Trade Liberalization and Rising Wage Inequality in Latin America: Reconciliation with HOS Theory

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August 30, 2006

Abstract

The paper puts forward the hypothesis that the transitory effects of trade liberalization on wage inequality can differ from the long-run outcome. In cases where the HOS theory predicts a decline in wage inequality in the long run, a temporary rise can, nevertheless, occur due to (i) the asymmetries in the speed of contraction in the import sector and expansion in other sectors, and (ii) the capital-skill complementarity in production. The asymmetric contraction and expansion causes a transitory capital accumulation that boosts the relative and the real wage of skilled labor due to capital-skill complementarity. Although the long-run HOS fundamentals are, therefore, dominated in the short run by the *transient* effects arising due to capital-skill complementarity, the observed rise in wage inequality is nonetheless consistent with the HOS theory appropriately extended to a dynamic setting.

Keywords: Wage inequality; Trade reform; HOS; Capital-skill complementarity; Dynamic analysis

JEL Classification: F11; F13; F17; J31

1 Introduction

The trade liberalization in Latin America over the past few decades has been accompanied by a rise in wage inequality as well as real skilled wage (Robbins, 1996; Goldberg and Pavcnik, 2004).[1] The pattern of rising wage inequality is, however, contrary to what one would expect based on evidence in

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[1] Also see Harrison and Hanson (1999), Revenga and Montenegro (1995), and Feliciano (2001).

Krueger (1981), who finds that the import-competing sector is relatively skill intensive in developing countries. Thus, reconciling the rise in wage inequality in Latin America with the HOS theory has been an active and important area of research.

Wood (1997) reconciles the rising wage inequality in Latin America with the HOS theory based on the entry of large low-income exporters such as China, India, Bangladesh, Indonesia, and Pakistan in the 1980s and 90s. Their entry, Wood argues, has reduced the relative price of less skill intensive exports thereby eliminating the comparative advantage of middle-income countries, but then wage inequality would have risen not only in the countries that had liberalized their trade regimes but also in the *already* relatively open middle-income countries. The evidence on the latter implication of Wood's hypothesis is, however, inconclusive (see Wood, 1997). In addition, the wage inequality would have fallen in the low-income exporters: a prediction that is contradicted by the evidence of rising wage inequality in urban India since the late 1980s (see Kijima, forthcoming).

Another explanation for the rising wage inequality in the South is due to Feenstra and Hanson (1996). They show that a simultaneous rise in wage inequality in the North and the South occurs when international capital movement shifts the production of middle skill-intensive goods from the North to the South thereby raising the skill intensity of employment everywhere. Trefler and Zhu (2005) demonstrate that such a product shifting, which leads to a rise in wage inequality, can also result from technological catch-up in the South. By linking these two reasons for product shifting with trade liberalization, the recent literature on trade in intermediate inputs and fragmentation of production finally forges the connection between trade liberalization and wage inequality (see Jones, 2000). Jones (1999), however, shows that product shifting does not always lead to a rise in wage inequality. Xu (2003), therefore, addresses the question whether southern trade liberalization alone, without increased foreign investment or induced technical change, can cause southern wage inequality to rise. In his set up, imposition of a tariff has an effect on the terms of trade that causes not only some importables but also some exportables to become nontradables. If, on tariff reduction, more exportable-turned-nontradables than importable-turned-nontradables become tradable, wage inequality can rise. However, the effect is quantitatively very small in his simulations. Furthermore, as tariff is progressively reduced by a larger amount, beyond a point, the effect gets weaker, and finally the wage inequality starts falling.

Yet another line of research beginning with Harrison and Hanson (1999) argues that the recent reforms in Latin America involved deprotection of unskilled-labor-intensive *manufacturing* industries, *i.e.,* unskilled labor intensive compared to other manufacturing industries. While Harrison and Hanson (1999) provide such evidence for 1985 Mexican reforms, Pavcnik, Blom, Goldberg, and

Schady (2004) and Attanasio, Goldberg, and Pavcnik (2004) do so for Brazil and Colombia. Such reforms imply a decline in the relative price of unskilled-labor-intensive manufactured goods which in turn increases wage inequality as has been observed in Latin America. Robertson (2004) also uses a closely related argument to reconcile the rise in wage inequality in Mexico over 1988-94 with the HOS theory.[2] The conclusion in these papers, however, depends on the very strong (implicit) assumption that there is no resource reallocation across manufacturing and other sectors, *e.g.,* the primary export sector. In fact, for plausible differences in the sizes of various sectors in the Latin American countries, the deprotection of unskilled-labor-intensive import-competing manufacturing sector leads to a *decline* in the wage inequality in the long run. The reason is that the overall export sector turns out to be unskilled labor intensive relative to the import-competing sector *even when* import-competing manufacturing is unskilled labor intensive relative to export manufacturing.[3]

The debate on whether the rise in wage inequality in Latin America accords with the HOS theory is, therefore, far from settled. This paper reconciles the rising wage inequality in Latin America with the HOS theory by showing that the transitional effects of trade liberalization on wage inequality can differ from the long-run outcome predicted by the Stolper-Samuelson theorem−the outcome that we have in mind when referring to the empirical puzzle of rising wage inequality vis-a-vis the HOS theory. The short-run rise in wage inequality, despite a long-run decline, occurs due to (i) the asymmetries in the speed of contraction in the import sector and expansion in other sectors (in particular, in the export sector), and (ii) the capital-skill complementarity in production.

I consider a three-sector model with an import-competing sector, an export sector, and a non-traded sector. Each sector uses capital, imported intermediate inputs, and two types of labor: skilled and unskilled. The labor is freely mobile across sectors whereas capital is subject to adjustment costs. The imported machines and the nontraded goods, *e.g.,* construction, are combined to produce the capital goods. The structure of production accords with the findings of the NBER study on trade and employment in developing countries (Krueger, 1981) which have been corroborated by Bussolo, Mizala and Romaguera (2002). In particular, the skill intensity of labor is higher in the import-competing sector than the export sector. The import-competing sector is protected by a tariff on the imported consumer good. The government also levies tariffs on intermediate inputs and

[2]However, also see Robertson's critique by Esquivel and Rodriguez-Lopez (2003).

[3]Consider a three-sector model with two types of skilled labor (managers and skilled operatives as in Krueger, 1981) and one type of unskilled labor. The cost shares of managers, skilled operatives and unskilled labor in the primary export, export-manufacturing, and import-competing-manufacturing sectors are (.15, .225, .625), (.3, .4, .3), and (.225, .3375, .4375). The share of the primary exports in value added is .4, and that of other sectors is .3 each, and the supply of managers is a half of that of the skilled operatives. Therefore, the import-competing-manufacturing sector is unskilled labor intensive relative to export manufacturing *a la* Harrison and Hanson. However, as the implied cost shares of managers, skilled operatives and unskilled labor in the overall export sector are (.2143, .3, .4857), the overall export sector is unskilled labor intensive relative to the import-competing-manufacturing sector. In this case, deprotection of import-competing manufacturing causes wage inequality to *decline* in the long run.

machines.

In the benchmark calibrated model, pursuant to a tariff reform, wage inequality and real skilled wage decline in the long run. However, both experience a significant and sustained rise in the short and the medium run. The tariff cut on the consumer good causes the import-competing sector to contract and release capital in the long run, but the process is *slow* due to adjustment costs. On the other hand, tariff cuts on the intermediate inputs and machines, by increasing the (positive) gap between the marginal value product of capital and its rental, create a strong incentive for *immediate* capital accumulation in other sectors. These asymmetries in contraction and expansion lead to a short-run capital accumulation which boosts the relative and the real wage of skilled labor due to capital-skill complementarity. In particular, wage inequality rises for 10-20 years or longer for plausible parameter values. The rise is so prolonged because, in HOS framework, a small change in relative prices leads to a significant change in sectoral outputs and a substantial reallocation of capital. As Leamer (1995) notes, "the Heckscher-Ohlin clock surely doesn't click year by year. Decade by decade is a better estimate of speed."

This mechanism is fundamentally different from that in Feenstra and Hanson (1996), where capital accumulation is accompanied by higher wage inequality because foreign firms start up new industries that are relatively skilled labor intensive in the host country. This is simply reallocation toward more skilled-labor-intensive industries; the complementarity of capital and skilled labor in the production process does not figure in the causal forces that worsen wage inequality. In this paper, liberalization results in reallocation toward *less* skilled-labor-intensive industries. Nevertheless, the wage inequality rises temporarily because of the asymmetries in the speed of contraction and expansion in different sectors and the capital-skill complementarity in production. It is true that, as in Feenstra and Hanson, capital accumulation and wage inequality are positively correlated. But the underlying causal mechanisms are different. Finally, there is one other crucial difference. In my model, the rise in wage inequality is temporary. In contrast, in Feenstra and Hanson, it is permanent.

In the remaining portion of the paper, section 2 lays out and solves the model. Section 3 compares the model to the standard 2×2 model. In section 4, I calibrate the model to match the characteristics of a typical developing country in Latin America. Section 5 contains the results of numerical simulation of the calibrated model and their discussion. Section 6 concludes.

2 The Model

I consider a three-sector model with an import-competing sector, an export sector, and a nontraded sector. The economy is small and the capital account is closed. I index the variables and relevant characteristics of these sectors by m, x, and n respectively. This three sector set up is standard in development economics. For example, Buffie (2001) uses it to examine the dynamic effects of trade liberalization in developing countries on underemployment and underinvestment.

The nontraded sector is assumed to consist of services and construction. Production in every sector requires capital (sector specific in short run but mobile in the long run), imported intermediate inputs, unskilled labor, and skilled labor. The capital is produced by combining imported machines and nontraded goods as in Buffie (2001). The skilled wage (w_s) and unskilled wage (w_u) are determined competitively, and hence, are equal across all sectors. This contrasts with Buffie who has one type of labor with a rigid wage in the import-competing sector.

Most technology specifications used in development literature have a 'two-tiered' production function where 'domestic value added' combines with imported intermediate inputs to produce the output. To allow for capital-skill complementarity, I use a more general 'three-tiered' (nested CES) production function with sectoral cost functions of the form $C^i\left(P_z, c^2\left(w_u, c^3\left(w_s, r\right)\right)\right)$ where P_z is the price of the intermediate inputs, r is the rate of return on capital, and $c^2(.)$ and $c^3(.)$ are the subcost functions for the inner nests with substitution elasticities σ_2 and σ_3. The elasticity of substitution for the outermost nest is σ_1. The specification extends those in Buffie (2001) and Krusell, Ohanian, Rios-Rull, and Violante (2000). Although the specification still forces an identical elasticity of substitution (σ_2) between unskilled labor and skilled labor, and between unskilled labor and capital, it is not restrictive given the empirical estimates as Krusell *et al.* note.

The domestic prices of the imported consumer good (P_m), the exported good (P_x), the imported machines or capital (P_c), and the imported intermediate inputs (P_z) are

$$P_m = 1 + h, \tag{1a}$$

$$P_x = 1, \tag{1b}$$

$$P_c = 1 + g_c, \tag{1c}$$

$$P_z = 1 + g_z, \tag{1d}$$

where h, g_c, and g_z are ad-valorem tariffs, and all world prices have been normalized to 1.

The zero profit condition for the production of capital is

$$P_k = C^k(P_c, P_n), \tag{2}$$

where P_n is the price of the nontraded good, and P_k and $C^k(.)$ are the price and the unit cost function for capital production.

The zero profit conditions for the three sectors are

$$P_i = C^i(P_z, w_u, w_s, r_i), \qquad i = m,\ x,\ n, \tag{3a-3c}$$

where $C^i(.)$ is the unit cost function for sector i.

Technology and Factor Demands Shephard's lemma yields the derived demands for intermediate inputs (Z_i), unskilled labor (L_i^u), skilled labor (L_i^s), and capital (K_i) as

$$Z_i = C^i_{P_z} Q_i, \tag{4a-4c}$$

$$L_i^u = C^i_{w_u} Q_i, \tag{5a-5c}$$

$$L_i^s = C^i_{w_s} Q_i, \tag{6a-6c}$$

$$K_i = C^i_r Q_i, \tag{7a-7c}$$

where for sector i ($i = m,\ x,\ n$), Q_i is the output, and C^i_j is the unit derived demand for the input whose factor price is j ($j = P_z,\ w_u,\ w_s,\ r$).

Agent's Problem The compensated demand of the representative agent for good i is $D^i(\mathbf{P}, u)$ where $\mathbf{P} \equiv (P_m,\ P_x,\ P_n)$ is the vector of goods prices and u is the utility which depends goods prices and consumption spending (E) and is summarized by the indirect utility function $V(\mathbf{P}, E)$. I work with the time separable CES-CRRA utility function with elasticity of substitution β and elasticity of intertemporal substitution τ. I_i denotes the investment by the agent in the capital of sector i. The representative agent chooses E and I_i to maximize his lifetime utility

$$\int_0^\infty V(\mathbf{P},\ E) e^{-\rho t} dt, \tag{8}$$

subject to the laws of motion for the sectoral capital stocks

$$\dot{K}_i = I_i - \delta K_i, \qquad i = m,\ x,\ n, \tag{9a-9c}$$

and the (momentary) budget constraint

$$E + P_k \sum_{i=m,x,n} [I_i + \phi_i(I_i/K_i - \delta)K_i] = R(\mathbf{P}, P_z, K_m, K_x, K_n) + J, \tag{10}$$

where ρ is the time rate of preference; δ is the common depreciation rate capital; J is the net lump-sum transfer; and $R(.)$ is the revenue function that measures the value added at domestic prices and has the following properties: $\partial R/\partial P_i = Q_i$, $\partial R/\partial K_i = r_i$, and $\partial R/\partial P_z = -Z$, where $Z \equiv Z_m + Z_x + Z_n$ is the total demand of the imported intermediate inputs. The dependence of the revenue function $R\,(.)$ on the (fixed) supply of skilled and unskilled labor is suppressed. The terms involving ϕ_i capture adjustment costs firms incur when making investment. They are modeled here as the use of additional capital input so that net investment is smaller than the actual use of capital goods. The adjustment costs are assumed to be symmetric, non-negative, and convex. Such costs are needed to support sector-specific capital.

Government Budget Constraint The government uses the revenue raised from the tariffs on the consumer good, intermediate inputs, and machines to make lump-sum transfers. The government's budget constraint is

$$J = h\left[D^m(\mathbf{P}, u) - Q_m\right] + g_z Z + g_c C^k_{P_c} \sum_{i=m,x,n} \left[I_i + \phi_i(I_i/K_i - \delta)K_i\right], \tag{11}$$

where $C^k_{P_c}$ is the unit derived demand for the imported machines for the production of capital.

Market Clearing Conditions The market clearing conditions for the nontraded goods and the two types of labor are

$$Q_n = D^n(\mathbf{P}, u) + C^k_{P_n} \sum_{i=m,x,n} \left[I_i + \phi_i(I_i/K_i - \delta)K_i\right], \tag{12}$$

$$L^u = L^u_m + L^u_x + L^u_n, \tag{13a}$$

$$L^s = L^s_m + L^s_x + L^s_n, \tag{13b}$$

where in (12), $C^k_{P_n}$ is the unit derived demand for the nontraded good for the production of capital. Note that the supply of the unskilled and the skilled labor is fixed.

Solving the Model

To solve the model, first eliminate E from the indirect utility function using the agent's budget constraint (10). Then form the Hamiltonian for the agent's problem, and let π_i denote the multiplier associated with the law of motion for the capital of sector i. The maximization of the Hamiltonian with respect to the control variables (I_i) gives the first-order conditions

$$V_E P_k(1+\phi_i') = \pi_i, \qquad i = m, x, n. \tag{14a-14c}$$

The corresponding co-state equations are

$$\dot{\pi}_i = (\rho+\delta)\pi_i - V_E\left[r_i + P_k(\phi_i' I_i/K_i - \phi_i)\right], \quad i = m, x, n. \tag{15a-15c}$$

Steady State Equilibrium

In a steady state K_i and π_i are constant, and $\phi_i = \phi_i' = 0$. Thus, by equations (9a-9c), (14a-14c), and (15a-15c) gross investment just offsets the depreciation of capital

$$I_i = \delta K_i, \tag{16a-16c}$$

and in each sector the common (net) return on capital equals the rate of time preference so that

$$r = (\rho+\delta)P_k. \tag{17}$$

Using these results and replacing E by the expenditure function and substituting for J and I_i from (11) and (16a-16c), the agent's budget constraint and the market clearing condition for the nontraded goods can be expressed as

$$E = R - P_k\delta \sum_{i=m,x,n} K_i + g_z Z + h\left(D^m - Q_m\right) + g_c \delta C_{P_c}^k \sum_{i=m,x,n} K_i, \tag{10$'$}$$

$$Q_n = D^n + C_{P_n}^k \delta \sum_{i=m,x,n} K_i, \tag{12$'$}$$

where I have suppressed the arguments of E, R, and D^i for brevity.

The steady-state equilibrium is defined by equations (1a-1d), (2), (3a-3c), (4a-4c), (5a-5c), (6a-6c), (7a-7c), (10$'$), (12$'$), (13a-13b) and (17): 25 equations to solve for 25 unknowns P_i, P_c, P_z, P_k, r, w_u, w_s, Z_i, L_i^u, L_i^s, K_i, Q_i, and u as functions of L^u, L^s, and tariffs h, g_c, and g_z.

3 Steady State Analysis

There have been a number of generalizations of the Stolper-Samuelson theorem to higher dimensions (See Ethier, 1984, for a comprehensive survey of the HOS theory in higher dimensions.) The Stolper-Samuelson theorem in higher dimensions implies that a rise in the price of a good causes the reward of some factor to rise in terms of all other goods and to fall in terms of none and causes the reward of some other factor to fall in terms of each good provided that it is initially produced and that every factor that it employs is subsequently also employed elsewhere in the economy. Thus, using the terminology of Jones and Scheinkman (1977), every good is a 'friend' to some factor and an 'enemy' to some other. A partial converse holds for the even case, where every factor has at least one enemy. However, in higher dimensions, the relationship between factor rewards and good prices need not depend on the factor intensity rankings in a simple, intuitive manner as in the 2×2 case. Krueger's conclusion about the fall in wage inequality was based on this simple 2×2 dependence. In this paper, the use of nontradables in the production of capital goods further confounds matters. Therefore, to ascertain if Krueger's conclusion holds in this model, it is necessary to work directly with the zero profit conditions of the model to which I turn next.

Comparison with the Standard HOS Model

For determining the long-run effect of a tariff reform on factor rewards, it is sufficient to solve zero profit conditions as in the static HOS model. The changes in P_m, P_x, P_c, and P_z are obtained from (1a-1d). Then (17) and (2) are solved to give the changes in r and P_k as

$$\hat{r} = \hat{P}_k, \tag{18}$$

$$\hat{P}_k = (1-\alpha)\,\hat{P}_c + \alpha \hat{P}_n, \tag{19}$$

where $\alpha \equiv C^k_{P_n} P_n / C^k$ is the cost share of nontradables in the production of capital and a 'hat' over a variable denotes proportional change ($\hat{x} = dx/x$). Further, the zero profit conditions (3a-3c) give the following equations:

$$\hat{P}_m = \theta^m_Z \hat{P}_z + \theta^m_{L^u} \hat{w}_u + \theta^m_{L^s} \hat{w}_s + \theta^m_K \hat{r}, \tag{20}$$

$$\hat{P}_x = \theta^x_Z \hat{P}_z + \theta^x_{L^u} \hat{w}_u + \theta^x_{L^s} \hat{w}_s + \theta^x_K \hat{r}, \tag{21}$$

$$\hat{P}_n = \theta^n_Z \hat{P}_z + \theta^n_{L^u} \hat{w}_u + \theta^n_{L^s} \hat{w}_s + \theta^n_K \hat{r}, \tag{22}$$

where θ^i_j is the cost share of factor j in sector i. These equations describe the long-run factor and goods price relationships in the model.

I, now, investigate the long-run response of the skilled and unskilled wage to the price changes arising out of a tariff reform and compare it to the response in the standard HOS model with two factors and two goods implicitly relied upon in Krueger (1981). It is instructive to begin with the simplified case where capital is entirely imported and only the tariff on the consumer good is reduced. In this case, $\hat{P}_x = \hat{P}_c = \hat{P}_z = \alpha = 0$, and using (18-19) in (20-21) yields

$$\hat{P}_m = \theta^m_{L^u}\hat{w}_u + \theta^m_{L^s}\hat{w}_s, \tag{20*}$$

$$0 = \theta^x_{L^u}\hat{w}_u + \theta^x_{L^s}\hat{w}_s. \tag{21*}$$

Thus, the 2×2 Stolper-Samuelson link between goods prices and wages holds in the sense that only the relative skill intensity of labor in the two sectors producing traded goods ($\theta^m_{L^s}/\theta^m_{L^u} - \theta^x_{L^s}/\theta^x_{L^u}$) is relevant for the determination of the response of wages to a change in the price of these goods. More importantly, qualitative effects are the same as in the 2×2 case. If the import-competing sector is skill intensive in accordance with Krueger's findings, *i.e.*, $\theta^m_{L^s}/\theta^m_{L^u} - \theta^x_{L^s}/\theta^x_{L^u} > 0$ (henceforth called the Krueger scenario), the unskilled wage rises and the skilled wage falls. Thus, Krueger's assertion regarding the fall in wage inequality is correct in this simplified case. In addition, as the sum of the cost shares of labor is less than one, some simple algebra shows that the magnification effect of Jones (1965) is stronger (*i.e.,* the unskilled and skilled wages rise or fall more strongly) than in the usual 2×2 case.

The reason that the model with three sectors and four factors reduces to a 2×2 model is not hard to grasp. The factors relevant for the Stolper-Samuelson effect of the goods prices on factor prices are those that are not traded. The prices of traded factors are exogenously given for a small economy. Similarly, the sectors relevant for the Stolper-Samuelson link are those that produce traded goods and hence the zero profit condition for the nontraded sector is not relevant either. This leaves the zero profit conditions for the two traded goods which determine the changes in return to the two nontraded (non-accumulable) factors, the skilled and the unskilled labor.

Krueger's assertion continues to hold for a more general reform that also reduces the tariffs on intermediate inputs and machines with the obvious modification that now it the (relative) change in effective protection not just the change in relative prices that is relevant. Specifically, now (20-21) become

$$\hat{P}_m - \theta_Z^m \hat{P}_z - \theta_K^m \hat{P}_c = \theta_{L^u}^m \hat{w}_u + \theta_{L^s}^m \hat{w}_s, \quad (20^{**})$$

$$-\theta_Z^x \hat{P}_z - \theta_K^x \hat{P}_c = \theta_{L^u}^x \hat{w}_u + \theta_{L^s}^x \hat{w}_s, \quad (21^{**})$$

where the left side is the change in the effective protection of the industry which is clearly positive for the export sector (21^{**}). It is negative for the import-competing sector (20^{**}), if its effective protection falls in accordance with the intent of the trade reform. It is then easy to show that once again skilled labor loses and unskilled labor gains in the long run under the Krueger scenario. It must be emphasized that, theoretically, the skilled labor can gain and the unskilled labor lose in the long run despite a reduction in P_m if larger reductions in P_z and P_c cause the effective protection of the import-competing sector to rise relative to the export sector.

The presence of the nontraded good in the production of capital in the two manufacturing sectors in this paper alters the link between the rewards for two types of labor and the prices of traded goods (and imported factors) yet Krueger's intuition remains valid under very weak and reasonable assumptions. In this case (20-21) yield

$$\hat{P}_m - \theta_Z^m \hat{P}_z - (1-\alpha)\, \theta_K^m \hat{P}_c - \alpha_m \theta_K^m \hat{P}_n = \theta_{L^u}^m \hat{w}_u + \theta_{L^s}^m \hat{w}_s, \quad (20^{***})$$

$$-\theta_Z^x \hat{P}_z - (1-\alpha)\, \theta_K^x \hat{P}_c - \alpha_x \theta_K^x \hat{P}_n = \theta_{L^u}^x \hat{w}_u + \theta_{L^s}^x \hat{w}_s. \quad (21^{***})$$

It is quite unlikely that the terms involving P_n in (20^{***}) and (21^{***}) would be so large and of such different magnitudes as to overturn the (relative) change in the effective protection of the two sectors due to the tariff reform that is captured by the other terms on the left side of these equations. In particular, note that the P_n terms are multiplied by α and θ_K^i both of which are of the order of .5. Thus, presumably, the reform hurts the import-competing sector more than the export sector even after taking into account the endogenous changes in the price of capital through the change in P_n (*i.e.*, the left side of (20^{***}) is less than the left side of (21^{***})) and, therefore, wage inequality still falls under the Krueger scenario. If this were not so, in the long run the import-competing sector would expand whereas the export sector would shrink. In fact, in the calibrated model presented later in the paper, our presumption holds causing the wage inequality to fall across steady states and validate the 2×2 intuition.

4 Calibration of the Model

In order to analyze the response of the model to a tariff reform, it is necessary to turn to numerical simulation which requires choosing the values of the parameters and calibrating the model. It may be emphasized that while the numerical simulations require choosing particular values of every parameter in the model, there are only a few whose values affect the outcome one is usually interested in. I do sensitivity analysis for such parameters where data is lacking or shows wide variation.

Choice of Parameter Values

The time preference rate (ρ) discounts future utility and determines the steady state return on capital. Matching data from developing countries on both these counts poses a dilemma as former implies $\rho < .05$ while latter requires it to lie in the range .10-.15. I choose it to be .1 as in Haltiwanger and Singh (1999). The intertemporal elasticity of substitution (τ) is assigned a value of .5 which is consistent with the estimates for low- and middle-income countries in Ogaki, Ostry, and Reinhart (1996). In highly aggregated demand systems with 5-11 goods, estimated compensated own-price elasticities lie in the range .15-.6 (see Deaton and Muellbauer, 1980 and Blundell, Pashardes, and Weber, 1993). With only 3 goods in the model, scope of substitution is even more limited, and hence, I choose $\beta = .5$ that yields compensated own-price elasticities that are on the lower side of this range ($\varepsilon^c_m = .35$, $\varepsilon^c_x = .375$, $\varepsilon^c_n = .275$). The results are quite robust to the change in values of ρ, τ, and β.

The consumption share of the nontraded good (γ_n) is set at .45 to match the share of services in value added. It yields the share of value added in the nontraded sector (VA_n) of 46.64% and the share of services (VA_n minus the share of domestic input in capital) in value added of 38.23%$-$the latter is between the weighted average figures for the low- and the middle-income countries in 1994 as reported in the World Development Report 1996.

In 1996, the value added share of manufacturing was below 17% in 15 out of 24 countries in Latin America and the Caribbean (Statistical Yearbook of Latin America and the Caribbean, 1997). While the import-competing sector entirely consists of manufacturing, a part of the manufacturing also occurs in the export sector. Moreover, domestic manufactured capital goods appropriately belong to the nontraded sector as domestic input in capital production is entirely nontraded in the model. Accordingly, I vary the value added share of the import competing sector (VA_m) over .07-.10 as in Buffie (2001). The benchmark value of VA_m (.10) is chosen along with that of the consumption share of the import-competing good ($\gamma_m = .20$) to obtain the share of consumer goods in imports that is consistent with the empirical data for Latin America for 1980s.[4] The rise in wage inequality in short run, however, does not depend on the specific value of γ_m.

The short-run rise in wage inequality and real skilled wage, however, does depend on the costs incurred in adjusting the capital stock. Estimates for the q-elasticity of investment spending (Ω) for developed countries mostly lie between .2-2.3.[5] I choose the same value as used by Buffie (2001) and for the same reason: smaller values lead to a very slow speed of adjustment. In particular, I set $\Omega = 2$ which is also the estimate for Ω in Shafik (1990).

Development economists generally agree that the elasticity of substitution between domestic and imported capital (σ^k) and domestic factors and imported intermediate inputs (σ_1) is small. Following Buffie, σ^k is fixed at .25. For σ_1 also, I choose a value of .25 which is within the range of values used in Buffie. The results are very robust to the change in values of σ^k and σ_1.

A number of studies report evidence in favor of capital-skill complementarity.[6] As Krusell *et al.* (2000) document, the majority of the estimates for the elasticity of substitution between unskilled labor and capital lie between .5 and 3 whereas most estimates of the elasticity of substitution between skilled labor and capital are below 1.2, and as they note, "several are near zero." While the benchmark case sets the values of σ_2 and σ_3 at the middle of the range of their estimates (.6 and 1.75), more plausible scenarios with a much lower substitutability between skilled labor and capital that yield a much stronger rise in wage inequality in short run are explored in sensitivity analysis.

I set the tariff on intermediate inputs and capital at 45% and consumer good at 90%. These values are representative of the situation in Latin American countries prior to their liberalization of trade over the past few decades. The escalated structure of protection is in line with the strategy of import-substituting industrialization pursued in these countries.[7] With consumer goods accounting for slightly less than a fifth of imports, the average weighted tariff rate in the model is 53.06%. The weighted average tariffs in South and Central America in 1985 were 51% and 66% whereas the (weighted) percentages of import lines covered by nontariff barriers were 60% and 100% (Edwards, 1995). If early reformers, Chile, Mexico, and Bolivia, are excluded average tariffs for other Latin

[4] With $VA_m = .10$ and $\gamma_m = .20$, in the benchmark case, 17.90% of imports are final goods. Vera (2001) reports the share for Latin America to be 14% in 1980 and 18% in 1990. Figures reported in Kim and Peters (1993) for Mexico for 1985 are similar (16%-20%) after correction for the skewed classification (see fn. 41 in Kim and Peters.) The value of γ_m at .20 is consistent with empirical evidence: the consumption share of manufactures in middle-income countries is about .30 (see Chenery and Syrquin, 1989, and de la Cuesta, 1990) and a part of the manufactured consumer goods is produced in the export sector.

[5] For producer's durable equipment and non-residential construction estimates in Engle and Foley (1975) are .78-.87 and 2-2.3 respectively. Malkiel, Von Furstenberg, and Watson (1979) estimate q-elasticity ranging from zero to 1.85 for 12 two-digit SIC industries with half of the estimates exceeding 1. Abel and Blanchard's (1986) estimates are in the range .1-.3 whereas Hayashi (1982) comes up with the estimate of .85 when as in the model $I = \delta K$ and $\delta = .05$.

[6] For example, see Grilliches (1969), Berndt and Christensen (1974), Fallon and Layard (1975), and Brown and Christensen (1995).

[7] Specifically, as Vernengo (2004) reports, average tariff on capital and intermediate inputs was 50% of that on consumption goods in Brazil over 1960-1980. Berlinski (2000) provides similar evidence for Argentina.

American (and Caribbean) countries for 1985 rise to 57.7% (Edwards, 1995, Table 5-2). Once again this excludes protection through nontariff barriers, which covered on an average 32.5% of imports in 1985-87, that was virtually eliminated in many countries by 1992.

Structure of Production

The structure of production is arrived at by matching a number of facts about middle-income countries. In particular, the cost share of domestic inputs in the production of capital, α, is given a value of .5 which is the average of the range of estimates (.35-.65) in Buffie (2001) that are consistent with those in Dervis, de Melo and Robinson (1982) and with Taylor's (1990) illustrative SAM.

The *levels* of the cost shares of skilled and unskilled labor in various sectors are chosen to match the overall labor share of income. The share of labor in national income in the calibrated model is 46.37% –average of the values in Taylor (1990) and Elias (1992).[8] The implied ratio of the skilled wage income to the unskilled wage income of 66.08% is close to the average of 65.4% for Chile (1974), Costa Rica (1984), and Uruguay (1984) in Robbins (1996).

To determine the sectoral pattern of the skill intensity of labor and the distribution of labor, I first note that the nontradable production is much more labor intensive (1.36-1.57) than agriculture.[9] To account for the presence of less labor intensive manufacturing besides agriculture (*i.e.*, primary exports) in the export sector, I target the value of the ratio of the cost share of labor in the nontraded sector to the export sector to be the higher value of 1.57. In the calibrated model, the nontraded sector uses 57.2% more labor than the export sector.

Recent evidence also indicates that the nontradables production is more skill intensive than manufacturing. For example, Bussolo *et al.* (2002) find that, compared to 28 percent in manufacturing, 32 percent of labor in the services sector is skilled. As manufacturing sector consists of the more skill-intensive import-competing sector and the less skill intensive export manufacturing, I set the skill-intensity of production in the nontraded and the import-competing sectors to be equal.

Consistent with evidence in Krueger (1981), I set skilled labor's cost share in value added in the export sector to be the same as in the import-competing sector.[10] For the import-competing sector, it implies the share of labor in value added of 28% that is similar to 30% for the manufacturing sector for low- and middle-income countries in 1990 (World Development Report, 1990). Following Dervis,

[8] In Taylor's (1990) illustrative SAM, it is 42.1% whereas Elias's (1992) study of seven Latin American economies implies a value of 50%.

[9] The ratio of the cost share of labor in services to that in agriculture is 1.36 for Mexico (Serra-Puche, 1984) and 1.57 for Colombia (de Melo, 1977). Baer and Fonseca (1987) and Kwan and Paik (1995) provide similar estimates for Brazil and South Korea.

[10] In Table 5 of Krueger (1981), the average ratio of the direct labor coefficients per unit of domestic value added for HOS exportables to HOS importables for 11 countries for the skilled and managerial labor are .9 and 1.06.

de Melo, and Robinson export sector is made 1.72 times more intensive in the use of unskilled labor ($(\theta^x_{L^u}/\theta^x_{L^s})/(\theta^m_{L^u}/\theta^m_{L^s})$) than the import-competing sector which is consistent with Krueger (1981) and Bussolo *et al.* (2002).[11]

The cost share of intermediate inputs in the import-competing sector (θ^m_Z) at .25 is based on Taylor's (1990) illustrative SAM. For the export sector, θ^x_Z is set at .14, 40% higher than the share in agriculture in Nicaragua as the export sector includes manufacturing (also see Buffie, 2001). For the nontraded goods, not much information is available on the use of imported intermediate inputs (θ^n_Z) except that, it is small. However, as the results of the paper are contingent only on the overall dependence of domestic production on the imported intermediate inputs (*i.e.,* the ratio of the imported intermediate inputs to GDP) and not their sectoral usage, θ^n_Z is set at .07 to capture this overall dependence. It yields the share of intermediate inputs in imports and the share of exports (as trade is balanced) in GDP similar to that in data.

The exports are 16.13% of GDP in the calibrated model which matches the pre-reform levels of openness in Latin America. The exports were 17% of GDP in Chile in 1992 (Bussolo *et al.*, 2002, Table 2) and 13.7% in 1969-70 (Corbo and Meller, 1981). For Latin America and the Caribbean, Loser and Guerguil (1999) report exports to GDP ratio of 13.2% in 1980 and 15.1% in 1990. There is a strong dependence of the economy on the imported intermediate inputs and machines which together account for 82.1% of imports consistent with the 84% figure reported in Vera (2001) for Latin America over 1980-90. For capital goods, Vera (2001) reports a share of 24%. Whereas in case of Chile, Machine Equipment, which are primarily capital goods, accounted for 40% of the imports in 1992 (see Bussolo *et al.*) In the model, the share of machines in imports at 32.1% is their average. This implies the import share of intermediate inputs of 50% that is close to but lower than the 60% share in Vera (2001).

As a final check for internal consistency, the capital output ratio of 3.14 in the calibrated model is typical. It implies the share of replacement investment in GDP of 15.7%. This is below the average of gross investment to GDP ratio of 18.15% for Argentina, Brazil, Chile, Colombia, Mexico, Paraguay, and Uruguay over 1975-84: the difference being accounted for by the accumulation of capital.

The detailed foregoing calibration captures two crucial aspects of the structure of production that

[11] The average ratio of the direct labor coefficients per unit of domestic value added for HOS exportables to HOS importables for unskilled labor is 1.79 in Krueger (1981).

While data for the export and import-competing sectors are not available, Bussolo *et al.* (2002) provide data for Chile that implies that the primary sector is 2-3 times more intensive in the use of unskilled labor than manufacturing depending on whether informal workers are excluded or considered as unskilled. In light of the fact that the size of the primary export sector is much larger than export manufacturing, the implied relative skill intensity of the import-competing and export sectors is similar to the calibrated model.

are vital for the results of the paper: the strong dependence of the economy on imported intermediate inputs and capital and the higher skill intensity of the import-competing sector vis-a-vis the export sector. First one determines whether the reduction of tariff on intermediate inputs and capital can potentially generate a short-run capital accumulation and hence a short-run rise in wage inequality. While the second one affects the long-run outcome through the usual 2×2 mechanism.

The remaining calibration of the model is routine. The details are relegated to Appendix 1. Table 1 lists the resulting values of the cost shares and other parameters of the calibrated model. The salient features of the resulting steady state are summarized in Table 2.

Trade Reform and Domestic Prices

Burstein, Neves, and Rebelo (2003) document that distribution costs are very large for the average consumer good: they represent more than 40% of the retail price in the US and roughly 62% of the retail price in Argentina. On the contrary, the distribution margin on gross private fixed investment is only 16% in U.S. The respective averages for G-7 (US, UK, Germany, France, Japan, Canada and Italy) are 42.84% and 13.99%. Burstein *et al.* also note that the high margin in Argentina is likely to reflect the inefficiencies of the Argentine distribution system which consists of numerous small retailers and wholesalers: large supermarkets accounted only for 5.4% of the employment in the retail sector in 1999. If so, such high margins for consumer goods will also exist in other countries in Latin America. On the other hand, the (domestic) distribution costs of the imported inputs and capital goods are likely to be even lower than the domestic capital goods as, in many cases, they are directly imported by the end users.

There is also evidence that the trade in intermediate inputs and capital goods is liberalized before the trade in consumer goods. In case of Mexico, the share of the imports subject to licensing declined from 83 percent to 37 percent over 1983-85, primarily for the intermediate and some capital goods (see Peres Núñez, 1990 and Pérez Motta, 1989).[12] By encouraging short-run capital accumulation, such sequencing of trade reforms, however, exacerbates the short-run rise in wage inequality as discussed later.

Both the differences in distribution costs between consumer and investment goods and the earlier reduction of tariff on imported intermediate inputs and machines make capital goods cheaper pursuant to trade liberalization. Canonero and Werner (2002) report that capital goods became cheaper

[12] This is not surprising. Trade reforms are generally part of an overall program of economic reforms including macroeconomic stabilization and structural adjustment with economic growth being an important if not the dominant objective (*e.g.,* see Krueger, 1986, and Attanasio, Goldberberg, and Pavcnik, 2004). Given that a large part of imports of intermediate inputs and capital goods is non-competing (*i.e.,* with no, or may be little, domestic production), earlier liberalization of their imports aids economic growth without engendering too much resistance to the economic reforms.

in Mexico after liberalization.[13] This differential impact of trade reform on the end-user prices of the imported capital and intermediate inputs and the imported consumer goods can be captured in the model by a relatively larger than actual reduction of the tariff on the imported intermediate inputs and capital goods (compared to the consumer goods). Accordingly, in contrast to the actual proportional reduction of tariff on all goods in Latin America (see Goldberg and Pavcnik, 2004 and references cited therein), I consider a decrease in all tariffs by the same amount (45%). It results in a 50% difference in the pass-through to the end-users prices for the consumer goods and the imported capital goods and inputs which closely mirrors the difference in their distribution costs.[14]

5 Results of Numerical Simulations[15]

Let t_{WI} and t_{SW} respectively denote the duration for which wage inequality ($WI = w_s/w_u$) and real skilled wage (SW) rise in response to the reduction of tariffs. Further, define η_{WI} ($= -\widehat{WI}/\hat{h}$) to be the elasticity of wage inequality with respect to the tariff on the consumer good, and let η^m_{WI} and η^{20}_{WI} respectively denote the maximum and the 20-year elasticity of wage inequality. Similarly, define η_{SW}, η^m_{SW}, and η^{20}_{SW}. The time dated elasticities of wage inequality and real skilled wage for the benchmark case are shown in Figure 1. Notice the prolonged rise in wage inequality and real skilled wage prior to their decline in the long run. Also note that the decline in the long run accords with the 2×2 intuition as the import-competing sector is skill intensive relative to the export sector. The first line of Table 3, with $\Omega = 2$, shows that in the benchmark case wage inequality rises for 62.6 years with the maximum time-dated elasticity of .316. The rise in the skilled wage is even stronger; it rises for 84.8 years with the maximum elasticity of .681.

For the tariff reform that reduces the tariff on the consumer good from 90% to 45% and on the intermediate inputs and machines from 45% to zero, during transition, wage inequality will rise by

[13] This is not hard to understand as distribution costs appear to be the major determinant of the difference in pass-through between import and end-user prices: for example, the difference of 50% for consumer goods for industrialized countries (see Bacchetta and van Wincoop, 2003, Goldberg and Knetter, 1997, and Campa and Goldberg, 2002) closely mirrors 40-45% distribution margin. If so, in absence of any evidence of difference in pass-through to import prices between consumer and investment goods, the difference in pass-through to the end-user prices between them should reflect the difference in their distribution costs and make capital goods cheaper.

[14] Here I have implicitly assumed a 100% pass-through to the import prices and the decrease in all tariffs by same amount implies a 50% pass-through to the end-user prices for the consumer goods and a complete pass-through for the capital goods and intermediate inputs. The results are similar if one assumes extent of pass-through to import prices in accordance with empirical data. What is relevant is the difference in pass-through to end-user prices between consumer goods and intermediate inputs and capital.

The estimate of the long-run pass-through of exchange rates to import prices is .7-.8 for the Euro Area (see Campa, Goldberg, and González-Mínguez, 2005). The studies on exchange rate pass-through for emerging economies find that, contrary to the case of developed countries, pass-through is much quicker in these countries (see Choudhari, Faruqee, and Hakura, 2005 and Calvo and Mishkin, 2003).

[15] In order to characterize the transition path in terms of the observable variables, I eliminate the shadow prices in (15a-15c) using (14a-14c). I, then, linearize the resulting system of equations. To solve for the transition path, I use the procedure outlined in chapter 5 of Buffie (2001); the details are relegated to Appendix 2.

15.8% and real skilled wage will rise by 34.1%. These are large responses. Far stronger than in the numerical example in Xu (2003) where WI falls from 5.601 to 5.598 when the tariff on the consumer good is reduced from 60% to 30%, and further reduction of the tariff to zero causes it to rise to 5.600. The adjustment speed is slow but not unrealistic (see Leamer, 1995). In HOS framework, small changes in (relative) output prices lead to large changes in output and a substantial reallocation of capital across sectors.

The intuition for the short-run rise in wage inequality and real skilled wage is simple. To see this, it is useful to first consider the case where only the tariff on the consumer good is reduced. In this case, there is no rise in wage inequality or real skilled wage in short run (Table 4). The marginal (value) product of labor falls in the import-competing sector causing it to release labor which is absorbed in the expanding sectors as wages fall. This lowers the marginal product of capital (below its rental) in the import-competing sector causing it to contract and raises it in other sectors causing them to expand. Since the contracting import-competing sector is the most capital intensive sector (and the price of capital is unchanged), aggregate capital stock declines across steady states. More importantly, the movement of labor from the most capital intensive sector to other sectors during transition, due to the difference in its marginal product, causes a monotonic decline in the aggregate capital stock. Given the capital-skill complementarity, this immediately lowers the relative demand of skilled labor, and hence, wage inequality and real skilled wage also fall in the short run.

However, when the tariff on the machines and intermediate inputs is also reduced, the supply price of capital falls thereby lowering its rental. Further, due to the greater use of intermediate inputs and gross complementarity, the marginal product of capital now rises by a larger amount compared to a reform where P_m alone is reduced. These effects widen the (positive) gap between the marginal product of capital and its rental in the expanding sectors of the economy leading to a faster accumulation of capital in these sectors. On the other hand, they narrow the (negative) gap in the contracting, import-competing sector thereby reducing the opportunity cost of holding back capital and making it optimal to reduce the capital in the import-competing sector more slowly. Notwithstanding the fact that the contracting sector is capital intensive compared to the expanding sectors leading to a long-run decrease in the aggregate capital stock (Figure 2), these asymmetries in contraction and expansion lead to a short-run capital accumulation which boosts the relative and the real wage of skilled labor due to capital-skill complementarity.[16]

The above discussion highlights the crucial role played by the dependence of the economy on the imported capital and intermediate inputs and the reduction of tariffs on them in the short-run rise

[16] Recall, the domestic input in capital production is nontraded; therefore, the upward sloping path of P_n (Figure 2) creates an added incentive to accumulate capital early on during transition.

in wage inequality. In absence of reduction of tariffs on intermediate inputs and capital, there is no short-run rise in inequality. Furthermore, the greater the dependence of the economy on imported inputs and capital, the stronger is the short-run effect of decrease in the tariff on intermediate inputs and capital on wage inequality.

The predictions of the model also match empirical facts reported in the literature. As Figure 3 shows, the stock of imported capital rises in the short run. Kashahara (2004) reports an increase in machine replacement rate with the fall in the tariff rate for Chile. More importantly, the model produces an increasing ratio of the imported capital stock to GDP as found by Robbins (1996) in his study of trade liberalization in nine developing countries including Chile, Colombia, Costa Rica, Uruguay, and Argentina (see Figure 3, where $\kappa_{ImK/GDP}$ is the ratio of the imported capital stock to GDP divided by -*dh/h*.) Robbins also finds a positive correlation between the (increasing) ratio of the imported capital to GDP and the relative demand of skilled labor which he uses as an evidence for his hypothesis of 'skill enhancing trade'. However, this correlation may simply reflect capital-skill complementarity with short-run capital accumulation raising the relative demand of skilled labor as in the model.

The short-run rise in wage inequality and real skilled wage will occur in any developing country with structural characteristics as in Krueger (1981) and Bussolo *et al.* (2002). For example, consider the case of India. The model predicts a rise in wage inequality in India in accordance with the evidence in Kijima (forthcoming) and in contrast to the counterfactual prediction of Wood (1997).

Trefler and Zhu (2005) present empirical evidence showing that countries with a stronger increase in wage inequality have witnessed a larger increase in export growth. They use it to motivate their hypothesis of technological catch-up in South which causes product shifting and rise in wage inequality both in the North and the South. However, note that the same outcome occurs in the model of this paper. Between two identical economies reducing tariffs, the one that reduces tariffs more witnesses a larger increase in exports and a stronger rise in wage inequality.

Sensitivity Analysis

For several reasons, the rise in wage inequality pursuant to trade liberalization is likely to be much higher than in the benchmark case. First, recall that several estimates of the elasticity of substitution between skilled labor and capital (σ_3) are close to zero implying much stronger capital-skill complementarity. Second, adjustment costs are likely to be greater in contracting import-competing sector compared to the expanding, more flexible, and dynamic export sector (see Obstfeld and Rogoff, 1996). Such an asymmetry results in higher capital accumulation in the short run. Finally, the benchmark reform ignores significant reduction in nontariff barriers in Latin America (Edwards, 1995). I now turn to the implications of stronger capital-skill complementarity; the implications of the asymmetry in the adjustment costs are analyzed in the following subsection.[17]

Empirical evidence suggests that the elasticity of substitution between skilled labor and capital (σ_3) may be much lower and close to zero (see Krusell *et al.* 2000). When σ_3 is, accordingly, reduced from .6 to .4 and .2 (second and third rows of Table 3), the transitory rise in wage inequality gets much stronger. For $\sigma_3 = .2$, the maximum short-run rise in wage inequality (η^m_{WI}) is almost twice than in the benchmark case (.316 vs. .579, Table 3 left panel). The rise is even stronger in the immediate short run with η^{20}_{WI} rising by more than 100% (.201 vs. .483, Table 3 left panel). Even if the elasticity of substitution between unskilled labor and capital (σ_2) is reduced to the lower end of its range of estimates, wage inequality rises significantly in short run for values of σ_3 close to zero.

The short-run rise in wage inequality and real skilled wage occurs even when adjustment costs are much smaller. As seen from their 20-year values in Table 3, the initial response of η_{WI} and η_{SW} remains much the same when Ω rises from 2 to 5, although the duration of rise and the maximum time dated elasticities get smaller (see Table 3).[18]

Asymmetric Adjustment Costs

For analytical tractability, adjustment costs are usually assumed to be symmetric: they are same irrespective of an accumulation or decumulation of capital. Such an assumption, however, strains belief. It is hard to disagree that setting up a new factory by ordering new machines is much easier than adapting the machinery belonging to an unprofitable industry to a *new use*; latter was designed for or adapted to a specific use whereas the former is a putty clay yet to be molded.[19]

There can also be differences in adjustment costs across sectors. In many developing countries a significant portion of the import-competing production occurs in parastatal industries with powerful labor unions who can delay the closure of factories and reallocation of capital. Obstfeld and Rogoff (1996) recognize differences in adjustment costs across sectors. In a model with nontraded and traded goods, they note (p. 261), "Our assumption of differential adjustment speeds reflects the idea that the *outward oriented* tradables sector is relatively flexible and dynamic." (italics added)

During the transition, the capital stock declines monotonically in the import-competing sector

[17] Although the effect of the reduction of nontariff barriers on wage inequality can be assessed by assuming higher levels of initial tariffs, in the absence of accurate data on the tariff equivalents of nontariff barriers, this has not been done.

[18] The results of sensitivity analysis for a lower value of VA_m that strengthens the short-run response of η_{WI} and η_{SW} are available from author upon request.

[19] Tariff reform renders certain industries or sectors unviable and existing capital in these sectors has to be employed in *different* expanding sectors or industries. This should be distinguished from the sale of existing production facilities by individual firms to other firms within the same industry.

whereas it rises monotonically in the export and the nontraded sectors. One can, therefore, capture both types of asymmetries in the adjustment costs by allowing for a lower value of the q-elasticity of investment spending (*i.e.*, higher adjustment costs) in the import-competing sector that contracts and is less flexible in the sense of Obstfeld and Rogoff (1996). The results of this exercise are enumerated in Table 5 for $\Omega_x = \Omega_n = 5$ and $\Omega_m = 0.5$ and 2, where $\Omega_m = .5$ is well within the range of estimates in the literature referred to earlier.

For the benchmark values of the elasticities of substitution (row 1, Table 5), η_{WI}^{20} rises from .201 to .277 when $\Omega_m = 2$ and to .326 when $\Omega_m = .5$. Real skilled wage also shows a larger response with η_{SW}^{20} now being .576 and .631 respectively for $\Omega_m = 2$ and .5 compared to its value of .458 in the absence of the asymmetries in the adjustment costs. These asymmetries and strong capital-skill complementary combine to produce an even stronger rise in wage inequality. If σ_3 takes a low value of .2, η_{WI}^{20} could be as high as .682 (row 3, Table 5).

Qualitatively, these results are as expected. Higher adjustment costs in the import-competing sector cause a slower decrease in the capital stock in this sector whereas capital accumulation in other sectors proceeds as usual. With greater short-run capital accumulation, wage inequality and real skilled wage rise more strongly in the short run. As the adjustment in the import-competing sector occurs over a longer time period, duration of rise is also larger compared to the case when $\Omega_m = \Omega_x = \Omega_n = 5$. Quantitatively, these effects are significant. The asymmetry in adjustment costs noticeably aggravates the rise in wage inequality in the short run. The rise in real skilled wage is also much higher.

Other Scenarios

In the paper, there is a close link between the short-run rise in wage inequality and short-run capital accumulation. Thus, a reform that first reduces the tariff on intermediate inputs and machines will lead to a stronger short-run rise in wage inequality as it will encourage immediate, and hence, larger short-run capital accumulation.

The short-run capital accumulation is also closely related to the relative magnitude of decline in the tariff on the imported intermediate inputs and capital and the consumer good. The larger the decline in P_z and P_c compared to P_m, the stronger is the impetus to short-run capital accumulation and short-run rise in wage inequality.[20] Thus, if P_z and P_c were to decline only proportionally

[20] Note that a reform biased towards a greater reduction of tariff on intermediates and capital can potentially lead not only to the short- but also a long-run rise in wage inequality as pointed out in section 3. This is certainly the case when only the tariff on imported intermediates and capital is reduced. The results for this case are available from author upon request.

with P_m (in contrast to a more than proportional decline in the benchmark case) the rise in wage inequality will be weaker. Yet as results in Table 6 show, in the calibrated model, wage inequality rises during transition in 23 out of 24 cases.[21]

6 Conclusion

The paper puts forward the hypothesis that the transitory effects of trade liberalization on wage inequality can differ from the long-run outcome based on the HOS theory. In cases where the HOS theory predicts a decline in wage inequality in the long run, it can rise temporarily because of the asymmetries in the speed of contraction in the import sector relative to expansion in other sectors (notably the export sector) and the capital-skill complementarity in production. This happens in the calibrated model for a typical reform implemented in Latin America. Although the HOS fundamentals are, therefore, dominated in the short run by the *transient* effects arising due to capital-skill complementarity, the observed rise in wage inequality is, nevertheless, consistent with the HOS theory appropriately extended to a dynamic setting.

The mechanism that produces the rise in wage inequality is fundamentally different from that in Feenstra and Hanson (1996), wherein there is simply a reallocation toward more skilled-labor-intensive industries. In this paper, liberalization results in reallocation toward *less* skilled-labor intensive industries. Finally, there is the crucial difference. Here the effect on wage inequality is temporary; in Feenstra and Hanson, the effect is permanent.

The model is also consistent with other empirical facts regarding the effects of trade liberalization. In the model, the higher relative demand of skilled labor is accompanied by a higher ratio of the imported capital to GDP as found by Robbins (1996) for a number of countries in Latin America. The model also reproduces the positive empirical relationship between rate of export growth and extent of rise in wage inequality as noted in Trefler and Zhu (2005). The rise in wage inequality in low-income exporters, in accordance with the evidence in Kijima (forthcoming), is very plausible in the model contrary to the counterfactual prediction of Wood (1997).

The results of the paper are robust to the specification of structure of the economy. Similar results can be obtained in a more general model with a rigid wage in the formal (manufacturing) sector as is the case for many developing countries and the export sector split into a primary-export and an export-manufacturing sector. In the present model, real unskilled wage rises despite the

[21] If instead of the esclated structure of protection, the reader prefers to think of equal initial levels of tariffs as the benchmark case, the short-run rise in wage inequality is stronger than in Table 6. This is due to a greater short-run capital accumulation as a result of a larger fall in the price of imported intermediates and capital goods.

rise in wage inequality. It would be useful to extend the model to have the real unskilled wage fall in some part of the parameter space in accordance with the experience of some countries in Latin America.

Appendix 1 : Calibration

As I analyze the effect of small changes, I calibrate the model at the pre-reform level. Without loss of generality, I normalize $P_n = P_k = 1$ in the initial equilibrium, and hence, (17) becomes

$$r = \rho + \delta.$$

The market clearing condition for the nontraded good (12′) can now be written as

$$Q_n = D^n + \alpha\delta(K_x + K_m + K_n),$$

as $C^k_{P_n} = C^k_{P_n} P_n/P_k = C^k_{P_n} P_n/C^k = \alpha$. Further multiplication by P_n/R gives

$$VA_n = \left[\gamma_n \bar{E} + \alpha\delta(\bar{K}_m + \bar{K}_x + \bar{K}_n)\right](1 - \theta^n_Z), \tag{A1.1}$$

where $\bar{K}_i \equiv K_i/R$ and $\bar{E} \equiv E/R$.

With little algebra, one also obtains

$$\bar{K}_i \equiv \frac{K_i}{R} = \frac{1}{\rho+\delta}\frac{\theta^i_K}{(1-\theta^i_Z)}VA_i, \qquad i = m, x, n. \tag{A1.2a-2c}$$

In addition,

$$VA_m + VA_x + VA_n = 1, \tag{A1.3}$$

and the agent's and the government's budget constraints yield

$$\bar{E} = 1 - \delta\left[\bar{K}_m + \bar{K}_x + \bar{K}_n\right] + \bar{J}, \tag{A1.4}$$

$$\bar{J} = \frac{g_z}{1+g_z}\sum_{i=m,x,n}\frac{\theta^i_Z VA_i}{(1-\theta^i_Z)} + \frac{g_c}{1+g_c}\sum_{i=m,x,n}(1-\alpha)\,\delta K_i + \frac{h}{1+h}\left[\gamma_m\bar{E} - \frac{VA_m}{(1-\theta^m_Z)}\right]. \tag{A1.5}$$

To complete calibration, solve (A1.1), (A1.2a-2c), (A1.3-5) for $\bar{E}$, $\bar{J}$, $\bar{K}_i$, VA_x, and VA_n.

Appendix 2 : Solving for the Transition Path

The first step in the solution procedure involves solving for the changes across steady states.

Solving for the Steady State

We have already solved for the changes in P_m, P_x, P_n, P_z, P_c, P_k, r_i, w_u, and w_s. Now, totally differentiate factor demands (4a-4c), (5a-5c), (6a-6c), and (7a-7c) to obtain

$$\hat{Z}_i = \sigma^i_{ZL^u}\theta^i_{L^u}\hat{w}_u + \sigma^i_{ZL^s}\theta^i_{L^s}\hat{w}_s + \sigma^i_{ZZ}\theta^i_Z\hat{P}_z + \sigma^i_{ZK}\theta^i_K\hat{r} + \hat{Q}_i, \quad \text{(A2.1a-1c)}$$

$$\hat{L}^u_i = \sigma^i_{L^uL^u}\theta^i_{L^u}\hat{w}_u + \sigma^i_{L^uL^s}\theta^i_{L^s}\hat{w}_s + \sigma^i_{L^uZ}\theta^i_Z\hat{P}_z + \sigma^i_{L^uK}\theta^i_K\hat{r} + \hat{Q}_i, \quad \text{(A2.2a-2c)}$$

$$\hat{L}^s_i = \sigma^i_{L^sL^u}\theta^i_{L^u}\hat{w}_u + \sigma^i_{L^sL^s}\theta^i_{L^s}\hat{w}_s + \sigma^i_{L^sZ}\theta^i_Z\hat{P}_z + \sigma^i_{L^sK}\theta^i_K\hat{r} + \hat{Q}_i, \quad \text{(A2.3a-3c)}$$

$$\hat{K}_i = \sigma^i_{KL^u}\theta^i_{L^u}\hat{w}_u + \sigma^i_{KL^s}\theta^i_{L^s}\hat{w}_s + \sigma^i_{KZ}\theta^i_Z\hat{P}_z + \sigma^i_{KK}\theta^i_K\hat{r} + \hat{Q}_i, \quad \text{(A2.4a-4c)}$$

where $\sigma^i_{j_1j_2} \equiv C^i_{j_1j_2}C^i/(C^i_{j_1}C^i_{j_2})$ is the Allen-Uzawa elasticity of substitution in sector i between factors with rewards j_1 and j_2. Further, (13a-13b) give

$$0 = \frac{\theta^m_{L^u}VA_m}{1-\theta^m_Z}\hat{L}^u_m + \frac{\theta^x_{L^u}VA_x}{1-\theta^x_Z}\hat{L}^u_x + \frac{\theta^n_{L^u}VA_n}{1-\theta^n_Z}\hat{L}^u_n, \quad \text{(A2.5a)}$$

$$0 = \frac{\theta^m_{L^s}VA_m}{1-\theta^m_Z}\hat{L}^s_m \frac{\theta^x_{L^s}VA_x}{1-\theta^x_Z}\hat{L}^s_x + + \frac{\theta^n_{L^s}VA_n}{1-\theta^n_Z}\hat{L}^s_n, \quad \text{(A2.5b)}$$

where VA_i is the value added in sector i, and I have used the fact that $VA_i = (P_iQ_i - P_zZ_i)/R = P_iQ_i(1-\theta^i_Z)/R$. Next, totally differentiate (12′), the market clearing condition for the nontraded goods, divide both sides by Q_n, and simplify the resulting equation to obtain

$$\hat{Q}_n = \frac{\gamma_n\bar{E}(1-\theta^n_Z)}{VA_n}\left[du - \sum_{i=m,x,n}\varepsilon^c_{ni}\hat{P}_i\right] \quad \text{(A2.6)}$$
$$+ \sum_{i=m,x,n}\frac{\alpha\delta\theta^i_K VA_i\,(1-\theta^n_Z)}{(\delta+\rho)\,VA_n\,(1-\theta^i_Z)}\left[\sigma^k(1-\alpha)\left(\hat{P}_c - \hat{P}_n\right) + \hat{K}_i\right],$$

where γ_i is the consumption share of good i, $\varepsilon^c_{ij} \equiv -P_j\partial D^i/D^i\partial P_j$ is the compensated cross price elasticity of demand, and for CES-CRRA preferences, we have $\varepsilon^c_{ii} = \beta(1-\gamma_i)$, $\varepsilon^c_{ij} = -\beta\gamma_j$. In (A2.6) I have also normalized u such that the coefficient, $E_u/E = D^n_u/D^n$, of du is 1 at the initial steady state, and for the last term on right side, I have applied Cournot aggregation condition for the production of capital.

Now, I totally differentiate (10′), divide the resulting equation by E, and once again, simplify the resulting equation to get

$$\sum_{i=m,x,n}\gamma_i\hat{P}_i+du = \sum_{i=m,x,n}\frac{VA_i\hat{P}_i}{(1-\theta^i_Z)\bar{E}}+\sum_{i=m,x,n}\frac{\theta^i_Z VA_i\hat{P}_z}{(1-\theta^i_Z)\bar{E}}+\sum_{i=m,x,n}\frac{\theta^i_K VA_i\hat{K}_i}{(1-\theta^i_Z)\bar{E}} \tag{A2.7}$$
$$-\sum_{i=m,x,n}\frac{\delta\theta^i_K VA_i(\hat{P}_k+\hat{K}_i)}{(\delta+\rho)(1-\theta^i_Z)\bar{E}}+\sum_{i=m,x,n}\frac{\theta^i_Z VA_i\left(dg_z+g_z\hat{Z}_i\right)}{\left(1-\theta^i_Z\right)P_z\bar{E}}$$
$$+\left[\gamma_m-\frac{VA_m}{(1-\theta^m_Z)\bar{E}}\right]\hat{P}_m+\frac{h}{P_m}\left[\gamma_m\left(du-\sum_{i=m,x,n}\varepsilon^c_{mi}\hat{P}_i\right)-\frac{VA_m\hat{Q}_m}{(1-\theta^m_Z)\bar{E}}\right]$$
$$+\frac{1}{\bar{E}}\frac{\delta}{\delta+\rho}\sum_{i=m,x,n}\frac{(1-\alpha)\,\theta^i_K VA_i}{1-\theta^i_Z}\left\{\hat{P}_c+\frac{g_c}{P_c}\left[\sigma^k\alpha\left(\hat{P}_n-\hat{P}_c\right)+\hat{K}_i\right]\right\},$$

where $\bar{E}=E/R$ as defined earlier in Appendix 1. The terms on the right side on the first line are obtained by differentiating the revenue function with respect to the commodity prices, the price of the intermediate input, and the capital stocks respectively. The next term in (10′) gives the first term on the second line, and the following term in (A2.7) corresponds to the term $g_z Z$ in (10′). The terms on the third line are obtained from the term for the tariff on the consumer good. The last term results from the terms arising from the tariff on the imported machines. One can solve (A2.1a-1c), (A2.2a-2c), (A2.3a-3c), (A2.4a-4c), (A2.5a-A2.5b), (A2.6) and (A2.7) for $\hat{Z}_i$, $\hat{L}_i$, $\hat{L}^s_i$, $\hat{K}_i$, $\hat{Q}_i$, and du.

Solving for the Linearized System

As I want to express the dynamics of the economy in terms of K_i and I_i, I use (2) to substitute out P_k in (14a-14c), then differentiate them with respect to time, and eliminate $\dot{\pi}_i$ from the resulting equation using (15a-15c) to get

$$\left[\frac{V_{En}}{V_E}\dot{P}_n+\frac{V_{EE}}{V_E}\dot{E}+\frac{P_nC^k_{P_n}}{C^k}\frac{\dot{P}_n}{P_n}\right](1+\phi'_i)+\frac{\phi''_i}{K_i}\left[\dot{I}_i-\frac{I_i}{K_i}\dot{K}_i\right]=\rho+\delta+\phi_i+\phi'_i[\rho+\delta-\frac{I_i}{K_i}]-\frac{r_i}{P_k},$$

for $i=m,x,n$. Now, note the following facts: $-V_E/V_{EE}E=\tau$, $V_{E\,i}/V_{EE}D^i=\mu_i\tau-1$, the income elasticity of demand (μ_i) equals 1 for homothetic preferences, and that $E(\mathbf{P},u)$ on log differentiation gives $\dot{E}/E=\gamma_n\dot{P}_n/P_n+\dot{u}$. These facts can be use to obtain

$$\left[(\alpha-\gamma_n)\frac{\dot{P}_n}{P_n}-\frac{\dot{u}}{\tau}\right](1+\phi'_i)+\frac{\phi''_i}{K_i}\left[\dot{I}_i-\frac{I_i}{K_i}\dot{K}_i\right] = \rho+\delta+\phi_i \tag{A2.8a-8c}$$
$$+\phi'_i[\rho+\delta-\frac{I_i}{K_i}]-\frac{r_i}{P_k},$$

for $i = m, x, n$.

As I need the differential equations for $\dot{K}_i$ and $\dot{I}_i$, I need to find how P_n, u, r_i, and P_k depend on them. Let this dependence be denoted as follows:

$$\begin{aligned} P_n &= G^1(\mathbf{I}, \mathbf{K}),\ u = G^2(\mathbf{I}, \mathbf{K}),\ r_m = G^3(\mathbf{I}, \mathbf{K}), \\ r_x &= G^4(\mathbf{I}, \mathbf{K}),\ r_n = G^5(\mathbf{I}, \mathbf{K}),\ P_k = G^6(\mathbf{I}, \mathbf{K}), \end{aligned}$$

where $(\mathbf{I}, \mathbf{K}) \equiv (I_m, I_x, I_n, K_m, K_x, K_n)$. Using these to substitute for P_n, u, r_i, and P_k in (A2.8a-8c) and linearizing the left side of the resulting equations gives

$$\left(a_{11} + \frac{\phi''_m}{K_m}\right)\dot{I}_m + a_{12}\dot{I}_x + a_{13}\dot{I}_n = \rho + \delta + \phi_m + \phi'_m[\rho + \delta - \frac{I_m}{K_m}] - \frac{G^3}{G^6} - \left(a_{14} - \frac{I_m \phi''_m}{(K_m)^2}\right)(I_m - \delta K_m) - a_{15}(I_x - \delta K_x) - a_{16}(I_n - \delta K_n), \tag{A2.8a$'$}$$

$$a_{21}\dot{I}_m + \left(a_{22} + \frac{\phi''_x}{K_x}\right)\dot{I}_x + a_{23}\dot{I}_n = \rho + \delta + \phi_x + \phi'_x[\rho + \delta - \frac{I_x}{K_x}] - \frac{G^4}{G^6} - a_{24}(I_m - \delta K_m) - \left(a_{25} - \frac{I_x \phi''_x}{(K_x)^2}\right)(I_x - \delta K_x) - a_{26}(I_n - \delta K_n), \tag{A2.8b$'$}$$

$$a_{31}\dot{I}_m + a_{32}\dot{I}_x + \left(a_{33} + \frac{\phi''_n}{K_n}\right)\dot{I}_n = \rho + \delta + \phi_n + \phi'_n[\rho + \delta - \frac{I_n}{K_n}] - \frac{G^5}{G^6} - a_{34}(I_m - \delta K_m) - a_{35}(I_x - \delta K_x) - \left(a_{36} - \frac{I_n \phi''_n}{(K_n)^2}\right)(I_n - \delta K_n), \tag{A2.8c$'$}$$

where

$$a_{ij} \equiv \left[(\alpha - \gamma_n)\frac{G^1_j}{G^1} - \frac{G^2_j}{\tau}\right](1 + \phi'_i) \qquad i = 1,\ 2,\ 3;\ \ j = 1, .., 6,$$

and G^i_j is the derivative of G^i with respect to its j^{th} argument, and in the definition of a_{ij}, for compactness in notation, I have denoted $\{\phi''_m, \phi''_x, \phi''_n\}$ by $\{\phi''_1, \phi''_2, \phi''_3\}$. I will also follow same convention with respect to some other variables, *e.g.*, γ_i, I_i, and K_i when necessary.

Now, define

$$\begin{aligned} A &\equiv [a_{ij} + \Pi_{ij}] \qquad i,\ j = 1, 2, 3, \\ A^{-1} &\equiv [\bar{a}_{ij}] \qquad\qquad i,\ j = 1, 2, 3, \end{aligned}$$

where

$$\Pi_{ij} \equiv \frac{\phi_i''}{K_i} \quad \text{if} \quad i = j \quad \text{and} \quad \equiv 0 \;\; \text{otherwise.}$$

Then (A2.8a′-8c′) can be written in matrix form and solved using matrix inversion to obtain

$$\dot{I}_m = \sum_{j=1}^{3} \bar{a}_{1j} \left[\left(\rho + \delta + \phi_j\right) + \phi_j' \left((\rho + \delta) - \frac{I_j}{K_j} \right) - \frac{G^{2+j}}{G^6} \right] - \sum_{j=1}^{3} b_{1j} (I_j - \delta K_j), \qquad \text{(A2.8a}''\text{)}$$

$$\dot{I}_x = \sum_{j=1}^{3} \bar{a}_{2j} \left[\left(\rho + \delta + \phi_j\right) + \phi_j' \left((\rho + \delta) - \frac{I_j}{K_j} \right) - \frac{G^{2+j}}{G^6} \right] - \sum_{j=1}^{3} b_{2j} (I_j - \delta K_j), \qquad \text{(A2.8b}''\text{)}$$

$$\dot{I}_n = \sum_{j=1}^{3} \bar{a}_{3j} \left[\left(\rho + \delta + \phi_j\right) + \phi_j' \left((\rho + \delta) - \frac{I_j}{K_j} \right) - \frac{G^{2+j}}{G^6} \right] - \sum_{j=1}^{3} b_{3j} (I_j - \delta K_j), \qquad \text{(A2.8c}''\text{)}$$

where

$$b_{ij} \equiv \bar{a}_{i1} a_{1,3+j} + \bar{a}_{i2} a_{2,3+j} + \bar{a}_{i3} a_{3,3+j} - \Delta_{ij}, \qquad i,\; j = 1, 2, 3,$$

$$\Delta_{ij} \equiv \bar{a}_{ii} \frac{I_i \phi_i''}{(K_i)^2} \quad \text{if} \quad i = j \quad \text{and} \quad \equiv 0 \;\; \text{otherwise.}$$

Finally, linearizing (A2.8a″-8c″), I obtain

$$\begin{bmatrix} \dot{I}_m \\ \dot{I}_x \\ \dot{I}_n \end{bmatrix} = \begin{bmatrix} \frac{\rho \bar{a}_{11} \phi_m''}{K_m} + y_{11} - b_{11} & \frac{\rho \bar{a}_{12} \phi_x''}{K_x} + y_{12} - b_{12} & \frac{\rho \bar{a}_{13} \phi_n''}{Kn} + y_{13} - b_{13} \\ \frac{\rho \bar{a}_{21} \phi_m''}{K_m} + y_{21} - b_{21} & \frac{\rho \bar{a}_{22} \phi_x''}{K_x} + y_{22} - b_{22} & \frac{\rho \bar{a}_{23} \phi_n''}{K_n} + y_{23} - b_{23} \\ \frac{\rho \bar{a}_{31} \phi_m''}{K_m} + y_{31} - b_{31} & \frac{\rho \bar{a}_{32} \phi_x''}{K_x} + y_{32} - b_{32} & \frac{\rho \bar{a}_{33} \phi_n''}{K_n} + y_{33} - b_{33} \end{bmatrix} \begin{bmatrix} I_m - I_m^* \\ I_x - I_x^* \\ I_n - I_n^* \end{bmatrix} + \qquad \text{(A2.9)}$$

$$\begin{bmatrix} \delta b_{11} - \frac{\delta \rho \bar{a}_{11} \phi_m''}{K_m} + y_{14} & \delta b_{12} - \frac{\delta \rho \bar{a}_{12} \phi_x''}{K_x} + y_{15} & \delta b_{13} - \frac{\delta \rho \bar{a}_{13} \phi_n''}{K_n} + y_{16} \\ \delta b_{21} - \frac{\delta \rho \bar{a}_{21} \phi_m''}{K_m} + y_{24} & \delta b_{22} - \frac{\delta \rho \bar{a}_{22} \phi_x''}{K_x} + y_{25} & \delta b_{23} - \frac{\delta \rho \bar{a}_{23} \phi_n''}{K_n} + y_{26} \\ \delta b_{31} - \frac{\delta \rho \bar{a}_{31} \phi_m''}{K_m} + y_{34} & \delta b_{32} - \frac{\delta \rho \bar{a}_{32} \phi_x''}{K_x} + y_{35} & \delta b_{33} - \frac{\delta \rho \bar{a}_{33} \phi_n''}{K_n} + y_{36} \end{bmatrix} \begin{bmatrix} K_m - K_m^* \\ K_x - K_x^* \\ K_n - K_n^* \end{bmatrix}$$

where K_i^* and I_i^* ($=\delta K_i^*$) are capital stock and investment in the new steady state, and

$$y_{ij} \equiv -(\rho + \delta) \sum_{l=1}^{3} \bar{a}_{i,l} \left[\frac{G_j^{2+l}}{G^{2+l}} - \frac{G_j^6}{G^6} \right], \qquad i = 1, 2, 3; \quad j = 1, .., 6.$$

Equation (A2.9) on adding the equations for capital accumulation gives the linearized system. Finally $G^1(\mathbf{I}, \mathbf{K}) - G^6(\mathbf{I}, \mathbf{K})$ are deduced from the solutions of P_n, u, r_i, and P_k in terms of the investment and capital stocks of various sectors obtained by solving the quasi-static variant of the model.

Solving the Quasi-Static Variant

This time one begins by solving (1a-1d), (19), (20-22) for P_m, P_x, P_z, P_c, P_k, and r_i as functions of P_n, h, s, g_z, g_c, w_u, and w_s. Then I use factor demands (4a-4c), (5a-5c), (6a-6c), and (7a-7c) to solve for Z_i, L_i^u, L_i^s, and Q_i in terms of P_n, h, s, g_z, g_c, w_u, w_s, and K_i. Next, I solve the market clearing condition for the nontraded good and the market clearing condition for the two types of labor for P_n, w_u, and w_s in terms of h, s, g_z, g_c, K_i, I_i, and u. Finally the agent's budget constraint can be solved for u. The linearized versions of the market clearing condition for the nontraded good and the agent's budget constraint can be obtained from those derived while solving for the steady state (A2.6, A2.7) by replacing $\hat{K}_i$ by $\hat{I}_i$, except in the last term on the first line of (A2.7).

Acknowledgements

I am grateful to Gerhard Glomm, Michael Kaganovich and specially to Edward Buffie, a referee, and the editor for thoughtful comments. I am also thankful to the participants of the Midwest International Economics Group Meeting, Spring 2002 at Evanston, Illinois where I presented an earlier draft of this paper. All errors remaining are mine.

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Preference and Demand-Side Parameters
$\rho = .1, \ \beta = .5, \ \tau = .5$
$\gamma_m = .20, \ \gamma_x = .35, \ \gamma_n = .45$

Depreciation Rate and q-Elasticity of Investment Spending
$\delta = .05, \ \ \Omega = 2$

Structure of Production
$VA_m = .100, \ VA_x = .434, \ VA_n = .466, \ \alpha = .5$
$\theta^m_Z = .250, \ \theta^m_{L^u} = .117, \ \theta^m_{L^s} = .093, \ \theta^m_K = .540$
$\theta^x_Z = .140, \ \theta^x_{L^u} = .230, \ \theta^x_{L^s} = .107, \ \theta^x_K = .523$
$\theta^n_Z = .070, \ \theta^n_{L^u} = .294, \ \theta^n_{L^s} = .236, \ \theta^n_K = .400$

Elasticities of Substitution in Production of Final Goods
$\sigma_1 = .25, \ \sigma_2 = 1.75, \ \sigma_3 = .6$

Elasticities of Substitution in Production of Capital
$\sigma^k = .25$

Structure of Protection
$h = .9, \ g_z = .45, \ g_c = .45$

Table 1: Benchmark values of parameters for the calibrated model.

Capital-Output Ratio	3.14
Share of Replacement Investment in GDP	15.70%
Skilled Labor's Share in National Income	18.45%
Unskilled labor's Share in National Income	27.92%
Exports as percent of GDP	16.13%
Import Shares	
Consumer Goods	17.90%
Intermediate Inputs	49.97%
Capital	32.13%
Share of Services in Value Added	38.32%

Table 2: Steady state of the calibrated model.

$\sigma_1,\ \sigma_2,\ \sigma_3$	$\Omega = 2$						$\Omega = 5$					
	WI			SW			WI			SW		
	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{SW}	η^m_{SW}	η^{20}_{SW}	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{SW}	η^m_{SW}	η^{20}_{SW}
.25, 1.75, .6	62.6	.316	.201	84.8	.681	.458	34.7	.227	.202	50.2	.588	.486
.25, 1.75, .4	57.7	.428	.307	73.2	.759	.552	33.3	.335	.304	44.3	.659	.573
.25, 1.75, .2	47.1	.579	.483	57.3	.853	.707	28.4	.475	.457	35.6	.748	.700
.25, 1.25, .4	48.0	.299	.222	64.7	.675	.502	26.9	.212	.202	38.9	.579	.513
.25, 1.25, .2	41.8	.479	.404	52.0	.789	.656	24.9	.372	.365	32.3	.681	.644
.25, 0.75, .2	32.7	.284	.252	43.8	.663	.565	18.8	.180	.179	26.9	.551	.535
.25, 0.75, .1	29.5	.436	.411	37.3	.759	.692	17.9	.314	.311	23.5	.639	.634

Table 3: Simulation results for the benchmark calibration with sensitivity analysis for elasticities of substitution in production and q-elasticity of investment spending.

$\sigma_1,\ \sigma_2,\ \sigma_3$	$\Omega = 2$			$\Omega = 5$		
	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{WI}	η^m_{WI}	η^{20}_{WI}
.25, 1.75, .6	–	–	−.056	–	–	−.167
.25, 1.75, .4	–	–	−.069	–	–	−.203
.25, 1.75, .2	–	–	−.092	–	–	−.256
.25, 1.25, .4	–	–	−.092	–	–	−.230
.25, 1.25, .2	–	–	−.124	–	–	−.299
.25, 0.75, .2	–	–	−.168	–	–	−.367
.25, 0.75, .1	–	–	−.210	–	–	−.441

Table 4: Simulation results for wage inequality when only tariff on final consumer good is reduced.

$\sigma_1,\ \sigma_2,\ \sigma_3$	$\Omega_m = 2, \quad \Omega_x = \Omega_n = 5$						$\Omega_m = .5, \quad \Omega_x = \Omega_n = 5$					
	WI			SW			WI			SW		
	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{SW}	η^m_{SW}	η^{20}_{SW}	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{SW}	η^m_{SW}	η^{20}_{SW}
.25, 1.75, .6	51.4	.364	.277	67.4	.756	.576	77.5	.479	.326	93.8	.881	.631
.25, 1.75, .4	47.3	.496	.406	58.7	.839	.683	69.0	.624	.469	80.7	.970	.751
.25, 1.75, .2	39.1	.657	.595	46.7	.939	.841	55.7	.797	.682	63.5	1.08	.929
.25, 1.25, .4	39.8	.357	.303	52.1	.750	.623	60.0	.481	.366	72.4	.880	.692
.25, 1.25, .2	34.8	.553	.507	42.3	.873	.787	50.1	.695	.598	57.7	1.01	.878
.25, 0.75, .2	27.6	.345	.329	35.6	.740	.684	41.4	.487	.427	49.6	.885	.778
.25, 0.75, .1	25.0	.510	.502	30.6	.844	.812	36.1	.670	.626	41.7	.998	.928

Table 5: Simulation results with asymmetric adjustment costs.

$\sigma_1,\ \sigma_2,\ \sigma_3$	$\Omega_m = 2$			$\Omega_m = 5$			$\Omega_m = 2$			$\Omega_m = .5$		
	$\Omega_x = \Omega_n = 2$			$\Omega_x = \Omega_n = 5$			$\Omega_x = \Omega_n = 5$			$\Omega_x = \Omega_n = 5$		
	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{WI}	η^m_{WI}	η^{20}_{WI}	t_{WI}	η^m_{WI}	η^{20}_{WI}
.25, 1.75, .6	30.0	.076	.071	9.6	.034	.015	30.6	.128	.120	59.2	.239	.185
.25, 1.75, .4	29.8	.126	.119	11.7	.059	.055	29.1	.191	.182	52.9	.317	.265
.25, 1.75, .2	24.5	.198	.196	11.2	.120	.101	23.3	.275	.273	41.2	.412	.382
.25, 1.25, .4	23.4	.066	.065	7.5	.014	−.014	23.8	.120	.118	45.8	.238	.201
.25, 1.25, .2	22.4	.141	.140	9.47	.064	.033	21.6	.213	.212	38.2	.354	.327
.25, 0.75, .2	16.2	.044	.042	–	–	−.094	16.7	.101	.99	31.7	.237	.223
.25, 0.75, .1	16.0	.104	.100	6.5	.016	−.065	15.8	.178	.173	27.7	.335	.327

Table 6: Simulation results for wage inequality for proportional reduction in all tariffs.

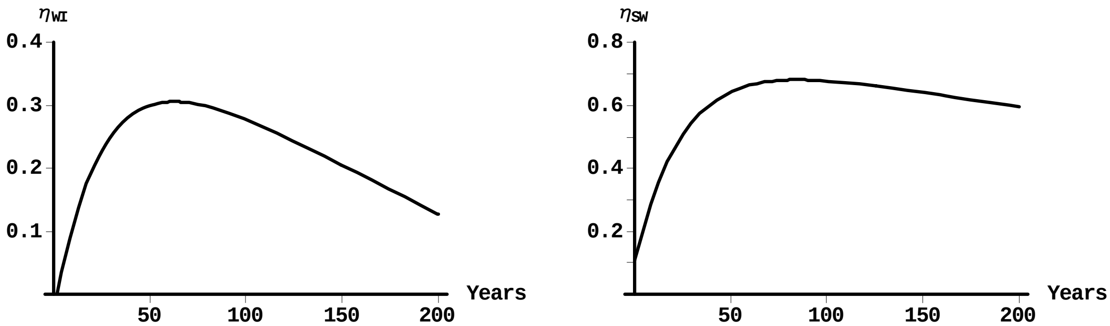

Figure 1: Time dated elasticities of wage inequality and real skilled wage (η_{WI} and η_{SW}) for the benchmark case.

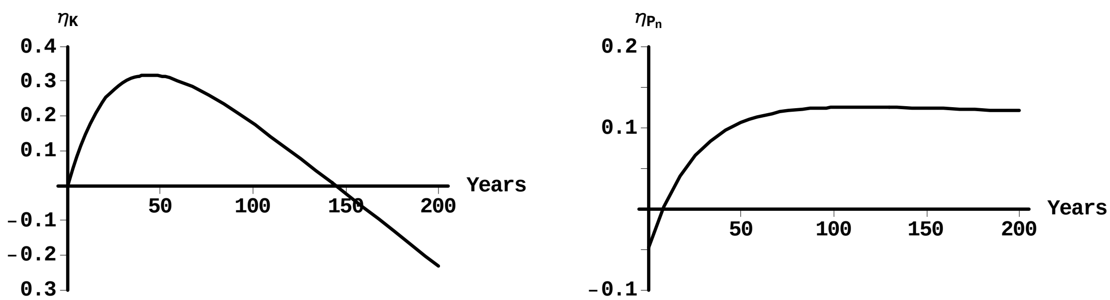

Figure 2: Time dated elasticities of aggregate capital stock and price of non-traded good (η_K and η_{P_n}) for the benchmark case.

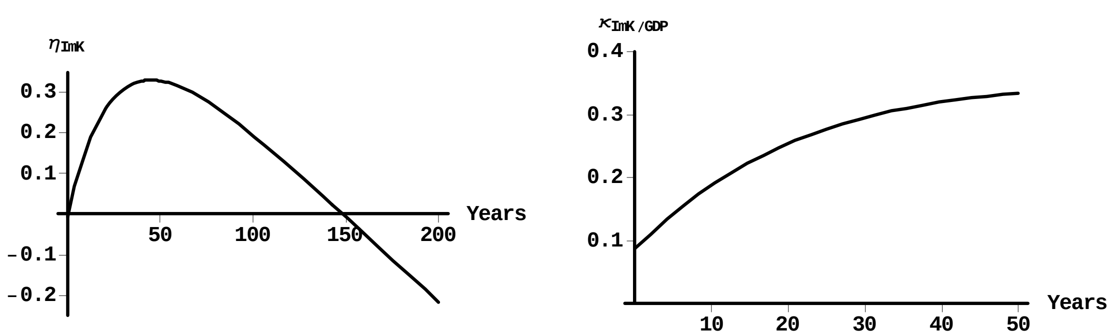

Figure 3: Response of imported capital and ratio of imported capital to GDP for the benchmark case.