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TRADE LIBERALIZATION, MACROECONOMIC ADJUSTMENT, AND WELFARES: UNIFYING TRADE AND MACRO MODELS

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Trade Liberalization, Macroeconomic Adjustment, and Welfare: Unifying Trade and Macro Models

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Abstract

Trade liberalization leads to long-run gains, but it can also involve costly short-run macroeconomic adjustment. The paper explores the relative importance of these effects within a dynamic general equilibrium (DGE) model that captures the key elements of both international trade and macroeconomic models. The welfare effect of trade liberalization is decomposed into a steady-state efficiency gain and a transitional loss arising from wage-price stickiness. Our estimates show that the transitional loss is small relative to the efficiency gain, and tends to be lower under flexible as compared to fixed exchange rates. We also show that the loss can be reduced further by a flexible price level targeting policy rule.

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1. Introduction

There are two distinct strands in the extensive literature on economic effects of trade policy. One strand is mainly concerned with the long-run effects of trade policy on economic welfare and employs international trade models with flexible prices to determine this effect. In this analysis, trade liberalization generally enhances welfare by improving economic efficiency.[2] The other strand uses macroeconomic models with nominal rigidities to examine the short-run consequences of trade policy on variables such as output, employment and the current account. The response of macroeconomic variables to trade liberalization in these models depends, among other things, on monetary policy. For example, under fixed exchange rates, tariff cuts lower the relative price of foreign goods and (in the presence of sticky prices) normally cause a contraction of output and employment as well as a deficit in the current account.[3] These effects can be altered by home currency depreciation under flexible exchange rates.[4] Macroeconomic adjustment to trade liberalization could potentially involve substantial costs. There is little work, however, which has integrated the two strands to compare the short-run adjustment costs of trade liberalization under different monetary policy regimes with the long-run efficiency benefits of this policy.

Early macroeconomic models did not have strong microeconomic foundations and thus, did not examine the welfare implications of macroeconomic adjustment to trade

[2] Adverse terms of trade effects or market failure can qualify this result.
[3] See Chacholiades (1978) and Dornbusch (1980) for a discussion of the macroeconomic effects a tariff (which are opposite to those of trade liberalization) under fixed exchange rates.
[4] For an early analysis of the macroeconomic effect of a tariff under flexible exchange rates, see Mundell (1961). Also see Boyer(1977) and Krugman (1982) for further analysis of these effects.

policy.[5] The optimizing framework of the new open economy macroeconomic models, however, makes it possible to evaluate the welfare effect of macroeconomic adjustment. These models, however, differ from international trade models in important respects. A key difference is that while international trade models allow wages and prices to be flexible and often assume competitive conditions, macroeconomic models introduce wage-price inertia and assume imperfect competition to motivate this behavior. Another important difference arises from the assumption regarding the number of sectors producing traded goods: there is one traded-goods sector in macroeconomic models, but at least two traded-goods sectors in international trade models. These differences make it difficult to compare the welfare results derived from the two types of models. This paper develops a simple hybrid model that captures the key elements of both approaches and provides a unifying framework to examine the welfare consequences of both the short- and long-run effects of changes in trade policy.

Macroeconomic adjustment to trade liberalization is captured in the model by transitional dynamics based on wage-price inertia. The total welfare effect of the removal of trade restrictions can be decomposed into a transitional effect related to macroeconomic adjustment and a steady-state effect associated with long-run changes in resource allocation. The transitional effect involves a loss because sticky nominal wages and prices delay adjustment to new steady-state values. This loss provides a welfare measure of the cost of macroeconomic adjustment to reduction of trade barriers. The paper estimates welfare effects of tariff reduction for a small emerging economy that is financially integrated with the rest of the world. One interesting result of the paper's

[5] There is literature going back to Razin and Svensson (1983), which uses an optimizing framework without nominal rigidities to analyze the effect of a tariff on the current account.

quantitative analysis is that the macroeconomic costs of a tariff reduction turn out to be small in relation to long-term efficiency gains for a wide range of parameter values.

The paper also explores how monetary policy affects macroeconomic costs of liberalizing trade. In addition to pure fixed and flexible exchange rate regimes, the paper considers an interest rate rule that targets the price level. The paper finds that flexible exchange rates (which maintain a constant price level) involve a lower loss than fixed exchange rates under plausible parameterization. The interest rate rule, moreover, can perform better than pure flexible exchange rates by allowing some price adjustment. In fact, a sufficiently weak interest rate response to the price level can come close to duplicating the flexible wage-price equilibrium that eliminates transitional dynamics.

The basic model is developed in Section 2. Section 3 parameterizes the model and uses it to estimate macroeconomic and welfare effects of trade liberalization. Section 4 concludes the paper.

2. Theoretical Framework

2.1 Basic Setup

This section develops a basic dynamic general equilibrium model to examine the short- and long-run effects of trade policy changes. There are two countries, a small home country and a large foreign country. Two goods, M and X, are produced in the two countries. The production of each good requires labor and capital specific to each sector. Capital endowments are fixed (as in trade models), but labor supply is variable (as in macroeconomic models).

To introduce nominal rigidities in the model, it is assumed that both goods and labor markets are characterized by monopolistic competition, and changes in wages and prices are subject to adjustment costs. There is interindustry as well as intraindustry trade. The home country is a net importer of good M and a net exporter of good X. Trade restrictions take the form of import tariffs.

Households trade a short-term foreign bond denominated in foreign currency to borrow or lend internationally. International borrowing or lending is unrestricted but subject to a transaction cost that increases in foreign debt. There are no stochastic shocks in the model and the inflation rate equals zero in steady state.

2.2 Consumption and Production

The household's consumption basket is given by

$$C_t = \left[\chi_M^{1/\eta} C_{M,t}^{(\eta-1)/\eta} + \chi_X^{1/\eta} C_{X,t}^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)}, \tag{1}$$

where $C_{M,t}$ and $C_{X,t}$ are consumption indexes for goods *M* and *X*, η is the elasticity of substitution between the two goods, and $\chi_M + \chi_X = 1$. The consumption index for each sector is defined as

$$C_{T,t} = \left[\chi_{TH}^{1/\theta_T} C_{TH,t}^{(\theta_T-1)/\theta_T} + \chi_{TF}^{1/\theta_T} C_{TF,t}^{(\theta_T-1)/\theta_T} \right]^{\theta_T/(\theta_T-1)}, T = M, X, \tag{2}$$

where, for sector *T (= M, X)*, $C_{TH,t}$ and $C_{TF,t}$ are consumption bundles of home and foreign varieties, θ_T represents the elasticity of substitution between the home and foreign bundles, and $\chi_{TH} + \chi_{TF} = 1$.

For each good, there is a continuum of home and foreign varieties in the unit interval. Consumption aggregates of home and foreign varieties, indexed by $h, f \in [0, 1]$, for the two goods are

$$C_{TH,t}=\left[\int_0^1 C_{TH,t}(h)^{(\varepsilon_T-1)/\varepsilon_T}\,dh\right]^{\varepsilon_T/(\varepsilon_T-1)},C_{TF,t}=\left[\int_0^1 C_{TF,t}(f)^{(\varepsilon_T-1)/\varepsilon_T}\,df\right]^{\varepsilon_T/(\varepsilon_T-1)},T=M,X,\quad(3)$$

where, for simplicity, the elasticity of substitution among varieties, ε_T, is assumed to be the same for home and foreign bundles of each good.

Optimal allocation of consumption expenditures between the two goods, between the home and foreign bundles of each good, and among different varieties of each bundle leads to the following demand functions:

$$C_{M,t}=\chi_M C_t(P_{M,t}/P_t)^{-\eta},\quad C_{X,t}=\chi_X C_t(P_{X,t}/P_t)^{-\eta},\quad(4)$$

$$C_{TH,t}=\chi_{TH}C_{T,t}(P_{TH,t}/P_{T,t})^{-\theta_T},C_{TF,t}=\chi_{TF}C_{T,t}(P_{TF,t}/P_{T,t})^{-\theta_T},T=M,X,\quad(5)$$

$$C_{TH,t}(h)=C_{TH,t}(P_{TH,t}(h)/P_{TH,t})^{-\varepsilon_T},C_{TF,t}(f)=C_{TF,t}(P_{TF,t}(f)/P_{TF,t})^{-\varepsilon_T},T=M,X,\quad(6)$$

where $P_{TH,t}(h)$ and $P_{TF,t}(f)$ are the prices of varieties of home and foreign goods; $P_{TH,t}$ and $P_{TF,t}$ are price indexes that minimize the unit cost of home and foreign bundles defined in (3), and P_t and $P_{T,t}$ are the cost-minimizing price indexes for the aggregate basket (1) and the consumption index (2). These price indexes are given by

$$P_t=\left[\chi_M P_{M.t}^{1-\eta}+\chi_X P_{X,t}^{1-\eta}\right]^{1/(1-\eta)},\quad(7)$$

$$P_{T,t}=\left[\chi_{TH}P_{TH,t}^{1-\theta_T}+\chi_{TF}P_{TF,t}^{1-\theta_T}\right]^{1/(1-\theta_T)},T=M,X,\quad(8)$$

$$P_{TH,t}=\left[\int_0^1 P_{TH,t}(h)^{1-\varepsilon_T}\,dh\right]^{1/(1-\varepsilon_T)},P_{TF,t}=\left[\int_0^1 P_{TF,t}(f)^{1-\varepsilon_T}\,df\right]^{1/(1-\varepsilon_T)},T=M,X.\quad(9)$$

Optimal allocation of consumption expenditures abroad yields similar expressions for foreign demand functions and price indexes. Letting an asterisk denote a foreign variable, the foreign demand for home bundles and varieties can be expressed as:

$$C^{*}_{TH,t} = \chi^{*}_{TH} C^{*}_{T,t} (P^{*}_{TH,t} / P^{*}_{T,t})^{-\theta_T}, \quad C^{*}_{TH,t}(h) = C^{*}_{TH,t} (P^{*}_{TH,t}(h) / P^{*}_{TH,t})^{-\varepsilon_T}, T = M, X. \quad (10)$$

For each good, the production technology for a firm is given by the following CES production function:

$$Y_{T,t} = \left[\alpha_T^{1/\sigma} L_{T,t}^{(\sigma-1)/\sigma} + (1-\alpha_T)^{1/\sigma} K_{T,t}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}, T = M, X, \quad (11)$$

where $Y_{M,t}$, $L_{M,t}$ and $K_{M,t}$ represent, respectively, output, a bundle of labor inputs and a specific capital input for good M; $Y_{X,t}$, $L_{X,t}$ and $K_{X,t}$ are the corresponding variables for good X; and σ is the elasticity of substitution between labor and capital for both goods. The optimal choice of inputs implies the following demand functions for labor and capital:

$$L_{T,t} = \alpha_T Y_{T,t} (W_t / MC_{T,t})^{-\sigma}, K_{T,t} = (1-\alpha_T) Y_{T,t} (RE_{T,t} / MC_{T,t})^{-\sigma}, T = M, X, \quad (12)$$

where W_t is the wage index (defined below); $RE_{M,t}$ and $RE_{X,t}$ are the rental rates for capital inputs specific to goods M and X; and $MC_{M,t}$ and $MC_{X,t}$ denote the marginal costs for the two goods. For each good, the marginal cost equals the minimum unit cost and can be derived from (11) as

$$MC_{T,t} = \left[\alpha_T W_t^{1-\sigma} + (1-\alpha_T) RE_{T,t}^{1-\sigma} \right]^{1/(1-\sigma)}, T = M, X. \quad (13)$$

The labor input bundles are aggregates of differentiated services supplied by a continuum of households in the unit interval. The aggregate index of labor services, indexed by $l \in [0,1]$, used in the production of each good is defined as

$$L_{M,t} = \left[\int_0^1 L_{M,t}(l)^{(\varepsilon_L-1)/\varepsilon_L} dl \right]^{\varepsilon_L/(\varepsilon_L-1)}, \quad L_{X,t} = \left[\int_0^1 L_{X,t}(l)^{(\varepsilon_L-1)/\varepsilon_L} dl \right]^{\varepsilon_L/(\varepsilon_L-1)}, \quad (14)$$

where ε_L is the substitution elasticity for labor services. The optimal allocation of the aggregate labor input among different services in the two sectors gives the total demand for each household's service as

$$L_t(l) = L_{M,t}(W_t(l)/W_t)^{-\varepsilon_L} + L_{X,t}(W_t(l)/W_t)^{-\varepsilon_L}, \tag{15}$$

where $W_t(l)$ represents the household's wage rate and W_t is the following wage index (which minimizes the cost of the labor input bundle):

$$W_t = \left[\int_0^1 W_t(l)^{1-\varepsilon_L} dl\right]^{1/(1-\varepsilon_L)}. \tag{16}$$

2.3 Households

The utility of an infinitely-lived household is given by

$$U_t(l) = \sum_{s=t}^{\infty} \beta^{s-t} u[C_s(l), L_s(l)], \tag{17}$$

where $C_s(l)$ is the household's aggregate consumption. The single-period utility is assumed to be

$$u_s(.) = \left(\frac{C_s^{1-\rho}(l)}{1-\rho} - \frac{\psi L_s^{1+\mu}(l)}{1+\mu}\right). \tag{18}$$

Households hold one-period domestic and foreign bonds. Domestic bonds are denominated in home currency while foreign bonds are denominated in foreign currency. Only foreign bonds are used for international borrowing or lending and their holding is subject to a transaction cost. Wage changes involve adjustment costs.

Household budget constraint is given by

$$\begin{aligned} &B_{t+1}(l) + S_t B_{t+1}^*(l) = (1+R_{t-1})B_t(l) + S_t(1+R_{t-1}^*)(1-TC_{t-1})B_t^*(l) \\ &+ W_t(l)L_t(l)(1-AC_{W,t}(l)) + PF_t(l) + RE_t(l) + TR_t(l) - P_t C_t(l), \end{aligned} \tag{19}$$

where $B_t(l)$ and $B_t^*(l)$ are home and foreign bonds held by households at the beginning of period *t*; S_t is the exchange rate; R_{t-1} and R_{t-1}^* are the home and foreign interest rates for a loan in period $t-1$ (paid at the beginning of period t); TC_{t-1} is the transaction cost for foreign borrowing or lending in period $t-1$; $PF_t(l)$ and $RE_t(l)$ are the household's shares of total profits and rents; $TR_t(l)$ are government transfers (discussed below); and $AC_{W,t}(l)$ is the household's cost of adjusting wages. The wage adjustment costs (as a proportion of wage income) are assumed to be given by the following quadratic function:

$$AC_{W,t}(l) = \frac{\omega_W}{2}\left(\frac{W_{L,t}(l)}{W_{L,t-1}(l)} - 1\right)^2. \tag{20}$$

Each household chooses consumption and sets the wage rate to maximize lifetime utility (17) subject to the budget constraint (19) and labor demand (15). The household optimization yields the following first order conditions:

$$\frac{\beta C_t(l)^{\rho} P_t}{C_{t+1}(l)^{\rho} P_{t+1}} = \frac{1}{1+R_t}, \tag{21}$$

$$\frac{S_t}{S_{t+1}} = \frac{(1+R_t^*)(1-TC_t)}{1+R_t}, \tag{22}$$

$$\begin{aligned}(\varepsilon-1)(1-AC_{w,t}(l))W_t(l) = \varepsilon\psi L_t^{\mu} P_t / C_t^{-\rho} - W_t^2(l)\partial AC_{W,t}(l)/\partial W_t(l) \\ -[(W_t(l)W_{t+1}(l)L_{t+1})/((1+R_t)L_t)]\partial AC_{W,t+1}(l)/\partial W_t(l).\end{aligned} \tag{23}$$

2.4 Firms

Each firm takes the demand for its variety as given and sets prices to maximize the present discounted value of profits. Price changes are subject to adjustment costs. Price adjustment costs (as a proportion of profits) for the two goods are of the same form as wage adjustment costs, and are given by the following quadratic functions:

$$AC_{T,t}(h) = \frac{\omega_P}{2}\left(\frac{P_{TH,t}(h)}{P_{TH,t-1}(h)} - 1\right)^2, \; T = M, X, \tag{24}$$

where the adjustment cost parameter, ω_P, is assumed to be same for both sectors.

Firms in both sectors are able to price discriminate between the home and foreign markets. For simplicity, we assume that prices in both markets are set in terms of the home currency. Let $P'_{TH,t}(h)$ denote the home-currency price of a home variety of good T set for the foreign market. This price is related to the foreign-currency price of the variety abroad as

$$P'_{TH,t}(h) = S_t P^*_{TH,t}(h)/(1+\tau^*_T), \quad T = M, X, \tag{25}$$

where τ^*_T represents the foreign import tariff rate. Let $P'_{TH,t} = \left[\int_0^1 P'_{TH,t}(h)^{1-\varepsilon_T} dh\right]^{1/(1-\varepsilon_T)}$,

$P^*_{TH,t} = \left[\int_0^1 P^*_{TH,t}(h)^{1-\varepsilon_T} dh\right]^{1/(1-\varepsilon_T)}$, and use (25) to obtain $P'_{TH,t}(h)/P'_{TH,t} = P^*_{TH,t}(h)/P^*_{TH,t}$.

Using this condition and (10), we can express profits of a home firm in each sector as

$$\begin{aligned} PF_{T,t}(h) &= (P_{TH,t}(h) - MC_{T,t})C_{TH,t}(P_{TH,t}(h)/P_{TH,t})^{-\varepsilon_T}(1 - AC_{T,t}(h)) \\ &+ (P'_{TH,t}(h) - MC_{TH,t})C^*_{TH,t}(P'_{TH,t}(h)/P'_{TH,t})^{-\varepsilon_T}(1 - AC'_{T,t}(h)), T = M, X, \end{aligned} \tag{26}$$

where $AC'_{T,t}$ is the adjustment cost for the foreign-market price analogous to (24). The firm chooses $P_{TH,t}(h)$ and $P'_{TH,t}(h)$ to maximize $\sum_{s=t}^{\infty} D_{t,s} PF_{T,s}(h)$, where $D_{t,s}$ denotes the rate used to discount s-period values at period t. The optimal choice for $P_{TH,t}(h)$ satisfies the following first-order condition:

$$\begin{aligned} &(1 - AC_{T,t}(h))[(\sigma - 1)P_{T,t}(h) - \sigma MC_{T,t}] = -P_{TH,t}(h)(P_{TH,t}(h) - MC_{T,t})\partial AC_{T,t}(h)/\partial P_{TH,t}(h) \\ &-[P_{TH,t}(h)(P_{TH,t+1}(h) - MC_{T,t+1})C_{TH,t+1})/((1+R_t)C_{TH,t})]\partial AC_{TH,t+1}(h)/\partial P_{TH,t}(h), T = M, X. \end{aligned} \tag{27}$$

The first-order conditions for $P'_{TH,t}$ has the same form as (27) and implies that $P'_{TH,t}(h) = P_{TH,t}(h)$. It follows that

$$P_{TH,t} = S_t P^*_{TH,t} / (1+\tau^*_T), \quad T = M, X \; . \tag{28}$$

Assuming similar price setting by foreign firms, we also have

$$P_{TF,t} = (1+\tau_T) S_t P^*_{TF,t}, \quad T = M, X \; , \tag{29}$$

where τ_T is the home import tariff rate.

2.5 Equilibrium

In equilibrium, all households make the same choice. Thus, aggregating over all households, $C_t = C_t(l), L_t = L_t(l), W_t = W_t(l)$. Also, since all households receive the same share of rents, profits and transfers, $RE_t = RE_t(l), PF_t = PF_t(l), TR_t = TR_t(l)$. Output of each sector equals demand at home and abroad, so that

$$Y_{T,t} = C_{TH,t} + C^*_{TH,t}, \quad T = M, X \; . \tag{30}$$

Foreign demand, $C^*_{TH,t}$, is determined by (10). The small home economy is assumed to have negligible effect on foreign prices, $P^*_{T,t}$. Total labor supply equals the sum of labor demand in the two sectors:

$$L_t = L_{M,t} + L_{X,t} \; . \tag{31}$$

For each sector, there is a fixed supply of capital specific to the sector. Letting a bar over the variable denote fixed supply, we have

$$K_{T,t} = \bar{K}_{T,t}, \quad T = M, X \; . \tag{32}$$

Tariff revenue is redistributed to households in the form of lump sum transfers. Thus total household transfers is

$$TR_t = \tau_M S_t P^*_{MF,t} C_{MF,t} + \tau_X S_t P^*_{XF,t} C_{XF,t} \,. \tag{33}$$

National product at home prices equals

$$NP_t = P_{MH,t} Y_{M,t} + P_{XH,t} Y_{X,t} + TR_t = W_t L_t (1 - AC_{W,t}) + RE_t + PF_t + TR_t \,. \tag{34}$$

Aggregating household budget constraints, noting that home bonds are not held abroad ($\int_0^1 B_t(l)dl = 0$), and using (34), we can express the national budget constraint as

$$S_t B^*_{t+1} = S_t (1 + R^*_{t-1})(1 - TC_{t-1}) B^*_t + NP_t - P_t C_t \,. \tag{35}$$

Following Laxton and Pesenti (2003), we assume that transaction costs are the following function of the real value of net foreign assets

$$TC_t = \phi_1 \frac{\exp(\phi_2 S_t B^*_{t+1} / P_t) - 1}{\exp(\phi_2 S_t B^*_{t+1} / P_t + 1} \,. \tag{36}$$

The current account is determined as

$$CA_t = S_t (B^*_{t+1} - B^*_t) \,. \tag{37}$$

We consider a range of monetary policies. The polar cases of pure fixed and flexible exchange rates have received considerable attention in the literature. These special regimes can be represented by the following assumptions

$$S_t = \overline{S} \,, \tag{38}$$

$$P_t = \overline{P} \,, \tag{39}$$

where the pure flexible exchange rate case is identified with a policy of fixing the price level (or maintaining a zero rate of inflation). We also explore a monetary policy regime that uses the interest rate as instrument and targets the price level. This policy regime is described by the following interest rate rule:

$$R_t = \overline{R} + \delta \log(P_t / \overline{P}), \quad \delta > 0 \,, \tag{40}$$

where $\overline{R}$ denotes the steady-state value of the interest rate and $\overline{P}$ is the target price level. This rule represents a flexible price level targeting policy. A stronger interest rate response (a larger value of δ) would keep the price level closer to the target. Indeed, the monetary policy rule (39) that fixes the price level (and lets the exchange rate float) can be obtained from (40) in the limit by letting $\delta \to \infty$.

3. Quantitative Analysis

3.1 Calibration

We calibrate the model for a small emerging economy that has higher tariffs initially than the large foreign economy. Parameterization of the baseline model is summarized in Table 1. We assume that home tariffs equal 20% while foreign tariffs equal 10% (i.e., $\tau_M = \tau_X = .2, \tau_M^* = \tau_X^* = .1$).[6] We choose the following shares for different consumption bundles in the initial steady state before trade liberalization (a bar over a variable denotes its initial steady-state value). Both goods are assumed to have equal share in aggregate consumption, so that $\overline{P}_X \overline{C}_X = \overline{P}_M \overline{C}_M = .5\overline{P}\overline{C}$. We also assume that imports (which equal exports in steady state) account for a quarter of aggregate expenditures, i.e., $\overline{P}_{MF} \overline{C}_{MF} + \overline{P}_{XF} \overline{C}_{XF} = \overline{S}(\overline{P}_{MH}^* \overline{C}_{MH}^* + \overline{P}_{XH}^* \overline{C}_{XH}^*) = .25\overline{P}\overline{C}$. This value accords with average long-run shares of imports and exports in GDP for all developing countries.[7] Given product differentiation, there is intraindustry trade for both goods. We assume that there is interindustry trade as well and the home country is a net importer (exporter) of

[6] The tariff rates tend to be higher for developing countries than for industrial countries. According to recent estimates by Anderson and Martin (2006), the average (import-weighted) tariff rates for developing and industrial countries were 10% and 3%, respectively. We assume higher rate to allow for additional restrictions arising from non-tariff barriers.
[7] The average share of imports in GDP for all developing countries over the 1990-2004 period is 26.1% and that of exports is 25.9% (source: WEO database).

good *M (X)*. Imports of *M* are assumed to be 80% of total imports while exports of *X* are assumed to be a similar percentage of total exports.[8] The labor share, $\overline{W}\overline{L}/\overline{P}\overline{C}$, is set equal to 0.6. We normalize the initial steady state values of consumption and the wage rate ($\overline{C},\overline{W}$) to equal one. We also set the initial values of all price indexes at home ($\overline{P},\overline{P}_M,\overline{P}_X,\overline{P}_{MH},\overline{P}_{MF},\overline{P}_{XH},\overline{P}_{XF}$) equal to one by normalization.[9] Given our assumed shares, these normalizations imply that $\chi_M = \chi_X = 0.5$, $\chi_{MF} = \chi_{XH} = 0.4$, $\chi_{MH} = \chi_{XF} = 0.1$ and $\overline{L} = 0.6$.

Letting a quarter represent a unit of time in the model, the discount factor (β) is assumed to be 0.99, which implies an estimate of the annualized real rate of interest equal to 4%. There is a wide range of estimates for other parameters of the utility function. For the baseline version, we choose a value of 0.5 for the intertemporal elasticity of substitution ($1/\rho$), and 0.25 for the elasticity of labor supply ($1/\mu$). Alternative values of these parameters are explored in our sensitivity analysis. Given the choice of values for $\rho,\mu,\overline{C},\overline{L}$, and of ε_L (as discussed below), the steady-state version of (23) is used to determine the value of ψ (the weight for the labor effort index in the utility function).

The substitution elasticity between the two traded goods (η) is set equal to 3.0. We choose a value of 6.0 for the elasticity of substitution between home and foreign bundles of each good (θ_M,θ_X), which is broadly consistent with recent estimates by Hertel et al. (2004).[10] Substitution elasticities for varieties of each product category

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[8] These assumptions imply that intraindustry trade accounts for about 40% of total trade for each good.
[9] Foreign price indexes, $\overline{P}_M^*,\overline{P}_X^*,\overline{P}_{MF}^*,\overline{P}_{XF}^*$, are also normalized to equal one. Equations (28) and (29) are used to determine the values of $\overline{S},\overline{P}_{MH}^*$ and $\overline{P}_{XH}^*$, and (10) to determine the values of $\chi_{MH}^*\overline{C}_M^*$ and $\chi_{XH}^*\overline{C}_X^*$.
[10] Their estimates of the elasticity vary across sectors and average to a value close to 6.0.

($\varepsilon_M, \varepsilon_X$) are assumed to equal 8.0. This value implies a mark up a little less than 15% and is within the range of various estimates for markups.[11] As the elasticity of substitution between home and foreign varieties and the markup (reflecting the degree of imperfect competition) could potentially play an important role in determining the effects of trade liberalization, we also consider variations of the baseline model that allow different values of these parameters. Although the home country is small, it still has monopoly power (because of producing differentiated goods) that depends on the elasticities of substitution between home and foreign varieties in the foreign market (θ^*_M, θ^*_X). We let these elasticities equal 12.0. This value leads to a reasonable value for Nash optimal tariff of less than 10%.

The substitution elasticity for labor services (ε_L) is assumed initially to also equal 8.0, which makes the markup in the labor market the same as that in the goods market. Later, we explore the sensitivity of results to different values of this elasticity. The elasticity of substitution between labor and capital (σ) is generally considered to be close to one, and we assume that this value equals 0.9.[12] We introduce labor intensity differences between the two goods and assume that good X (the net export of the home country) is labor intensive ($\alpha_X > \alpha_M$).[13]

Parameters of the adjustment cost functions (ω_P and ω_W) determine the degree of wage–price inertia. There are no reliable estimates for these parameters. We use a value

[11] Martins, Scarpetta and Pilat (1996), for example, estimate the average markup for manufacturing sectors in OECD countries at around 20%. Chari, Kehoe and McGrattan (2002) use a markup estimate of 11% based on US studies

[12] For the use of a similar value, see Jomini et al. (1991), for example.

[13] We let $\alpha_M = 1.25\alpha_X$ and determine α_M and α_X to make $\bar{L}_M$ and $\bar{L}_X$ consistent with the assumption that $\bar{L} = .6$.

of 800 for each parameter in the baseline case, which is within the range of recent estimates.[14] Alternative values of the parameters are considered in our sensitivity analysis. In the transaction cost function, values of both parameters (ϕ_1 and ϕ_2) are assumed to equal 0.01. This assumption implies a very slow convergence to a steady state with zero net foreign assets. Variations in this assumption make little difference to the results

3.2 Macroeconomic Adjustment

We first discuss the macroeconomic effects of trade liberalization under pure fixed and flexible exchange rate regimes. Trade liberalization takes the form of a unilateral reduction of home tariffs from 20% to 10%.[15] DYNARE program is used to obtain a deterministic steady-state solution to the nonlinear model before and after trade liberalization and derive the dynamic response of model variables to this policy.

Figure 1 shows the dynamic response of output, employment, consumption and the current account over 20 quarters to a decrease in home tariff rates by 0.1 in the baseline model under the two polar exchange rate regime.[16] The macroeconomic dynamics in this model arises from stickiness in wages and prices. To illustrate the influence of these nominal rigidities, the figure also displays time paths of the variables in a variant of the model where these rigidities are absent and wages and prices are fully flexible (these time paths are derived by setting $\omega_P = \omega_W = 0$ in the baseline model). In this variant, there is no transitional dynamics and the tariff cut causes all variables to

[14] Bayoumi, Laxton and Pesenti (2004), for example, use values of 1400 and 700 for the Euro area and the rest of the world, respectively, for the parameters of a variant of the adjustment cost functions used in this paper.
[15] Both τ_M and τ_X are reduced from 0.2 to 0.1, while τ_M^* and τ_X^* are kept equal to 0.1.
[16] Output is defined as $(P_{MH,t}Y_{M,t} + P_{XH,t}Y_{X,t})/P_t$. Quarter 1 represents the initial steady state and quarter two the first quarter after tariff reduction.

adjust to their new steady-state values in the same period. The response of these variables is very different in the presence of nominal rigidities for both exchange rate regimes.

In the case of sticky wages and prices and fixed exchange rates, the tariff cut lowers the price of foreign varieties relative to home varieties and shifts demand from domestic to imported goods. This shift leads to an initial decline in both output and employment. The output and employment response in this case is opposite to that in the model without any nominal rigidity. Also, consumption decreases less than output because of consumption smoothing considerations, and thus tariff reduction causes a temporary deterioration in the current account.

In contrast, home-currency depreciation under flexible exchange rates brings about an initial increase in output and employment as well as a current account surplus by stimulating foreign demand for domestic goods and dampening the shift in home demand from domestic to imported goods. In fact, the exchange rate overshoots its new equilibrium value and the initial expansion in output and employment is greater than that in the absence of nominal rigidities.

Figure 2 shows the 20-quarter response of the price level, the exchange rate and the interest rate to lower tariffs. Under fixed exchange rates, the interest rate does not change and the price level falls gradually to accommodate relative price changes induced by tariff cuts. In the case of flexible exchange rates, on the other hand, the price level is not allowed to adjust and the exchange rate initially jumps above its long-run value.[17] This response requires a sharp initial reduction in the interest rate.[18]

3.3 Welfare Effects

We next examine welfare effects of trade liberalization under different monetary policies. Welfare gains are measured by an equivalent-variation index, γ, which is defined as the constant amount (expressed as a fraction of steady-state consumption before trade liberalization) that needs to be given to households to make them indifferent between the initial steady state and the new state (including the transition period) after trade liberalization. This index is given by the following relation:

$$\sum_{s=0}^{\infty} \beta^s u[(1+\gamma)\overline{C}, \overline{L}] = \sum_{s=t_0}^{\infty} \beta^{s-t_0} u(C_s, L_s), \tag{41}$$

where $\{C_s, L_s\}_{s=t_0}^{\infty}$ is the sequence of consumption and labor supply after trade liberalization at time t_0, and $u(.)$ is defined in (18). The index γ measures the total welfare effect of tariff reduction and can be decomposed as

$$\gamma = \gamma_{TR} + \gamma_{SS}, \tag{42}$$

where γ_{TR} and γ_{SS} measure the transitional and steady-state welfare effects of trade liberalization. Letting a tilde denote a variable's steady-state value after trade liberalization, we calculate the steady-state index as

$$u[(1+\gamma_{SS})\overline{C}, \overline{L}] = u(\tilde{C}, \tilde{L}), \tag{43}$$

and use (42) to determine the transitional index residually.

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[17] The reason for the overshooting behavior of the exchange rate in response to tariff reduction is similar to that for the well-known Dornbusch (1976) result that under sticky prices, a permanent increase in the money supply causes the exchange rate to overshoot its equilibrium value.

[18] The interest rate, in fact falls to a level very close to zero. Note that a flexible exchange rate regime with a fixed price level would not be feasible if the adjustment requires the interest rate to fall below zero.

Table 2 displays the welfare effects of trade liberalization for the baseline model as well as two variations of this model. In this table, welfare indexes are multiplied by 100 to express these in percentage terms. For the baseline model, the table shows that lowering tariff rates by 10 percentage points leads to a steady-state welfare gain of about 0.4 percent of initial steady-state consumption. The transition process involves a loss which is larger under fixed than flexible exchange rates. However, even in the fixed exchange rate case, the loss is small and amounts to a little over one tenth of the steady-state gain. Thus our results suggest that accounting for macroeconomic adjustment makes only a small difference to the estimate of the welfare effect of trade liberalization.

The table also explores the sensitivity of the results to variations in the assumptions about the degree of competition in the goods markets. Trade models often assume traded goods to be more competitive than the baseline model. Variation 1 moves in this direction by raising the elasticity of substitution between home and foreign goods and lowering the markup for both goods. In this variation, $\theta_M = \theta_X = 9$ and $\varepsilon_M = \varepsilon_X = 11$. As would be expected, this variation leads to higher steady-state gains. Interestingly, while the transitional loss for flexible exchange rate decreases, that for fixed exchange rate increases. Variation 2 explores an asymmetric case where good M is less competitive while good X is more competitive than the baseline model. For this case, we let $\theta_M = 3$, $\theta_X = 9$, $\varepsilon_M = 5$, and $\varepsilon_X = 11$. The asymmetric case does not make much difference and produces only marginal changes in both the steady-state and transitional effects.

We next explore welfare effects of macroeconomic adjustment under interest rate rule (40). In this rule, parameter δ represents the monetary policy response to deviations from the price level target. Although different values of δ do not affect the new steady-state levels of variables, they influence the macroeconomic adjustment and thus can alter the transitional loss associated with tariff reduction. An interesting issue is whether a weaker interest rate response to the price level would improve or worsen welfare. Figure 3 shows the relation between the transitional loss ($100\gamma_{TR}$) and δ. As the figure shows, the transitional loss falls as δ decreases and becomes very small as δ gets close to zero.

The reason that the transitional loss increase in δ can be explained by the help of Figure 1. For a very large value of δ, macroeconomic response of real variables is very close to the response under pure flexible exchange rates shown in the figure. As δ decreases, the path of the variables moves towards the no-nominal-rigidities path in the figure. For very small values of δ, the interest rate rule gets close to duplicating the flexible wage-price equilibrium, and nearly eliminates the transitional loss.[19]

Although a weak monetary policy response to the price level helps reduce transitional losses caused by tariff cuts, two caveats need to be added. First, in a more general model, the optimal response would also depend on shocks other than trade policy changes. Second, our analysis assumes that the monetary policy can commit itself to any form of the rule. If this is not the case, a weak response to the price level may not be desirable because it could signal a lack of commitment to the price level target.

3.4 Sensitivity Analysis

We performed extensive sensitivity analysis to examine the robustness of our results to variations in values of key parameters. We first explored the effects of changes

[19] The equilibrium in the flexible wage-price case does not represent the socially optimal allocation because of the presence of distortions in the model. Transitional losses, however, arise largely because of departures from full flexibility of wages and prices.

in the values of ρ, μ and ε_L, which could potentially influence both short- and long-run effects of tariff reduction. We let ρ and μ vary from 2 to 5, and ε_L from 6 to 11. These variations have little effect on the steady-state welfare measure. The transitional loss remains small, but is affected differently by these variations under fixed and flexible exchange rates. For example, an increase in ρ or ε_L raises the transitional loss in the case of flexible but lowers it in the case of fixed exchange rates. In all cases, a decrease in δ under flexible price level targeting reduces the transitional loss, and this loss is virtually eliminated for very small values of δ.

We also explored the effect of changing the values of wage-price adjustment cost parameters (ω_W, ω_P) over a range from 200 to 1400. An increase in the values of these parameters increases wage-price stickiness and would be expected to increases the transitional loss associated with macroeconomic adjustment. Our analysis shows that the loss increases more rapidly under flexible than under fixed exchange rates. However, even at the upper end of the range of values for these parameters, the loss remains small under both regimes.

4. Conclusions

Trade liberalization confers long-run efficiency benefits, but it can also give rise to costly short-run macroeconomic adjustment. Although there is an extensive literature on measuring long-tem gains from trade liberalization, there is little or no work on estimating short-term costs of this policy. This paper provides estimates of these costs based on a framework that incorporates key features of international trade and macroeconomic models. The estimates are derived for a small economy that initially has higher trade restrictions in the form of tariffs than the rest of the world.

The paper finds that short-run costs of tariff reduction are higher under fixed than flexible exchange rates for plausible parameter values. In both exchange rate regimes, however, the short-run loss caused by tariff cuts is small relative to the long-run gain from this policy. Under fixed exchange rate, for example, the short-run loss is about one-tenth of the long-run gain in the baseline model. The paper also shows that macroeconomic adjustment costs of trade liberalization are not only small but also can be avoided by an appropriate monetary policy. Costly adjustment arises from nominal rigidities that impede adjustment of relative prices and cause real variables to temporarily depart from their long-run equilibrium values. A flexible targeting rule facilitates relative price adjustment by allowing the aggregate price level to deviate from its target value, and thus helps reduce adjustment costs.

The paper's estimates are based on a simple two-sector model. The basic results, however, are likely to hold for extensions of the model to higher dimensions (with more sectors) and variations that introduce nontraded goods and intermediate inputs. Following standard international trade models, the paper's model treats the capital stock as an exogenously determined endowment. Allowing capital to be determined endogenously via investment would represent a significant variation of the model. Exploring how macroeconomic adjustment cost of trade liberalization would be affected by such a variation would be an interesting topic for future research.

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Table 1. Baseline Model: Parameter Values and Normalizations

Shares	$\chi_M = \chi_X = 5.0, \chi_{MF} = \chi_{XH} = 0.4, \chi_{MH} = \chi_{XF} = 0.1$
Utility Parameters	$\rho = 2.0, \mu = 4.0, \psi = 6.75$
Elasticities of Substitution	$\eta = 3.0, \theta_M = \theta_X = 6.0, \varepsilon_M = \varepsilon_X = \varepsilon_L = 8.0$
Technology Parameters	$\sigma = .9, \alpha_M = .61, \alpha_X = .76$
Adjustment and Transaction Costs	$\omega_P = \omega_W = 800, \phi_1 = \phi_2 = 0.01$
Initial Steady-State Values	$\tau_M = \tau_X = .2, \tau_M^* = \tau_X^* = .1$, $\bar{C} = 1$, $\bar{L} = .6$, $\bar{S} = .833$ $\bar{W} = \bar{P} = \bar{P}_M = \bar{P}_X = \bar{P}_{MH} = \bar{P}_{MF} = \bar{P}_{XH} = \bar{P}_{XF} = 1$

Table 2. Welfare Effects of Trade Liberalization

	Total Effect (%)		Transitional Effect (%)		Steady-State
	Fixed ER	Flexible ER	Fixed ER	Flexible ER	Effect (%)
Baseline Model	0.32968	0.34065	-0.04676	-0.03575	0.37643
Variation 1	0.40151	0.44431	-0.05914	-0.01634	0.46065
Variation 2	0.30706	0.32515	-0.04140	-0.02332	0.34847

Note: $\theta_M = \theta_X = 9, \varepsilon_M = \varepsilon_X = 11$ for variation 1, and $\theta_M = 4, \theta_X = 9, \varepsilon_M = 6, \varepsilon_X = 11$ for varition 2

Figure 1. Dynamic Response of Real Variables to Trade Liberalization

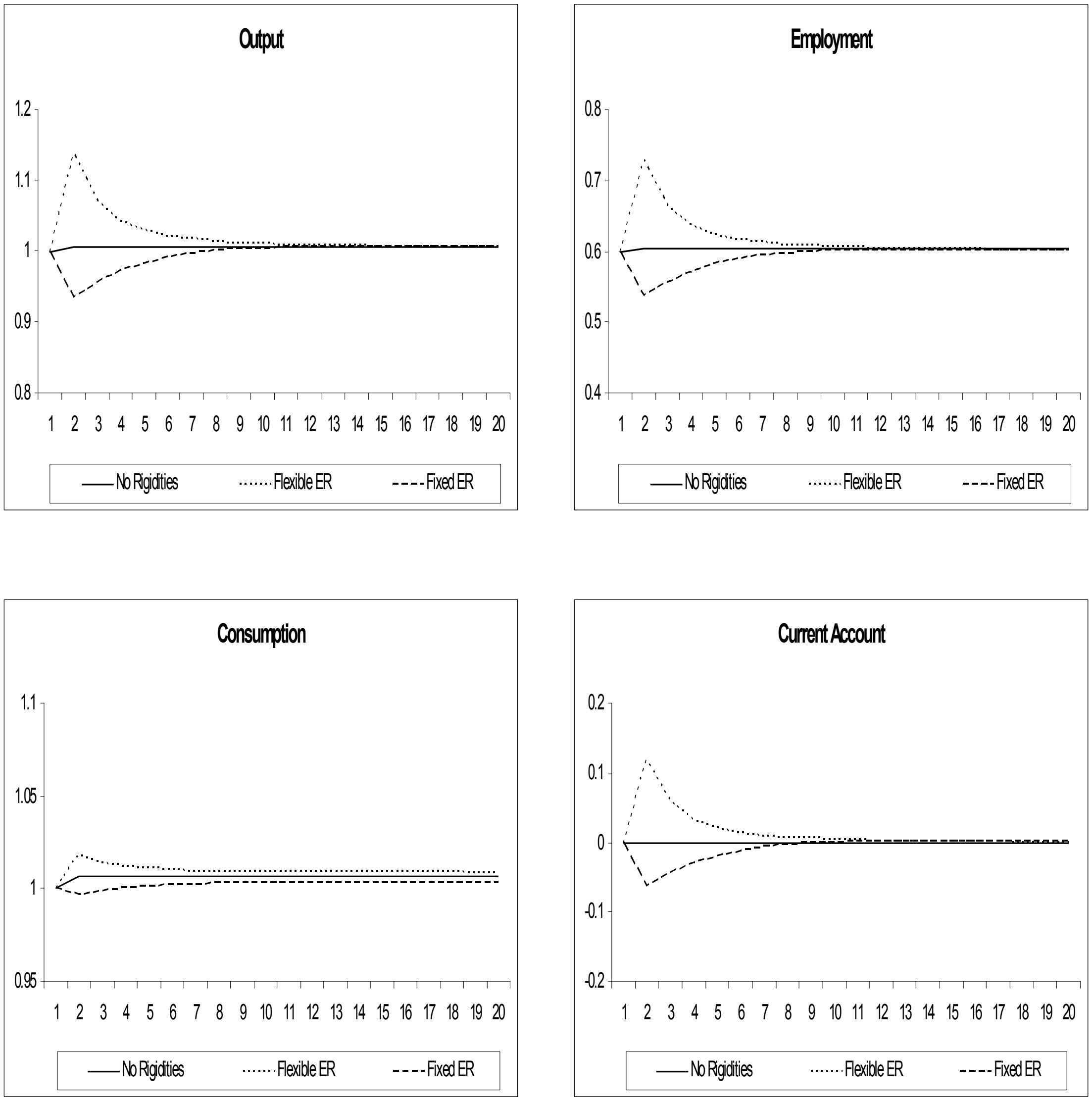
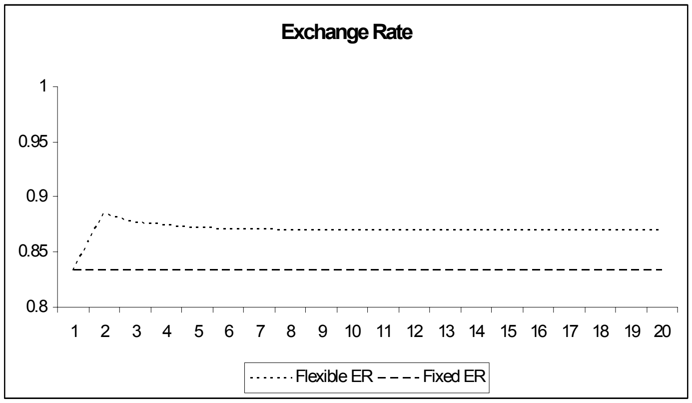
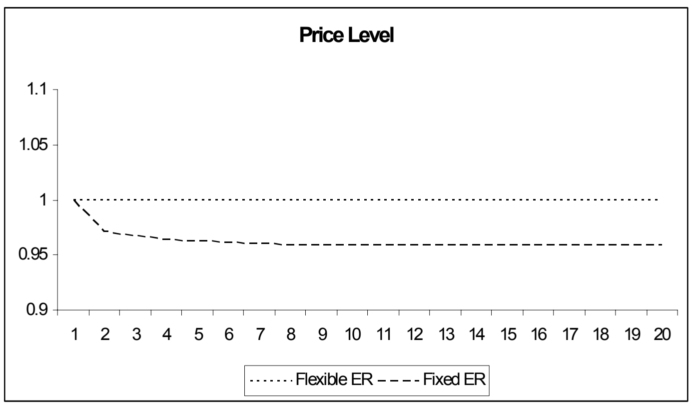


Figure 2. Dynamic Response of Nominal Variables to Trade Liberalization





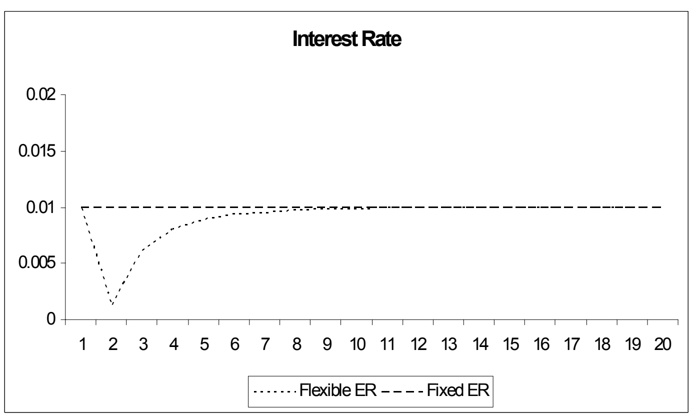


Figure 3. Transitional Loss under Different values of Delta