_{ROW,t} \\
\hat{y}^*_{T,t} &= \frac{C^*_T}{Y^*_T}\hat{c}^*_{T,t} + \frac{G^*_T}{Y^*_T}\hat{g}^*_{T,t} + \frac{I^*_T}{Y^*_T}\hat{i}^*_{T,t} \\
\hat{y}^*_{N,t} &= \frac{C^*_N}{Y^*_N}\hat{c}^*_{N,t} + \frac{G^*_N}{Y^*_N}\hat{g}^*_{N,t} + \frac{I^*_N}{Y^*_N}\hat{i}^*_{N,t} + \frac{\lambda^* Y^*_H}{Y^*_N}\hat{y}^*_{H,t} + \frac{\lambda^* Y^*_{ROW}}{Y^*_N}\hat{y}^*_{ROW,t}
\end{aligned}$$

Capital and labor

$$\begin{aligned}
\hat{k}_{T,t-1} &= \hat{z}_t - (1-\eta)\hat{r}_{T,t} + (1-\eta)\hat{w}_t - (1-\eta)\hat{p}_{T,t} \\
\hat{k}_{N,t-1} &= \hat{y}_{N,t} - (1-\theta)\hat{r}_{N,t} + (1-\theta)\hat{w}_t - (1-\theta)\hat{p}_{N,t} \\
\hat{k}^*_{T,t-1} &= \hat{z}^*_t - (1-\eta^*)\hat{r}^*_{T,t} + (1-\eta^*)\hat{w}^*_t - (1-\eta^*)\hat{p}^*_{T,t} \\
\hat{k}^*_{N,t-1} &= \hat{y}^*_{N,t} - (1-\theta^*)\hat{r}^*_{N,t} + (1-\theta^*)\hat{w}^*_t - (1-\theta^*)\hat{p}^*_{N,t}
\end{aligned}$$

$$\begin{aligned}
&\hat{c}_t - \hat{c}_{t+1} + \hat{a}_{\beta,t+1} - \hat{a}_{\beta,t} + \hat{\pi}_{T,t+1} - \hat{\pi}_{t+1} - \hat{f}_{t+1} \\
&= \chi(\hat{k}_{T,t} - \hat{k}_{T,t-1} + \hat{f}_{t+1}) - \beta\chi E_t(\hat{k}_{T,t+1} - \hat{k}_{T,t} + \hat{f}_{t+2}) - \beta r_T \hat{r}_{T,t+1} \\
&\hat{c}_t - \hat{c}_{t+1} + \hat{a}_{\beta,t+1} - \hat{a}_{\beta,t} + \hat{\pi}_{N,t+1} - \hat{\pi}_{t+1} - \hat{f}_{t+1} \\
&= \chi(\hat{k}_{N,t} - \hat{k}_{N,t-1} + \hat{f}_{t+1}) - \beta\chi E_t(\hat{k}_{N,t+1} - \hat{k}_{N,t} + \hat{f}_{t+2}) - \beta r_N \hat{r}_{N,t+1} \\
&\hat{c}^*_t - \hat{c}^*_{t+1} + \hat{a}^*_{\beta,t+1} - \hat{a}^*_{\beta,t} + \hat{\pi}^*_{T,t+1} - \hat{\pi}^*_{t+1} - \hat{f}_{t+1} \\
&= \chi^*(\hat{k}^*_{T,t} - \hat{k}^*_{T,t-1} + \hat{f}_{t+1}) - \beta\chi^* E_t(\hat{k}^*_{T,t+1} - \hat{k}^*_{T,t} + \hat{f}_{t+2}) - \beta r^*_T \hat{r}^*_{T,t+1} \\
&\hat{c}^*_t - \hat{c}^*_{t+1} + \hat{a}^*_{\beta,t+1} - \hat{a}^*_{\beta,t} + \hat{\pi}^*_{N,t+1} - \hat{\pi}^*_{t+1} - \hat{f}_{t+1} \\
&= \chi^*(\hat{k}^*_{N,t} - \hat{k}^*_{N,t-1} + \hat{f}_{t+1}) - \beta\chi^* E_t(\hat{k}^*_{N,t+1} - \hat{k}^*_{N,t} + \hat{f}_{t+2}) - \beta r^*_N \hat{r}^*_{N,t+1}
\end{aligned}$$

$$\hat{k}_{T,t} = (1-\delta)\hat{k}_{T,t-1} + \delta\hat{i}_{T,t} - (1-\delta)\hat{f}_{t+1} \quad \hat{k}_{N,t} = (1-\delta)\hat{k}_{N,t-1} + \delta\hat{i}_{N,t} - (1-\delta)\hat{f}_{t+1}$$
$$\hat{k}^*_{T,t} = (1-\delta)\hat{k}^*_{T,t-1} + \delta\hat{i}^*_{T,t} - (1-\delta)\hat{f}_{t+1} \quad \hat{k}^*_{N,t} = (1-\delta)\hat{k}^*_{N,t-1} + \delta\hat{i}^*_{N,t} - (1-\delta)\hat{f}_{t+1}$$

$$\hat{l}_t = \frac{L_T}{L}\hat{l}_{T,t} + \frac{L_N}{L}\hat{l}_{N,t} \quad \hat{l}^*_t = \frac{L^*_T}{L^*}\hat{l}^*_{T,t} + \frac{L^*_N}{L^*}\hat{l}^*_{N,t}$$

$$\hat{l}_{T,t} = \hat{z}_t + \eta\hat{r}_{T,t} - \eta\hat{w}_t + \eta\hat{p}_{T,t} \qquad \hat{l}_{N,t} = \hat{y}_{N,t} + \theta\hat{r}_{N,t} - \theta\hat{w}_t + \theta\hat{p}_{N,t}$$
$$\hat{l}^*_{T,t} = \hat{z}^*_t + \eta\hat{r}^*_{T,t} - \eta^*\hat{w}^*_t + \eta^*\hat{p}^*_{T,t} \qquad \hat{l}^*_{N,t} = \hat{y}^*_{N,t} + \theta^*\hat{r}^*_{N,t} - \theta^*\hat{w}^*_t + \theta^*\hat{p}^*_{N,t}$$

Consumption and bond

$$\hat{\pi}_{t+1} - \hat{r}_t = \hat{c}_t - \hat{c}_{t+1} - \hat{f}_{t+1} + \hat{a}_{\beta,t+1} - \hat{a}_{\beta,t}$$
$$\hat{\pi}^*_{t+1} - \hat{r}^*_t = \hat{c}^*_t - \hat{c}^*_{t+1} - \hat{f}_{t+1} + \hat{a}^*_{\beta,t+1} - \hat{a}^*_{\beta,t}$$

$$\hat{q}_{t+1} - \hat{c}_{t+1} + \hat{a}_{\beta,t+1} - \hat{f}_{t+1} - \hat{\pi}^*_{t+1} = \hat{q}_t - \hat{c}_t + \hat{a}_{\beta,t} - (1-\mu)\hat{r}^*_t + \mu\hat{b}_{F,t} - \mu\hat{y}_t + \hat{\varphi}_t$$
$$-\hat{q}_{t+1} - \hat{c}^*_{t+1} + \hat{a}^*_{\beta,t+1} - \hat{f}_{t+1} - \hat{\pi}_{t+1} = -\hat{q}_t - \hat{c}^*_t + \hat{a}^*_{\beta,t} - (1-\mu^*)\hat{r}_t + \mu^*\hat{b}^*_{H,t} - \mu^*\hat{y}^*_t - \hat{\varphi}_t$$

$$\hat{c}_{T,t} = \hat{c}_t - \varsigma\hat{p}_{T,t} \qquad \hat{c}_{N,t} = \hat{c}_t - \varsigma\hat{p}_{N,t} \qquad \hat{g}_{T,t} = \hat{g}_t - \varsigma\hat{p}_{T,t} \qquad \hat{g}_{N,t} = \hat{g}_t - \varsigma\hat{p}_{N,t}$$
$$\hat{c}^*_{T,t} = \hat{c}^*_t - \varsigma^*\hat{p}^*_{T,t} \qquad \hat{c}^*_{N,t} = \hat{c}^*_t - \varsigma^*\hat{p}^*_{N,t} \qquad \hat{g}^*_{T,t} = \hat{g}^*_t - \varsigma^*\hat{p}^*_{T,t} \qquad \hat{g}^*_{N,t} = \hat{g}^*_t - \varsigma^*\hat{p}^*_{N,t}$$

Monetary policy

$$\hat{r}_t = \rho_r\hat{r}_{t-1} + (1-\rho_r)(\alpha_\pi\hat{\pi}_t + \alpha_y\hat{y}_t) + \epsilon_{r,t}$$
$$\hat{r}^*_t = \rho^*_r\hat{r}^*_{t-1} + (1-\rho^*_r)(\alpha^*_\pi\hat{\pi}^*_t + \alpha^*_y\hat{y}^*_t) + \epsilon_{r^*,t}$$

Balance of payment condition

$$(\hat{b}_{H,t} - \hat{b}_{F,t}) - R(\hat{b}_{H,t-1} - \hat{b}_{F,t-1}) - (\hat{r}_t - \hat{r}^*_t) - (1-R)\hat{q}_t + R(\hat{\pi}_t - \hat{\pi}^*_t) = \frac{SP^*_H Y^*_H}{PY}\hat{y}^*_{H,t}$$
$$+ \frac{SP^*_H D_{ROW}}{PY}\hat{d}_{ROW,t} + \left(\frac{SP^*_H Y^*_H}{PY} + \frac{SP^*_H D_{ROW}}{PY}\right)(\hat{p}^*_{H,t} + \hat{q}_t) - \frac{P_{IM}Y_{IM}}{PY}(\hat{p}_{IM,t} + \hat{y}_{IM,t})$$

A.3 Stochastic Shocks

$$\hat{f}_t = \rho_f\hat{f}_{t-1} + \epsilon_{ft} \qquad \hat{\varphi}_t = \rho_\varphi\hat{\varphi}_{t-1} + \epsilon_{\varphi t}$$
$$\hat{g}_t = \rho_g\hat{g}_{t-1} + \epsilon_{g,t} \qquad \hat{g}^*_t = \rho^*_g\hat{g}^*_{t-1} + \epsilon_{g^*,t}$$
$$\hat{a}_{\beta,t} = \rho_{a\beta}\hat{a}_{\beta,t-1} + \epsilon_{a\beta,t} \qquad \hat{a}^*_{\beta,t} = \rho^*_{a\beta}\hat{a}^*_{\beta,t-1} + \epsilon^*_{a\beta,t}$$
$$\hat{d}_{ROW,t} = \rho_{rd}\hat{d}_{ROW,t-1} + \epsilon_{rd,t} \qquad \hat{d}^*_{ROW,t} = \rho^*_{rd}\hat{d}^*_{ROW,t-1} + \epsilon^*_{rd,t}$$
$$\hat{p}_{ROW,t} = \rho_{rp}\hat{p}_{ROW,t-1} + \epsilon_{rp,t} \qquad \hat{p}^*_{ROW,t} = \rho^*_{rp}\hat{p}^*_{ROW,t-1} + \epsilon^*_{rp,t}$$

Reference:

Berger D., J. Faust, J. Rogers and K. Steverson. 2007. "Border Prices and Retail Prices." Draft.

Bernanke, B. 2005. "The Global Saving Glut and the U.S. Current Account Deficit." Homer Jones Lecture, St. Louis, Missouri.

Bouakez, H. and N. Rebei. 2008. "Has Exchange Rate Pass-Through Really Declined? Evidence from Canada." *Journal of International Economics* 75(2):249–67.

Burstein, A., J. Neves and S. Rebelo. 2003. "Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based Stabilizations." *Journal of Monetary Economics* 50(6): 1189–214.

Calvo, G. 1983. "Staggered Prices in a Utility Maximization Framework." *Journal of Monetary Economics* 12(3): 383–98.

Campa, J. M. and L. S. Goldberg. 2005. "Exchange Rate Pass-Through into Import Prices." *Review of Economics and Statistics* 87(4): 679–90.

——. 2008. "Pass-Through of Exchange Rates to Consumption Prices: What Has Changed and Why?" *International Financial Issues in the Pacific Rim: Global Imbalances, Financial Liberalization and Exchange Rate Policy.* Chicago: University of Chicago Press.

Chinn, M. 2005. "Getting Serious about the Twin Deficits." Council on Foreign Relations Special Report 10.

Chinn, M. and S. J. Wei. 2008. "A Faith-based Initiative: Does a Flexible Exchange Rate Regime Really Facilitate Current Account Adjustment?" NBER Working Paper No. 14420.

Corsetti, G., L. Dedola, and S. Leduc. 2005. "DSGE Models of High Exchange-Rate Volatility and Low Pass-Through." Federal Reserve Board International Finance Discussion Papers No. 845.

Corsetti, G. and P. Pesenti. 2005. "International Dimensions of Optimal Monetary Policy." *Journal of Monetary Economics* 52(2): 281–305.

Devereux, M. And A. Sutherland. 2008. "Valuation Effects and the Dynamics of Net External Assets." Draft.

Drozd, L. and J. Nosal. 2008. "Understanding International Prices: Customers as Capital." Federal Reserve Bank of Minneapolis Staff Report No. 411.

Engel, C. and J. Rogers. 2006. "The U.S. Current Account Deficit and the Expected Share of World Output." *Journal of Monetary Economics* 53(5): 1063–93.

Erceg, C., L. Guerrieri and C. Gust. 2005. "Expansionary Fiscal Shocks and the U.S. Trade Deficit." *International Finance* 8(3): 363–97.

Goldberg, L. S. and C. Tille. 2005. "Vehicle Currency Use in International Trade." Federal Reserve Bank of New York Staff Report No. 200.

Goldberg, P. K. and M. M. Knetter. 1997. "Good Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature* 35(3): 1243–72.

Gourinchas, P. and H. Rey. 2007. "From World Banker to World Venture Capitalist: U.S. External Adjustment and the Exorbitant Privilege." *G7 Current Account Imbalances: Sustainability and Adjustment* 11–55, Chicago: University of Chicago Press.

Gruber J. and S. Kamin. 2007. "Explaining the Global Pattern of Current Account Imbalances." *Journal of International Money and Finance* 26(4):500–22.

Lane, P. and G. M. Milesi-Ferretti. 2005. "A Global Perspective on External Positions." NBER Working Paper No. 11589.

Lubik, T. and F. Schorfheide. 2005. "A Bayesian Look at New Open Economy Macroeconomics." *NBER Macroeconomics Annual 2005*, 313–66, edited by D. Acemoglu, K. Rogoff and M. Woodford.

Marazzi, M. and N. Sheets. 2007. "Declining Exchange Rate Pass-Through to U.S. Import Prices: The Potential Role of Global Factors." *Journal of International Money and Finance*, 26(6): 924–47.

Obstfeld, M. and K. Rogoff. 2000. "Perspectives on OECD Capital Market Integration: Implications for U.S. Current Account Adjustment." in Federal Reserve Bank of Kansas City, Global Economic Integration: Opportunities and Challenges, March 2000, 169–208.

Obstfeld, M. and K. Rogoff. 2005. "Global Current Account Imbalances and Exchange Rate Adjustments." *Brookings Papers on Economic Activity* 1: 67–146.

——. 2007. "The Unsustainable U.S. Current Account Position Revisited." *G7 Current Account Imbalances: Sustainability and Adjustment* 339–76, Chicago: University of Chicago Press.

Ruhl, K. J. 2008. "The International Elasticity Puzzle." Draft.

Smets F. and R. Wouters. 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area." *Journal of the European Economic Association* 1(5): 1123–75.

Stockman, A. C. and L. L. Tesar. 1995. "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements." *American Economic Review* 85(1): 168–85.

Taylor, J. 2006. "Economic Reform and the Current Account: Implementing the Strategy." Speech at the IMF Conference on Current Account, Washington D.C.

Valentinyi, Á. and B. Herrendorf. 2007. "Measuring Factor Income Shares at the Sector Level — A Primer." Centre for Economic Policy Research (CEPR) Discussion Paper No. 6271.

Table 1: Model Validation: Persistence and Volatility

	Data		**Model**	
	Std.	Autocorrelation	Std.	Autocorrelation
			1970:1-1991:4	
$\Delta\hat{w}_t$	0.6979	0.4200	0.3644 (0.3103,0.4324)	0.2468 (0.0420,0.4941)
$\Delta\hat{y}_t$	1.0185	0.2710	3.2831 (2.8298,3.9560)	-0.0655 (-0.1997,0.0649)
$\Delta\hat{w}_t^*$	0.7333	0.1150	1.0864 (0.9355,1.2824)	0.4553 (0.3003,0.6052)
$\Delta\hat{y}_t^*$	3.6322	0.4030	2.8128 (2.4544,3.2819)	-0.0112 (-0.1601,0.1504)
$\Delta\hat{tot}_t$	1.7597	0.4070	5.0277 (4.3749,5.7383)	0.0304 (-0.1169,0.1934)
$\Delta\hat{tot}_t^*$	1.5072	0.3400	6.6429 (5.7185,7.6461)	-0.0945 (-0.2278,0.0447)
$\Delta\hat{d}_{ROW,t}$	7.0659	-0.2550	7.1942 (6.2400,8.2844)	-0.0593 (-0.1920,0.0789)
$\Delta\hat{d}^*_{ROW,t}$	10.056	-0.6800	10.357 (9.0268,11.932)	-0.1229 (-0.2530,0.0224)
$\hat{r}_t$	2.5903	0.9260	1.2115 (0.7592,2.1224)	0.9060 (0.7528,0.9901)
$\hat{r}_t^*$	2.4957	0.9520	3.9097 (2.3362,6.4504)	0.9725 (0.8135,1.0317)
$\hat{\pi}_t$	0.8162	0.8050	1.2369 (0.7993,2.1008)	0.8830 (0.7286,0.9759)
$\hat{\pi}_t^*$	1.2599	0.5750	4.1739 (2.6299,6.7617)	0.9390 (0.7897,1.0123)
			1992:1-2008:1	
$\Delta\hat{w}_t$	0.3997	0.1610	0.2662 (0.2214,0.3192)	0.1366 (-0.1285,0.4318)
$\Delta\hat{y}_t$	0.4894	0.1210	1.6956 (1.4488,1.9821)	-0.0519 (-0.2104,0.1043)
$\Delta\hat{w}_t^*$	0.3347	-0.1160	0.6277 (0.5087,0.7940)	0.6370 (0.4466,0.7830)
$\Delta\hat{y}_t^*$	3.0289	0.1460	2.0672 (1.6746,2.5116)	-0.0337 (-0.2031,0.1517)
$\Delta\hat{tot}_t$	0.8140	0.1830	3.8328 (3.3098,4.3376)	-0.0162 (-0.1749,0.1588)
$\Delta\hat{tot}_t^*$	0.7538	-0.1180	3.3738 (2.9311,3.8880)	-0.0539 (-0.2094,0.0932)
$\Delta\hat{d}_{ROW,t}$	6.0421	-0.5090	5.9972 (5.0708,7.0276)	-0.1630 (-0.3173,-0.0099)
$\Delta\hat{d}^*_{ROW,t}$	7.4838	-0.4970	7.4890 (6.4089,8.8500)	-0.0870 (-0.2410,0.0757)
$\hat{r}_t$	1.5252	0.9480	0.4968 (0.2986,0.8432)	0.8814 (0.6837,0.9899)
$\hat{r}_t^*$	1.7970	0.9120	1.8102 (1.0554,3.0648)	0.9505 (0.7501,1.0399)
$\hat{\pi}_t$	0.3096	0.0930	0.5807 (0.3968,0.9082)	0.7764 (0.5539,0.9257)
$\hat{\pi}_t^*$	0.1847	0.2670	1.9308 (1.1437,3.1633)	0.9404 (0.7411,1.0282)

Table 2: Model Validation: Cross Correlations

	1970:1 − 1991:4		1992:1-2008:1	
	Data	**Model**	**Data**	**Model**
$\hat{\pi}_t, \hat{\pi}_t^*$	0.6222	0.4960 (-0.2045,0.8503)	0.5032	0.4680 (-0.2202,0.8270)
$\Delta\hat{y}_t, \Delta\hat{y}_t^*$	0.0501	-0.2742 (-0.4181,-0.1253)	-0.0444	-0.3597 (-0.5136,-0.1952)
$\Delta\hat{tot}_t, \hat{\pi}_t$	-0.4300	-0.1785 (-0.3714,0.0475)	-0.6381	-0.2257 (-0.4179,-0.0166)
$\Delta\hat{tot}_t^*, \hat{\pi}_t^*$	-0.2324	-0.0669 (-0.1861,0.0395)	-0.1463	-0.0237 (-0.1567,0.1006)
$\Delta\hat{tot}_t, \Delta\hat{y}_t$	0.1270	0.1756 (-0.0047,0.3378)	-0.0660	0.4193 (0.2330,0.5834)
$\Delta\hat{tot}_t^*, \Delta\hat{y}_t^*$	0.2609	0.2450 (0.0693,0.4045)	0.2200	-0.0460 (-0.2463,0.1697)
$\Delta\hat{d}_{ROW,t}, \Delta\hat{y}_t$	0.1025	0.0289 (-0.1194,0.1784)	0.3666	-0.0562 (-0.2169,0.1125)
$\Delta\hat{d}_{ROW,t}, \Delta\hat{y}_t^*$	0.1546	0.1464 (0.0066,0.2814)	0.1506	0.1186 (-0.0393,0.2926)
$\Delta\hat{d}_{ROW,t}^*, \Delta\hat{y}_t$	-0.0293	-0.0407 (-0.1791,0.1111)	0.1255	-0.0539 (-0.2159,0.1142)
$\Delta\hat{d}_{ROW,t}^*, \Delta\hat{y}_t^*$	0.3914	0.0871 (-0.0520,0.2342)	0.4893	0.1513 (-0.0235,0.3161)

Table 3: Parameter Estimates: 1970:1 -1991:4

	1970:1 − 1991:4							
	Prior Distribution			Posterior Maximization		Posterior Distribution		
Parameters	Distribution	Mean	Std	Mode	Std Error	Mean	10%	90%
ψ_d	Beta	0.75	0.05	0.9106	0.0097	0.9148	0.8992	0.9294
ψ_w	Beta	0.75	0.05	0.8552	0.0097	0.8617	0.8450	0.8783
τ_d	Beta	0.50	0.10	0.2564	0.0585	0.2837	0.1808	0.3878
τ_w	Beta	0.50	0.10	0.3008	0.0644	0.3250	0.2185	0.4351
ψ_d^*	Beta	0.75	0.05	0.6810	0.0442	0.6724	0.5917	0.7556
ψ_w^*	Beta	0.75	0.05	0.6454	0.0234	0.6559	0.6208	0.6910
τ_d^*	Beta	0.50	0.10	0.3281	0.0730	0.3413	0.2206	0.4669
τ_w^*	Beta	0.50	0.10	0.1625	0.0454	0.1782	0.1001	0.2556
σ	Gamma	0.50	0.15	0.4688	0.1475	0.5084	0.2577	0.7508
σ^*	Gamma	0.50	0.15	0.5145	0.1609	0.5584	0.2873	0.8108
ρ_r	Beta	0.70	0.10	0.9910	0.0036	0.9905	0.9858	0.9960
α_π	Gamma	1.40	0.10	1.3231	0.0941	1.3233	1.1708	1.4804
α_y	Gamma	0.40	0.15	0.2934	0.0923	0.2924	0.1446	0.4333
ρ_r^*	Beta	0.70	0.10	0.6958	0.0455	0.6847	0.6091	0.7623
α_π^*	Gamma	1.40	0.10	1.4850	0.0902	1.4659	1.3171	1.6078
α_y^*	Gamma	0.40	0.15	0.4079	0.0954	0.3813	0.2254	0.5351
ϱ	Beta	0.40	0.15	0.2567	0.1430	0.2690	0.0810	0.4500
ϱ^*	Beta	0.40	0.15	0.2648	0.1361	0.3357	0.1171	0.5479
ρ_f	Beta	0.30	0.10	0.2449	0.0877	0.2501	0.1188	0.3785
ρ_g	Beta	0.75	0.10	0.7818	0.1041	0.7516	0.5930	0.9280
ρ_g^*	Beta	0.75	0.10	0.9695	0.0166	0.9609	0.9369	0.9859
ρ_β	Beta	0.75	0.10	0.9114	0.0228	0.7885	0.6288	0.9410
ρ_β^*	Beta	0.75	0.10	0.7650	0.0314	0.7966	0.7444	0.8487
ρ_p	Beta	0.75	0.10	0.8276	0.0460	0.8173	0.7429	0.8927
ρ_p^*	Beta	0.75	0.10	0.7892	0.0587	0.8155	0.7352	0.9007
ρ_d	Beta	0.75	0.10	0.8807	0.0410	0.8748	0.8160	0.9373
ρ_d^*	Beta	0.75	0.10	0.7779	0.0443	0.7780	0.7070	0.8505
ρ_φ	Beta	0.75	0.10	0.7559	0.0967	0.7184	0.5684	0.8760
σ_φ	Beta	0.50	4.00	0.2095	0.0713	0.2780	0.1253	0.4353
σ_f	Inv Gamma	0.50	4.00	1.1925	0.1672	1.2113	0.9295	1.4879
σ_g	Inv Gamma	0.50	4.00	0.2315	0.0943	0.5764	0.1100	1.0751
σ_g^*	Inv Gamma	0.50	4.00	4.6008	2.0542	6.2419	3.5199	9.4377
σ_β	Inv Gamma	0.50	4.00	3.8913	0.8897	1.3100	0.1115	4.1533
σ_β^*	Inv Gamma	0.50	4.00	7.2531	0.7064	7.7805	6.5411	9.0178
σ_r	Inv Gamma	0.50	4.00	0.3911	0.0435	0.3991	0.3253	0.4717
σ_r^*	Inv Gamma	0.50	4.00	0.1750	0.0431	0.2056	0.1223	0.2863
σ_p	Inv Gamma	0.50	4.00	4.5104	0.4285	4.8160	4.0222	5.6071
σ_p^*	Inv Gamma	0.50	4.00	7.3810	0.7224	8.0412	6.6465	9.4347
σ_d	Inv Gamma	5.00	4.00	6.7673	0.5129	6.8909	5.9957	7.7558
σ_d^*	Inv Gamma	5.00	4.00	9.3523	0.7003	9.4760	8.2885	10.645

Table 4: Parameter Estimates: 1992:1 -2008:1

	1992:1 − 2008:1							
	Prior Distribution			Posterior Maximization		Posterior Distribution		
Parameters	Distribution	Mean	Std	Mode	Std Error	Mean	10%	90%
ψ_d	Beta	0.75	0.05	0.9244	0.0173	0.9211	0.9056	0.9367
ψ_w	Beta	0.75	0.05	0.8860	0.0185	0.8787	0.8592	0.8981
τ_d	Beta	0.50	0.10	0.1656	0.0488	0.1805	0.1025	0.2558
τ_w	Beta	0.50	0.10	0.2907	0.0661	0.2968	0.1922	0.3981
ψ_d^*	Beta	0.75	0.05	0.8081	0.0287	0.7913	0.7432	0.8406
ψ_w^*	Beta	0.75	0.05	0.7127	0.0235	0.7142	0.6788	0.7491
τ_d^*	Beta	0.50	0.10	0.7380	0.0681	0.7387	0.6352	0.8467
τ_w^*	Beta	0.50	0.10	0.3193	0.0748	0.3320	0.2113	0.4480
σ	Gamma	0.50	0.15	0.4543	0.1428	0.5055	0.2583	0.7423
σ^*	Gamma	0.50	0.15	0.4583	0.1435	0.4989	0.2605	0.7380
ρ_r	Beta	0.70	0.10	0.9946	0.0016	0.9931	0.9896	0.9960
α_π	Gamma	1.40	0.10	1.3819	0.0951	1.3580	1.2013	1.5131
α_y	Gamma	0.40	0.15	0.1684	0.0583	0.2051	0.0951	0.3160
ρ_r^*	Beta	0.70	0.10	0.7648	0.0532	0.7496	0.6689	0.8349
α_π^*	Gamma	1.40	0.10	1.3233	0.1018	1.3568	1.2100	1.4977
α_y^*	Gamma	0.40	0.15	0.4138	0.1127	0.4245	0.2535	0.5927
ϱ	Beta	0.40	0.15	0.3171	0.1613	0.3160	0.1082	0.5197
ϱ^*	Beta	0.40	0.15	0.4403	0.1629	0.4367	0.1999	0.6705
ρ_f	Beta	0.30	0.10	0.2252	0.0910	0.2465	0.1074	0.3853
ρ_g	Beta	0.75	0.10	0.7818	0.1041	0.7501	0.5890	0.9100
ρ_g^*	Beta	0.75	0.10	0.9389	0.0320	0.9352	0.8971	0.9752
ρ_β	Beta	0.75	0.10	0.7834	0.1041	0.7656	0.6160	0.9302
ρ_β^*	Beta	0.75	0.10	0.7756	0.0325	0.7737	0.7234	0.8242
ρ_p	Beta	0.75	0.10	0.7366	0.0917	0.7136	0.5831	0.8549
ρ_p^*	Beta	0.75	0.10	0.9015	0.0564	0.8732	0.7917	0.9574
ρ_d	Beta	0.75	0.10	0.6724	0.0750	0.6671	0.5539	0.7874
ρ_d^*	Beta	0.75	0.10	0.8238	0.0388	0.8158	0.7518	0.8786
ρ_φ	Beta	0.75	0.10	0.7302	0.0995	0.6912	0.5425	0.8504
σ_φ	Beta	0.50	4.00	0.1920	0.0589	0.2397	0.1203	0.3606
σ_f	Inv Gamma	0.50	4.00	0.9628	0.1628	0.9277	0.6854	1.1625
σ_g	Inv Gamma	0.50	4.00	0.2316	0.0944	0.4401	0.1158	0.8432
σ_g^*	Inv Gamma	0.50	4.00	5.8876	2.8605	6.6138	3.9859	9.9537
σ_β	Inv Gamma	0.50	4.00	0.2331	0.0963	0.5624	0.1096	1.2996
σ_β^*	Inv Gamma	0.50	4.00	4.7864	0.5795	5.0374	4.1049	5.9667
σ_r	Inv Gamma	0.50	4.00	0.1703	0.0305	0.1819	0.1385	0.2232
σ_r^*	Inv Gamma	0.50	4.00	0.1165	0.0200	0.1269	0.0910	0.1619
σ_p	Inv Gamma	0.50	4.00	3.3153	0.5101	3.3860	2.6882	4.0634
σ_p^*	Inv Gamma	0.50	4.00	2.9020	0.3291	3.0442	2.4670	3.6113
σ_d	Inv Gamma	5.00	4.00	5.2487	0.4581	5.3694	4.5759	6.1194
σ_d^*	Inv Gamma	5.00	4.00	7.0189	0.6123	7.2026	6.1371	8.2268

Figure 1: Pass-through of Exchange Rates to U.S. Imports ($\hat{y}_{IM,t}$) and Exports ($\hat{y}^*_{H,t}$)

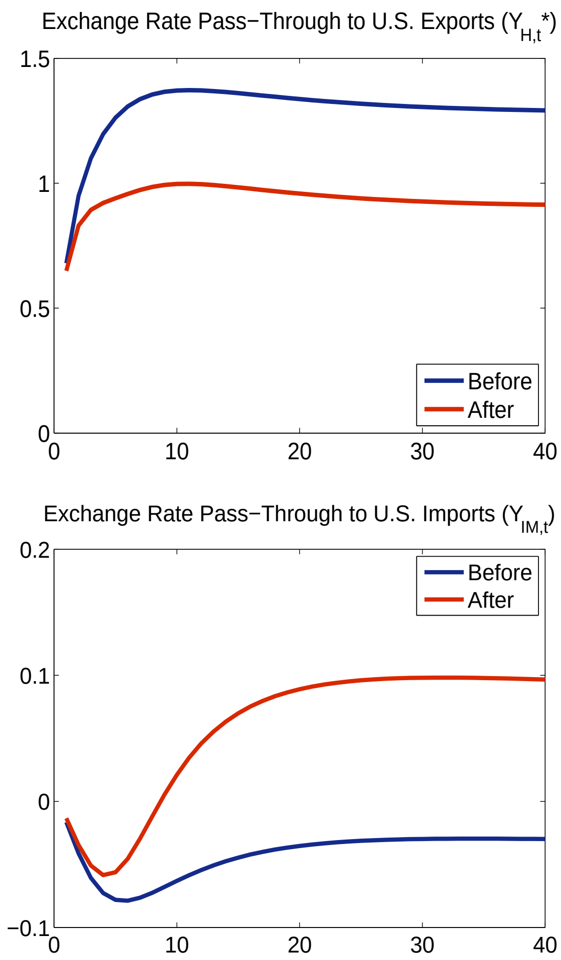

Figure 2: Counterfactual Analysis: Pass-through of Exchange Rates to U.S. Exports ($\hat{y}^*_{H,t}$)

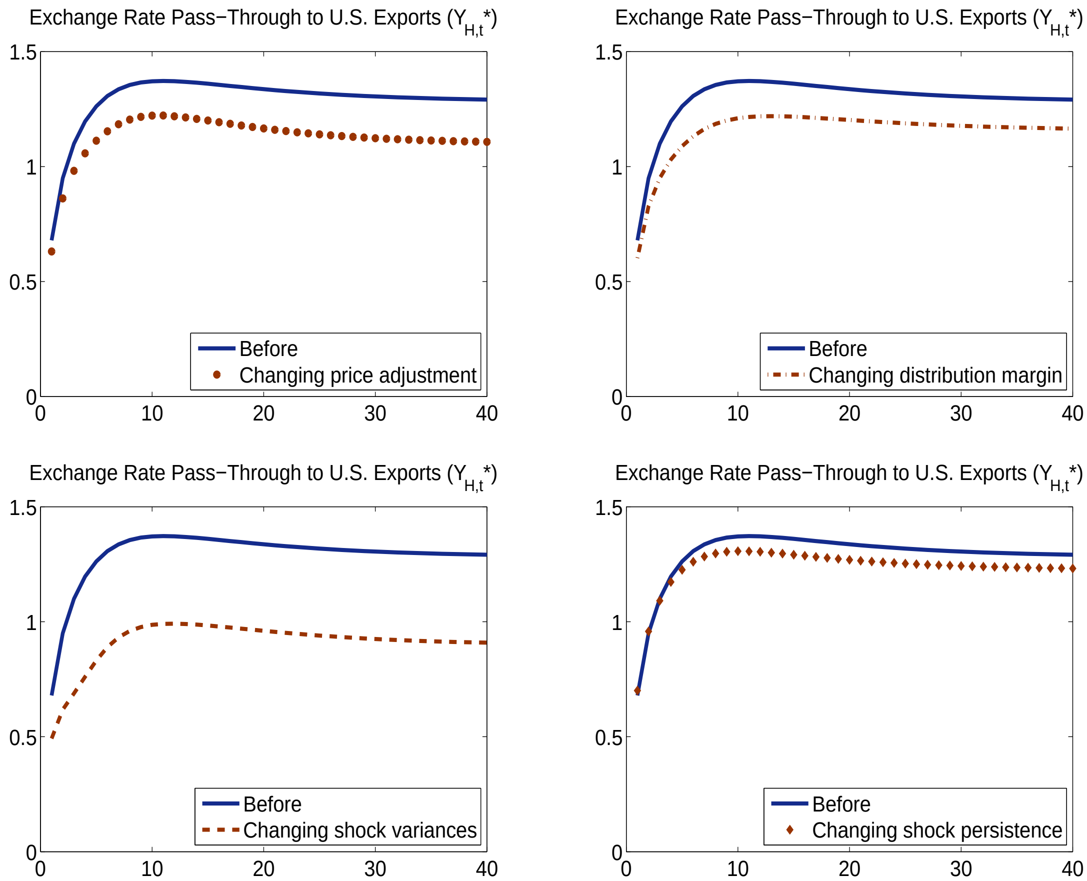

Figure 3: Counterfactual Analysis: Pass-through of Exchange Rates to U.S. Imports ($\hat{y}_{IM,t}$)