Discussion Paper 108

Institute for Empirical Macroeconomics
Federal Reserve Bank of Minneapolis
250 Marquette Avenue
Minneapolis, Minnesota 55480-0291

March 1996

NAFTA and Mexican Development

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ABSTRACT

Using a calibrated growth model, the dynamic effects of NAFTA on Mexican development are studied. Two scenarios are analyzed. In the first, NAFTA is assumed to stimulate inflows of physical capital into Mexico. These inflows reduce the interest rate and raise the wage rates for both skilled and unskilled labor. The skilled wage rises more sharply, however, increasing the skill premium and rapidly accelerating the accumulation of human capital. In the second scenario, NAFTA is assumed to have the effect of fully integrating Mexico with the U.S. and Canada. Integration also reduces the interest rate and raises both wage rates in Mexico, but in this case the skill premium falls and human capital accumulation speeds up only a little. The welfare gains are large in both cases.

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The heated debate that preceeded the passage of the North American Free Trade Agreement stimulated a great deal of work assessing its likely effects. These studies covered a broad spectrum of topics, including NAFTA's impact on wage rates, regional employment, pollution, and output levels and locations of specific industries. All have been static, however: none has explicitly addressed NAFTA's dynamic effects on interest rates and wage rates in the integrating economies, and hence on the incentives for individuals in those economies to invest in physical and human capital.[1] Yet NAFTA's effects on capital accumulation, especially on decisions to acquire education and other forms of human capital, may, over the next couple of decades, be its most important consequences, altering in a substantial way the speed and character of North American development.

The current disparities between Mexico and its two northern neighbors in terms of educational attainment and physical capital per worker are very large, and the rates of return on both physical and human capital differ quite dramatically between the two regions. Hence there are strong incentives for capital to flow toward Mexico. These flows can be direct (at least for physical capital), in the form of U.S. and Canadian investment in Mexico, or indirect (for both human and physical capital), in the form of increased exports to Mexico of capital-intensive goods and services.

Two studies that incorporate capital flows into basically static models find that they are a very large source of potential welfare gains for Mexico. Brown, Deardorff, and Stern (1994) conclude that capital inflows will raise the welfare gains from NAFTA in Mexico from 2.2% of GDP to 5.4%, and Sobarzo (1994) that they will increase the gains from 3.7% to 10.9% of GDP. Since neither model is dynamic, however, these numbers have to taken as fairly crude estimates.

A simple dynamic general equilibrium model is used here to assess the impact

[1] For example, see the papers in Garber (1993) and Francois and Shiells (1994) and the survey in Kehoe and Kehoe (1994). A notable exception is Gonzalez (1993).

of NAFTA on the rates of capital accumulation in Mexico and it partners. The basic framework is a standard neoclassical growth model with constant returns to scale: there are no increasing returns, external effects, or learning by doing. The main distinguishing feature of the model is that skilled labor, unskilled labor, and physical capital are separate factors of production, with physical capital and unskilled labor assumed to be good substitutes, and skilled labor complementary to both of them. Two considerations motivate this choice.

First, both anecdotal evidence (events like the Luddite rebellion) and formal econometric studies support the notion that machines have, on the whole, been substitutes for unskilled labor and complements for skilled labor. (See Stokey (1994) for a more detailed discussion of the evidence.) Since one of the main effects of NAFTA will be to encourage inflows of physical capital into Mexico, it is important to recognize that those flows may have quite different effects on the wages of different types of labor.

Second, since a main goal of the analysis is to look at the effects of NAFTA on the incentives for Mexicans to acquire human capital, it is convenient to use a model in which the level of human capital and the returns to it correspond to easily observed values. Here the level is simply the proportion of the workforce that has attained a critical level of schooling, and the return is the average wage differential between those with and without that level of attainment. Although crude, this choice avoids the problems entailed in estimating and averaging rates of return to various kinds of human capital. In addition, to the extent that various kinds of human capital investment move together, looking at one index may not be too misleading.

Other aspects of the model are standard. Each country has an infinitely lived representative household, so heterogeneity within countries and demographic differences among them are ignored. Population growth and technological change are also ignored. The model does *not* display sustained growth, it converges to a steady state. Since the purpose here is to study transitional dynamics, however, this seems innocuous.

The best way to model the dynamic effects of NAFTA on Mexico is not obvious, since NAFTA does several things and it is not clear which are most important. One effect is to reinforce the 1988 Mexican policy opening its stock market to foreign private portfolio investment. That policy triggered very large inflows of foreign capital (see Kehoe, 1993, Figure 2), which seem likely to continue. These inflows will affect interest rates and wage rates for both skilled and unskilled labor, and through them the incentives for Mexicans to invest in both physical and human capital.

A second effect of NAFTA is to reduce trade barriers, stimulating flows of goods and services. Increased trade in goods, which in terms of its effect on factor returns is equivalent to allowing inflows of both physical and human capital into Mexico, will also affect returns to all factors of production, moving them in the direction indicated by factor price equalization. As we will see below, these changes are quite different from those produced by physical capital inflows alone, so this aspect of NAFTA has quite different consequences for Mexican investments in human and physical capital.

To capture these two aspects of NAFTA, two stylized regimes are studied here. Each focuses on one effect and carries it to an extreme.

In the first, Mexico is assumed to be small and to be completely open to capital inflows from abroad. At each date, capital flows into Mexico until the rate of return there is equal to the (constant) world interest rate. Mexican wage rates for skilled and unskilled labor, however, depend on the domestic supplies of those factors. This model is a good description of NAFTA if labor is fairly immobile across national boundaries *and* nontraded goods are important. Notice that *both* conditions are needed if domestic wages are to depend on domestic labor supplies. Capital inflows are shown to accelerate the pace of development very dramatically, by reducing the return on physical capital and increasing the skill premium, thereby stimulating a very rapid accumulation of human capital. Under this regime it takes only 8 years for Mexico to reach the current U.S. level of development, as measured by the proportion of the workforce that is skilled, rather than the 35 years it would require as a closed economy.

A two-country world is then studied, in which the countries are calibrated to represent Mexico and a combined U.S.-Canada aggregate (henceforth referred to as the U.S.), and the two are open in the sense of being fully integrated. This model is relevant if all factors are mobile across national boundaries, *or* if there are enough traded goods (intermediate or final) so that factor price equalization holds.

In an integrated North America, returns to all three factors of production depend on the aggregate stocks of those factors. Initially the returns are, roughly, a weighted average of the returns that prevail in the U.S. and Mexico at the time of integration, with weights equal to the relative population sizes. In Mexico integration reduces the return on physical capital, raises both wage rates, and reduces the skill premium. The effect on interest rates is much greater than the effect on the skill premium, however, and Mexican investment in human capital speeds up slightly. Under this scenario it takes 30 years for Mexico to reach the current U.S. level of development.

In the U.S., NAFTA has the opposite effect on factor returns, raising the interest rate, reducing both wage rates, and increasing the skill premium. All of the effects are quite modest, however, and U.S. investment in human capital is virtually unchanged. Total North American investment in physical capital also changes very little, although its national composition is significantly altered. Saving falls in Mexico and rises in the U.S., leading to a permanent change in the distribution of wealth. In the steady state under NAFTA, consumption and wealth in the U.S. permanently exceed consumption and wealth in Mexico, although the continent average is exactly what it would have been in either country under autarky.

In section I the basic model is described and calibrated, and development in

Mexico as a closed economy is analyzed. Section II treats the case where Mexico is open to capital inflows, and section III the case where Mexico and the U.S. operate as an integrated economy. The likely effects of NAFTA are discussed in section IV, and Section V concludes.

I. DEVELOPMENT IN MEXICO AS A CLOSED ECONOMY

In this section the model is set out and used to study development in Mexico as a closed economy.[2]

The production technology

Three factors of production—skilled labor N_s, unskilled labor N_u, and physical capital K—are used to produce homogeneous output. The single technology, which has constant returns to scale, produces goods that can be consumed, invested as physical capital, or used to convert unskilled labor into skilled labor. Labor provides two distinct productive services, which we may think of as physical effort ("brawn") and mental effort ("brains"). Unskilled labor provides both services, while skilled labor supplies only the latter. The aggregate production function is

$$F(K, N_s, N_u) = a_1 \left[\theta K^\nu + (1-\theta) N_u^\nu\right]^{\alpha/\nu} (N_s + eN_u)^{1-\alpha},$$

where $0 < a_1$ and $0 < \theta, \nu, \alpha, e < 1$. Physical capital and the physical effort of unskilled labor are combined into an aggregate by a CES technology with an elasticity of substitution, $1/(1-\nu)$, that exceeds unity. This physical aggregate is then combined with mental effort by a Cobb-Douglas technology, with share α for the physical aggregate. The parameter e is the relative efficiency of unskilled labor in supplying

[2]A more detailed discussion of the theoretical properties of the model is contained in Stokey (1994).

mental effort. On a per capita basis the technology is

$$f(k,z) = a_1 \left[\theta k^{\nu} + (1-\theta)(1-z)^{\nu}\right]^{\alpha/\nu} \left[z + e(1-z)\right]^{1-\alpha}, \tag{1}$$

where $k \equiv K/(N_u + N_z)$ is the capital stock per capita and $z \equiv N_z/(N_u + N_z)$ is the proportion of labor that is skilled.

This technology is a simple way of capturing the idea that physical capital is a good substitute for unskilled labor, and that skilled labor is complementary to both of the other inputs. The parameter e is important in determining the wage differential between skilled and unskilled labor. If $e = 0$, then skilled labor's share is fixed at $1-\alpha$, and the skilled wage is extremely high when the proportion of skilled labor is low. Hence $e > 0$ is needed to fit observed skill premia.

The elasticity parameter ν is important in determining the effects of foreign capital inflows on domestic wage rates. Suppose $e = 0$. If $\nu = 1$, so physical capital and unskilled labor are perfectly substitutable, then such inflows reduce the unskilled wage and raise the skilled wage, sharply increasing the skill premium. If $\nu = 0$, so the production function is Cobb-Douglas in all three inputs, then capital inflows raise both wage rates by the same proportion. Thus, for any $0 < \nu < 1$, i.e., for any elasticity exceeding unity, inflows of physical capital from abroad raise the return on domestic investment in human capital. A similar argument holds if $e > 0$.

The investment technologies and preferences

All investment in human capital is privately financed. For the representative household, the law of motion for z is

$$\dot{z}(t) = BI_z(t)^{\phi} - \eta z(t),$$

where $0 < B, \eta$ and $0 < \phi < 1$. The rate at which labor is transformed from unskilled to skilled depends on the quantity of goods invested, I_z. The parameter ϕ acts like an adjustment cost: a low value for ϕ means that rapid accumulation of human capital is very costly. Skilled labor depreciates—backslides into the unskilled category—at the rate η if there is no investment. Depreciation includes retirement.

There are no costs of adjustment for investment in physical capital and capital depreciates at the constant rate $\delta > 0$. The utility function is additively separable over time, with a constant rate of time preference $\rho > 0$, and a constant elasticity of intertemporal substitution $1/\sigma$.

Assume that households are the direct owners of physical capital, which they rent to firms in the (perfectly competitive) goods industry. Households also supply labor, inelastically. Let $\{r(t),\ w_z(t),$ and $w_u(t),\ t \geq 0\}$ be the return on capital, the skilled wage, and the unskilled wage. The household's problem is, given its initial stocks (k_0, z_0) and given the paths for factor prices, to choose paths for consumption and investment, $\{c(t),\ I_k(t),$ and $I_z(t),\ t \geq 0\}$ to maximize discounted utility:

$$\max \int_0^\infty e^{-\rho t} \frac{c(t)^{1-\sigma} - 1}{1-\sigma}\, dt \tag{2}$$

$$\text{s.t.}\quad \dot{k}(t) = I_k(t) - \delta k(t),$$

$$\dot{z}(t) = B I_z(t)^\phi - \eta z(t),$$

$$c(t) + I_k(t) + I_z(t) - r(t)k(t) - w_u(t)[1 - z(t)] - w_z(t)z(t) \leq 0, \quad \text{all } t.$$

Factors are paid their marginal products, so it follows from (1) that the returns on physical and human capital, the interest rate and the wage gap, are

$$r(t) = f_k\left[k\left(t\right), z\left(t\right)\right], \tag{3}$$

$$w_z(t) - w_u(t) = f_z\left[k\left(t\right), z\left(t\right)\right]. \tag{4}$$

In addition, since the production function is homogeneous of degree one, total factor payments exhaust output. These facts together with the conditions for the household's optimum characterize the economy's competitive equilibrium development path.

The dynamics will be discussed below, after the model has been calibrated. For now, note that the steady state (k_{ss}, z_{ss}) satisfies

$$f_k(k_{ss}, z_{ss}) = \rho + \delta, \tag{5}$$

$$f_z(k_{ss}, z_{ss}) = \frac{\rho + \eta}{\phi} \left(\frac{(\eta z_{ss})^{1-\phi}}{B} \right)^{1/\phi}. \tag{6}$$

The rate of return on physical capital offsets depreciation and discounting, and the return on human capital satisfies a similar condition, with an adjustment for concavity in the technology for human capital accumulation. As in the Cass-Koopmans model, properties of preferences other than the discount rate ρ do not affect the steady state levels of the state variables.

Calibration

To provide a quantitative picture of NAFTA's effects, the model must be calibrated. Some parameters can be taken from direct empirical estimates. The rest will be chosen to fit data on output, capital stocks, rates of return on capital, and wage ratios in the two countries, and on the speed of convergence. Here we will review the available evidence.

In most of the empirical literature on returns to human capital investments, human capital is assumed to be continuously variable, so there are no studies that closely match the specification adopted here. For an accumation technology of the form $\dot{h} = BI_h^{\phi} - \eta h$, Heckman (1975, Table 1) estimates the elasticity parameter ϕ to be 0.67. The value $\phi = .70$ will be used here.

Estimates of the elasticity of substitution between capital and unskilled labor, $1/(1-v)$, range from 0.14 to 2.92, although most exceed 0.90 and and several exceed 2.00 (Hammermesh, 1992). An elasticity of 2.00 will be used here, so $\nu = .50$. This elasticity is large enough to capture the intuition in the introduction, yet lies well within the range suggested by the data.

The evidence suggests a depreciation rates of 6% for physical capital (Stokey and Rebelo, 1993). For human capital, estimates of depreciation at the individual level range from 0.2% (Heckman, 1975) to 1.2% (Mincer, 1974) to 3-4% (Haley, 1976). If the average working lifetime is 35-40 years, then retirement adds 2.5-3.0% to this figure. Hence any number in the range from 2.5% to 7.0% seems defensible. The values $\delta = .06$ and $\eta = .07$ will be used here.

Using investment and output data for 1960-88 (Summers and Heston, 1991) and a depreciation rate of 6%, the capital-output ratios are calculated to be 2.5 for the U.S. and 2.4 for Mexico. Using more disaggregated data for investment and depreciation, Mexican capital per worker is estimated to be 25% of its U.S. level, implying a Mexican capital-output ratio of 1.6. The numbers in Garber and Weisbrod (1993, Table 8.2) suggest an even lower figure. In 1988, GDP per worker in Mexico was about 40% of its U.S. level.

Capital's share in GDP in the U.S. is 30%, so the rate of return on capital is about $.30/2.4 = 12.5\%$. In Mexico, the real rate of return on bank loans, which is a major source of private capital, was 28.2% for the period 1988-1990 (Garber and Weisbrod, 1993, Table 8.3). Notice that if capital's share is also 30% in Mexico, then the implied capital-output ratio is 1.1.[3]

In the U.S. in 1985, 19.5% of the adult population had completed college, 12.7% had 1-3 years of college, 38.4% had completed high school, and 29.4% had not completed high school. In Mexico, the corresponding figures were 4.0%, 2.9%, 2.8%, and 90.3%. Of the lattermost group, 7.7% had some high school and 82.6% had a

[3]Mexican data distinguish only between wage and salary income and an aggregate of capital income and proprietors' income. Since proprietors' income is a large fraction of the total, a direct measure of capital's share is not available.

primary education or less (Barro and Lee, 1993). Ignoring differences between the composition of the adult population and the labor force, if a skilled worker is defined to be one with at least a high school education, then in 1985 the proportion of skilled labor was about 71% in the U.S. and 10% in Mexico. In the U.S., that proportion had apparently leveled off, while in Mexico it was still rising rapidly. Thus, the initial proportions of skilled labor for the two economies will be set at $z_{us} = 0.71$ and $z_{mex} = 0.15$.

In the U.S. over the period 1963-1989, the wages of college graduates, college dropouts, and high school dropouts relative to high school graduates were 1.44, 1.15, and 0.75 (Murphy and Welch, 1993, p. 296). Weighting by the population proportions above, we find that the ratio of the skilled wage to the unskilled wage is 1.53. For Mexico in 1963, the wage rates of college graduates, college dropouts, high school graduates, high school dropouts, and those with a primary school education or less, relative to the economy-wide average, were 6.82, 3.44, 2.30, 1.74, and 0.84 (Elias, 1992, Table 15). Weighting by the population proportions above, the ratio of the skilled to the unskilled wage would have been 4.90 in 1985 if the wage structure had not changed. If the relative wages of the highly educated fell over that period, as the educational attainment of the workforce improved, then that figure is too high.

The calibrated model

The model here was calibrated to fit as many of these facts as possible, at least roughly, with the U.S. lying a little below the steady state. The parameter values are

$$a_1 = 1.00, \quad \alpha = 0.37, \quad \nu = 0.50, \quad \theta = 0.50, \quad e = 0.30, \quad \delta = 0.06,$$

$$\phi = 0.70, \quad B = 0.22, \quad \eta = 0.07, \quad \rho = 0.04, \quad \sigma = 2.5.$$

The resulting steady state values are

$$z = 0.81, \ \frac{k}{y} = 3.1, \ \frac{w_z}{w_u} = 1.4, \quad r = 0.10,$$

$$\frac{c}{y} = 0.74, \ \ \frac{I_k}{y} = 0.19, \ \ \frac{I_z}{y} = 0.08,$$

$$R_1 = -0.32, \quad R_2 = -0.046,$$

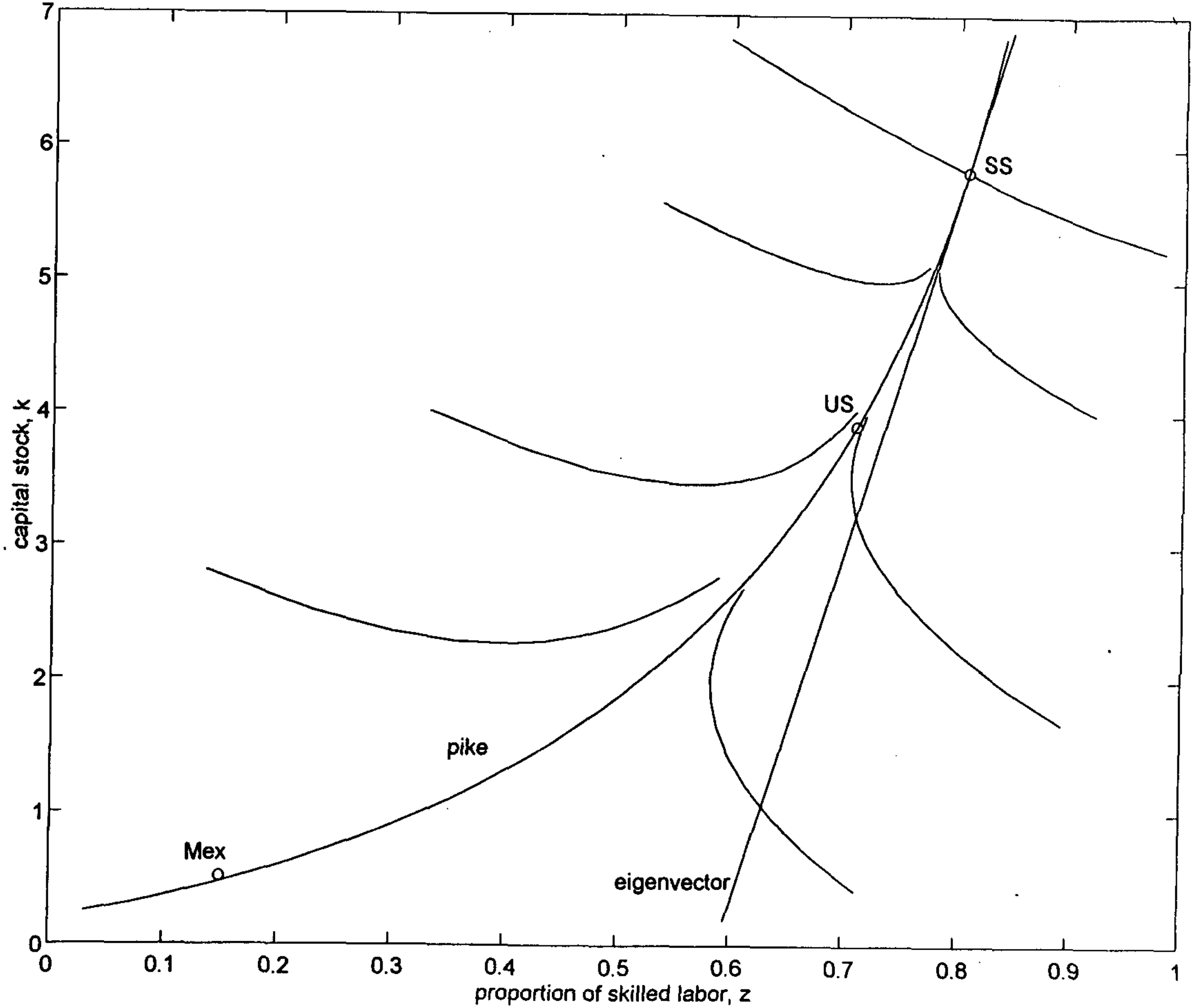
where the R_i's are the stable roots. The parameters ϕ, ν, δ and η are set at values suggested by direct estimates. The rate of time preference, ρ, is chosen to make the steady state interest rate 10%. Barro and Sala-i-Martin (1992) conclude on the basis of cross-state and cross-country data that the overall speed of adjustment, R_2, is about 2% per year. The intertemporal elasticity, $1/\sigma$, which is a major determinant of this speed, is set at the low end of the commonly accepted range. The resulting adjustment speed is still too high, but a lower value for $1/\sigma$ seems implausible. The other parameters are chosen to fit initial conditions for the U.S. and Mexico.

A global approximation was calculated,[4] and the resulting phase diagram in $z-k$ space is displayed in Figure 1. The system converges to the steady state from any initial conditions, and in general the transition paths have have two components. If there is an initial imbalance in the capital stocks, new investment is tilted toward the stock in relatively short supply. This type of adjustment is very rapid, with a half-life of 2.2 years. If the stocks are in balance, in the sense that their rates of return are equal, then there is substantial investment in both types of capital, and both stocks grow. This trajectory is labelled as the pike in Figure 1, and along it the composition of total investment maintains equality in the rates of return. This type of adjustment is much slower, with a half-life of 15.1 years.

Since transitions from off the pike are very rapid, initial conditions for the U.S. and Mexico will be assumed to lie on the pike, as shown in Figure 1, at the points

[4]The method developed in Mulligan (1992) was used for all of the simulations.

Figure 1


SS
US
Mex
pike
eigenvector
capital stock, k
proportion of skilled labor, z
0
1
2
3
4
5
6
7
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

where the proportions of skilled labor match the values calculated above. At these points, we have

	z	y	k/y	wz	wu	wz/wu	r	rk/y
U.S.	.71	1.6	2.4	1.3	.82	1.5	.12	.29 .
Mex.	.15	.76	.63	1.2	.54	2.2	.25	.16

The remaining model parameters were chosen so that these initial conditions would match as closely as possible the values suggested by the data. Although all the parameters affect all the variables, their impact is very asymmetric. Roughly speaking, α and θ control capital's share, a_1 affects the capital-output ratio, and B and e affect the proportion of skilled labor and the ratio of the skilled wage to the unskilled.

For the U.S., the capital-output ratio, the wage ratio, the rate of return on capital, and capital's share all fit the data quite well. The calculated ratio between output per worker in Mexico and the U.S. is .47, which is not far from the 1988 value reported above. For Mexico, the capital-output ratio is below even the lowest of the rather wide range of values suggested by various data. The evidence on the wage ratio in Mexico is very imprecise, so the calculated value of 2.2 may not be too far off. Notice that the skilled wage is similar in the two countries, while the unskilled wage in Mexico is only about 2/3 of its U.S. level. Thus, it is unskilled Mexicans, not skilled ones, who have an incentive to migrate. The model's prediction for the return on capital in Mexico agrees closely with the value reported above, but capital's share is probably too small.

Mexican development as a closed economy

Figure 2 displays the first 40 years of the transition path for an economy starting at the point *Mex* in Figure 1. Since the model parameters were calibrated to current U.S. data, all variables are measured relative to their levels at the point *US* in Figure 1.

Figure 2a: capital and skill

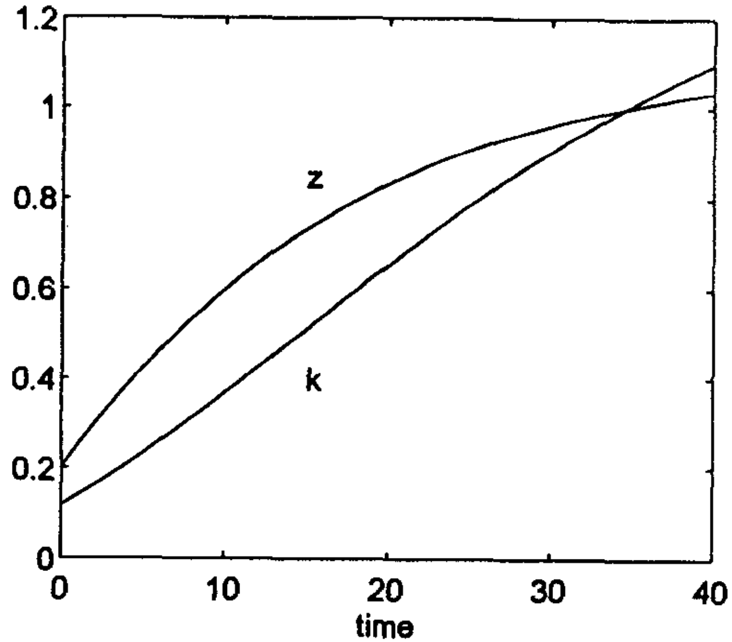


Figure 2b: output and consumption

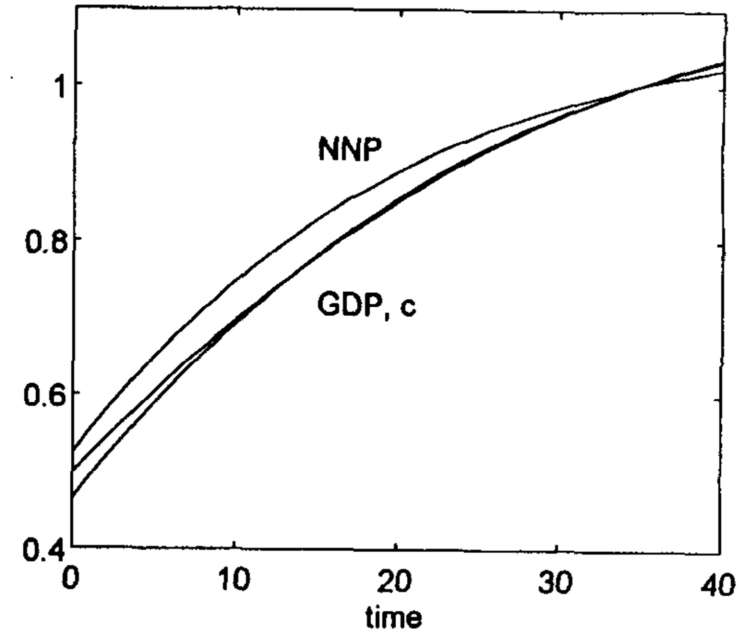


Figure 2c: wage rates

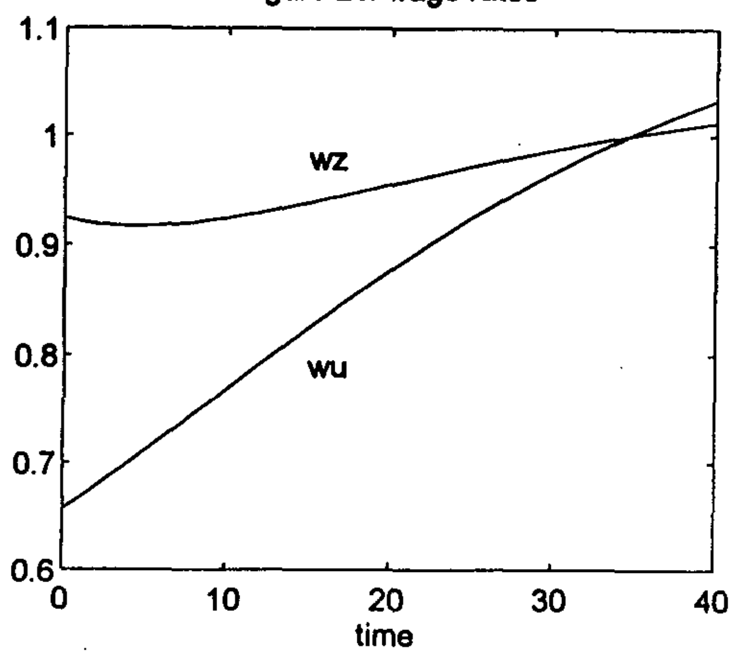
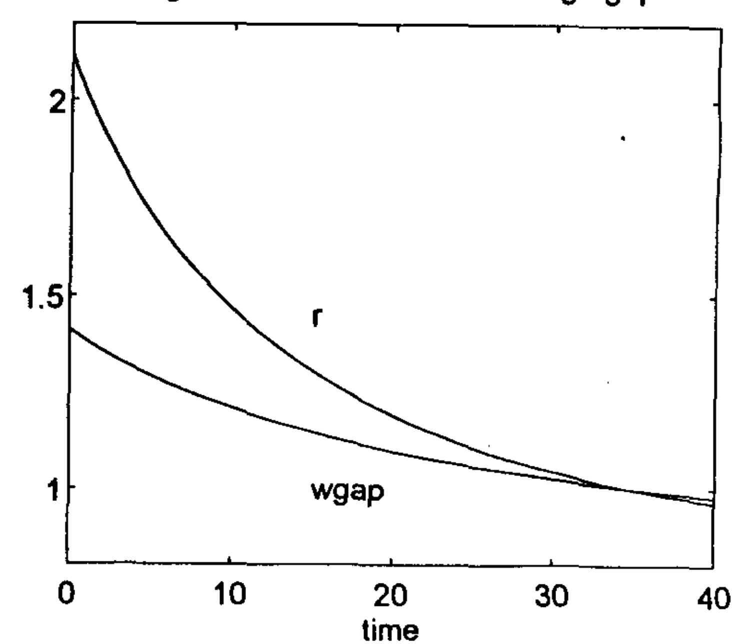


Figure 2d: interest rate and wage gap



The first two panels display capital stocks, output, and consumption. There is substantial investment in both types of capital and both increase smoothly, with human capital growing a little more rapidly than physical capital. It takes about 35 years for Mexico to reach the current U.S. level of development in terms of the proportion of skilled labor. Output, measured by either GDP or NNP, and consumption also grow smoothly. The path for consumption tracks the former most closely.

Factor returns are displayed in the last two panels. The skilled wage displays very modest growth. This is not surprising, given the very similar values in the table above for the current skilled wage in Mexico and the U.S. The unskilled wage, which starts out at about 2/3 of its U.S. level, rises dramatically as Mexico develops. Recall that unskilled labor supplies both mental and physical effort. The return to mental effort, the skilled wage, is growing very little, so the increase in the unskilled wage is coming almost entirely through the increased return to physical effort. Since supplies of both physical capital and skilled labor (mental effort) are growing substantially, while the supply of physical effort from unskilled labor is shrinking, it is not surprising that the return to the latter is increasing.

It follows immediately that the difference between the two, the wage gap, shrinks. This gap measures the return on investment in skill. It is initally quite large, stimulating the large investments in human capital. As it falls as the economy approaches the steady state, and growth in human capital tapers off.. A similar argument applies to physical capital. The interest rate, which starts out at about twice the current U.S. level, falls dramatically as capital is acumulated.

II. CAPITAL INFLOWS

As noted above, one of the major effects of NAFTA is to reinforce the Mexican policy of opening up to foreign capital inflows. In this section we will suppose that improved capital mobility is the *only* effect of NAFTA, and that capital mobility is perfect. Specifically, we will suppose that Mexico can borrow from abroad at a constant rate of interest, and assume that the world interest rate is at the steady state level, $r^w = \rho + \delta$. Wage rates for skilled and unskilled labor will depend on domestic supplies of those factors, however.

The model

Let $t = 0$ be the date when capital inflows begin. When the doors are opened to foreign investment, the capital stock immediately jumps to the level that produces a rate of return equal to the world interest rate. That is, it jumps to $\kappa(z(0))$, where the function κ is defined by

$$f_k\left(\kappa(z), z\right) \equiv \rho + \delta.$$

As human capital accumulation proceeds, the stock of physical capital adjusts continuously so that $k(t) = \kappa(z(t))$, all t.

In the open economy the representative Mexican household can borrow and lend at the world interest rate, so its investment and consumption decisions can be analyzed separately. Its investment problem is to choose a path for human capital accumulation that maximizes the present discounted value of its labor income stream, net of investment costs, where future flows are discounted at the (net) world interest rate:

$$\max_{\{I_z\}} \int_0^{\infty} e^{-\rho t} \left[w_u(t)[1 - z(t)] + w_z(t)z(t) - I_z(t)\right] dt \tag{7}$$

$$\text{s.t.} \quad \dot{z}(t) = BI_z^{\phi}(t) - \eta z(t),$$

given $z(0)$.

The household's second problem is to choose a consumption stream to maximize its lifetime utility, given the discounted value of its net income stream, where the (constant) net interest rate is again ρ. The solution is a constant consumption stream whose level is $\bar{c} = \rho\left[V(z(0)) + k(0)\right]$, where $V(z(0))$ is the maximized value in (7) and $k(0)$ is the Mexican capital stock at date $t = 0$.

Mexican development with capital mobility

The steady state values for z and k are the same here as in the closed economy, but part of the capital stock is foreign-owned, so steady state national product and consumption are smaller if the economy is open to capital inflows. Their levels depend on the initial conditions when the economy opens up. Convergence in the open economy is much more rapid, since households can borrow abroad to finance both consumption and investment in skill. For the parameter values here, the half-life is 2.6 years in the open economy, compared with 15.1 in the closed one.

Figure 3 displays the first 20 years of the transition paths for Mexico as a closed economy and with capital inflows, in both cases starting from the initial conditions corresponding to the point Mex in Figure 1. As before, all variables are measured relative to their values at the point labeled US in Figure 1.

The first two panels display capital stocks, output, and consumption. Both stocks grow much more quickly in the open economy. The stock k of physical capital jumps at date $t = 0$ and grows smoothly thereafter. The stock of skilled labor cannot jump, but it grows much more quickly. With capital inflows, the proportion of skilled labor in Mexico reaches its current U.S. level (71%) in only 8 years! Opening spurs faster growth in human capital for two reasons.

First, the inflow of foreign capital eliminates incentives for Mexicans to invest in physical capital, since it reduces the rate of return to an unattractively low level. Second, although capital inflows raise wage rates for both skilled and unskilled labor, they have a larger impact on the former, raising the skill premium. Both the higher skill premium and the lower return on physical capital stimulate very rapid accumulation of skill. At the same time, Mexican ownership of physical capital declines, as domestic wealth (not pictured) is decumulated to finance consumption smoothing.

Figure 3b shows time paths for output and consumption. Recall that GDP in

Figure 3a: capital and skill

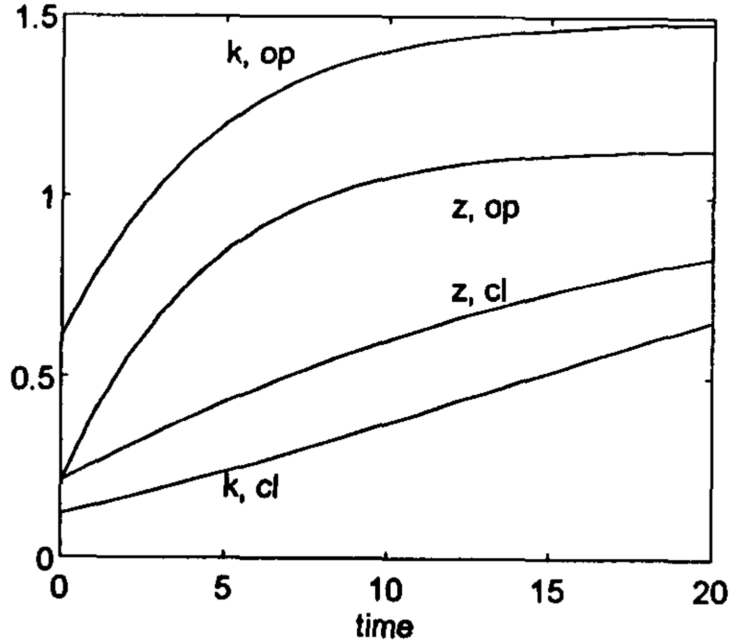


Figure 3b: output and consumption

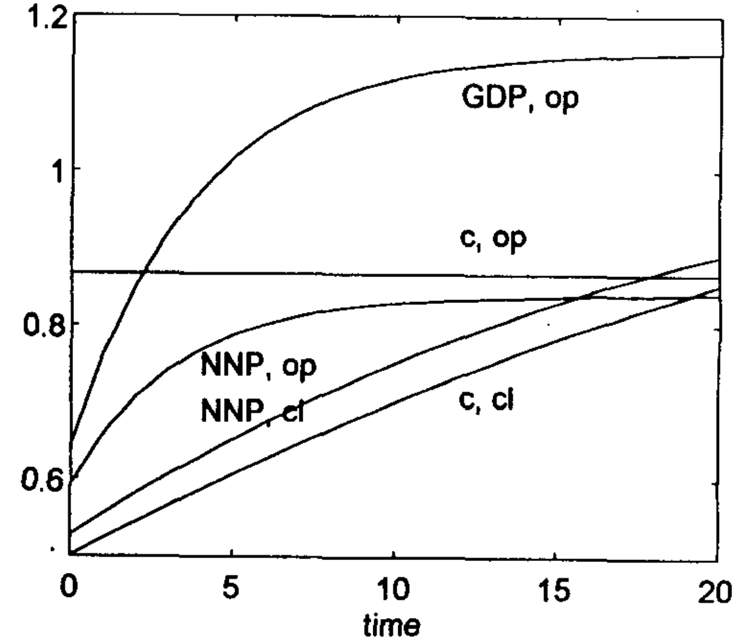


Figure 3c: wage rates

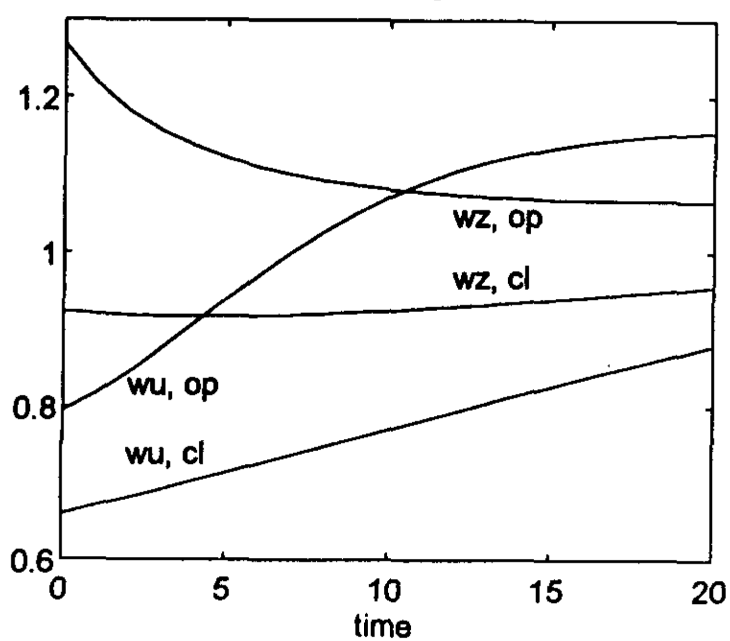
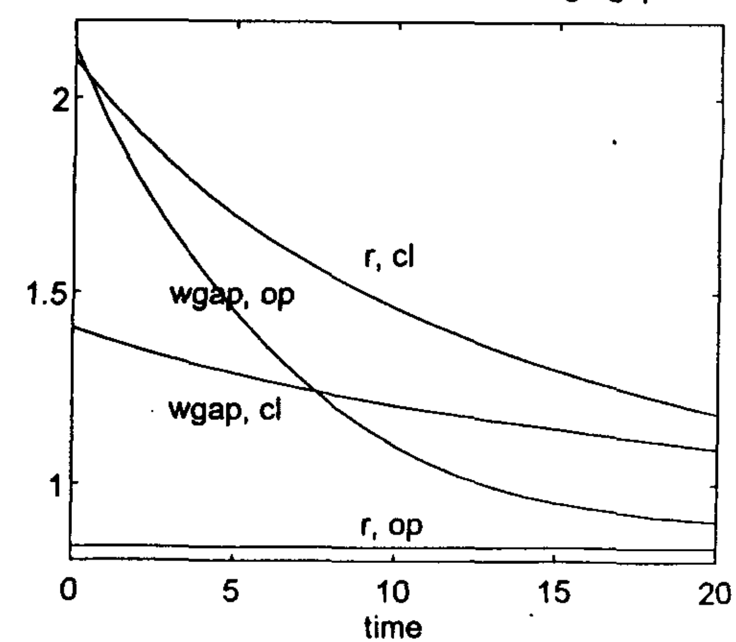


Figure 3d: interest rate and wage gap



the closed economy (not pictured here) tracks consumption very closely. Opening up initially raises GDP and NNP, as the higher wage rates more than offset the lower return on capital. GDP continues to grow more quickly in the open economy, but NNP does not. Households decumulate wealth in the open economy, in order to smooth consumption. Hence domestic wealth declines, converging to a constant (which here is negative), and a growing fraction of the capital stock is foreign owned. Hence the time paths for NNP cross, and steady state NNP is smaller in the open economy.

The time paths for consumption also cross. In the closed economy consumption rises with income, while in the open economy the consumption profile is flat. Thus, opening up initially raises both NNP and consumption, but leaves both lower in the steady state.

Figures 3c and 3d show factor returns. Opening up raises both wage rates over the entire horizon, as the large inflows of foreign capital raise the marginal products of both of the other factors of production. The skilled wage jumps by about 37% when the economy opens, and then declines gradually as the proportion of skilled labor grows. The unskilled wage jumps by about 21% when the economy opens. It continues to grow thereafter, but very gradually. Thus, the gains to both types of labor are greatest at the instant when the economy opens and decline thereafter. They are positive at all dates, however.

It follows that the wage gap widens quite substantially when the economy opens, and narrows quickly as the proportion of skilled labor grows. Compared with the closed economy, the wage gap in the open economy declines much more rapidly, since the proportion of skilled labor grows much more rapidly. Hence the two cross.

With capital inflows, the interest rate jumps immediately to its steady state level and stays there. In the closed economy the marginal product of capital is initially very high, and it declines gradually as capital is accumulated.

The welfare gain from capital inflows is equivalent to increasing the consumption profile in the closed economy by about 14.3%. That is, at date $t = 0$ the representative household is indifferent between the (flat) consumption steam for the open economy, and a consumption stream that has the same time profile as the one for the closed economy, but is 14.3% higher at every date. This is a very substantial gain. Of this total, 8.1% is *from consumption smoothing* alone. That is, replacing the consumption stream for the closed economy with one that has the same present value (discounted at a constant interest rate of 4%) and is flat, raises utility by the same amount as does increasing the original consumption profile by 8.1% at every date. The increase in real income from opening to capital inflows is 5.7%. That is, the present value of total consumption is 5.7% greater in the economy that has access to capital inflows.

Both gains are large. It should be noted, however, that both are quite sensitive to the assumed value for the intertemporal elasticity, $1/\sigma$. Recall that changing σ does not affect the steady state for the closed economy, although it does affect the speed of adjustment. Notice, too, that the equilibrium path for the open economy does not depend on σ: the optimal path for human capital accumulation depends only on the technologies, and the optimal consumption profile is flat.

Both components of the welfare gain are very sensitive to σ. The welfare gain from smoothing consumption falls as $1/\sigma$ rises, because the household cares less about unevenness in its consumption stream. In addition, since a higher value for $1/\sigma$ speeds up the transition in the closed economy, opening up to foreign capital inflows has a smaller impact on wage rates and hence on real income. For example, with $\sigma = 1.5$, the total gain from opening is 9.0%, of which 6.5% is from consumption smoothing and 3.4% is from higher real income. For $\sigma = 1.0$, the values are 7.4%, 5.2% and 2.1%.

III. INTEGRATION WITH THE U.S. AND CANADA

In this section we take a second view of the consequences of NAFTA, and consider the case in which Mexico, the U.S., and Canada integrate completely, in the sense that factor price equalization holds. Although NAFTA is unlikely to result in substantial labor mobility, this description is a useful one if there are enough traded goods, both intermediate and final, to equalize factor prices. Since Canada is very similar to the U.S. in terms of its (per capita) stocks of physical and human capital, the two are aggregrated and treated as a single unit for the analysis here.

The model

Let n_{mex} and n_{us}, with $n_{mex} + n_{us} = 1$, be the relative sizes of the two countries, let (k_{mex}, z_{mex}) and (k_{us}, z_{us}) be the capital stocks, and let $t = 0$ be the date of integration. The per capita stock of physical capital and the proportion of skilled labor in the integrated economy are

$$k = n_{mex}k_{mex} + n_{us}k_{us}, \quad \text{and} \quad z = n_{mex}z_{mex} + n_{us}z_{us}.$$

Factor returns, which are still given by (3) and (4), depend on these aggregates. There are now two representative households, one in each country, and each faces the problem in (2). The conditions for the two households' maxima, together with the factor return conditions, describe the equilibrium.

The steady state for the integrated economy satisfies (5) and (6), so the aggregate stocks are identical to those in the closed economy. In addition, productive efficiency requires the steady state proportion of skilled labor to be the same in the two countries. The distribution of nonhuman wealth depends on initial conditions, however, as does the distribution of consumption.

The only additional parameters needed to simulate the two-country model are the relative population sizes. In 1989 the population of Mexico was 85 million, with a labor force participation rate of about 1/3, the U.S. population was 250 million, with a labor force participation rate of about 1/2, and the Canadian population was 25 million. Hence in terms of labor force, the U.S. and Canada are together about 80% of the integrated economy, so $n_{us} = .80$ and $n_{mex} = .20$.

Development in the integrated economies

Consider development in an integrated North America, starting at the initial conditions described by the points Mex and US. The transition has three phases.

During the first phase, which lasts for about 5 years, an initial imbalance in the ratio of the aggregate stocks is corrected. As Figure 1 shows, averaging the initial positions for Mexico and the U.S. gives a point slightly above the pike, so the initial ratio of physical capital to skilled labor in the integrated economy is slightly too high. During this short initial phase, human capital grows more rapidly than physical capital, and that imbalance is corrected. As in the closed economy, adjustment of this type is very rapid, with a half-life of 2.6 years.

During the second phase, which lasts for about 40 years, the imbalance in the composition of the human capital stock between its country components is corrected. The proportion of skilled labor in the Mexico grows very substantially, while the proportion in the U.S. grows only slightly. This type of adjustment is much slower, with a half-life of 9.9 years. By the end of this phase, the two countries have virtually identical proportions of human capital.

The final phase corresponds to a transition along the pike in Figure 1. The proportion of skilled labor grows at the same rate in both countries, so equality in the two proportions is maintained, and physical capital also grows. As in the closed economy, this type of adjustment is quite slow, with a half-life of about 15.1 years. During this phase the integrated economy behaves exactly like a single closed economy except that the distribution of consumption is unequal. The rest of the discussion here will focus on the first two phases.

Figure 4 displays time paths for the first 30 years of the transitions for the U.S. and Mexico as closed economies and for an integrated North America. All variables are measured relative to their initial levels in the U.S. The first two panels display the stocks of human and physical capital, the next two show net national product and consumption, the next two display wage rates, and the final pair show returns to investments, the wage gap and interest rate.

Integrating accelerates human capital accumulation very slightly in both countries, as shown in Figure 4a. After seeing the dramatic effect that capital inflows have on Mexican investment in human capital, it is somewhat surprising that the effect here is so small. Integration has an even smaller effect on the growth of aggregate physical capital (not shown), but a large impact on the distribution of its ownership. As Figure 4b shows, integration reduces accumulation of physical capital in Mexico (in fact it becomes negative), and raises it in the U.S.

To interpret these results it is useful to look at factor returns and to begin with physical capital, for which the intutition is clearer. First note that the initial levels for factor prices in the integrated economy are, roughly, weighted averages of their initial levels in the two closed economies. Hence in Mexico the initial impact of integration is to raise both wage rates and to reduce the wage gap and interest rate. In the U.S. the effects are reversed. Moreover, since the weights for factor returns in the integrated economy are roughly proportional to the relative population sizes in the merging components, the changes are much larger in Mexico than in the U.S.

As Figure 4h shows, integration reduces the interest rate in Mexico very dramatically and raises it slightly in the U.S. Hence Mexicans have an incentive to adopt a much smoother consumption profile under integration than under autarky, financing it with the decumulation of physical assets. Figure 4d confirms this interpretation:

Figure 4a: proportion of skilled labor

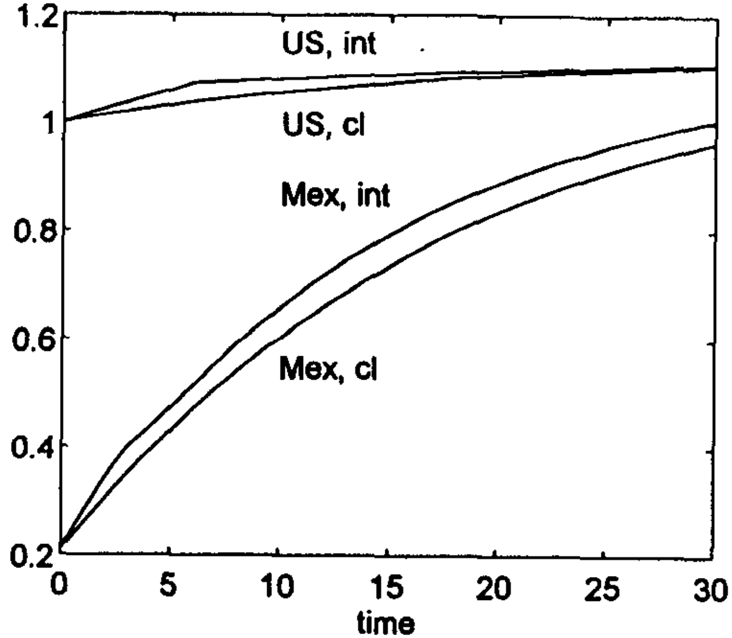


Figure 4b: domestic wealth

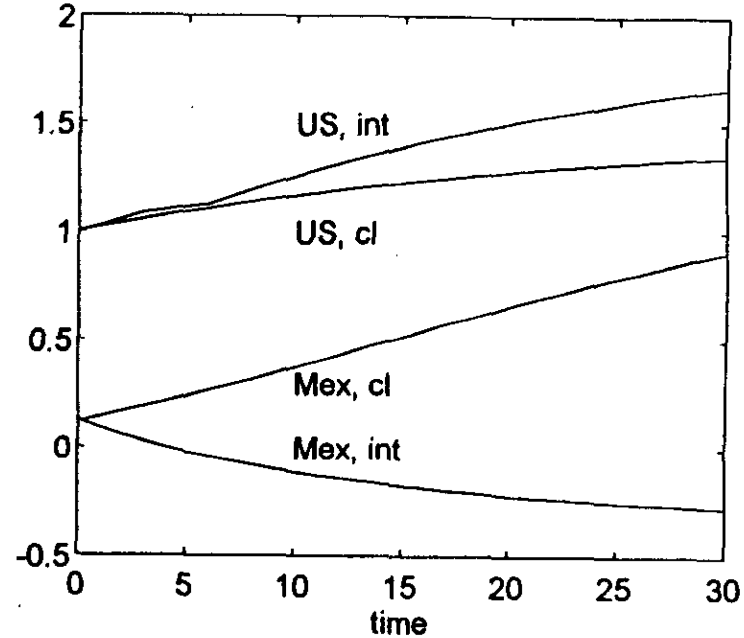


Figure 4c: net national product

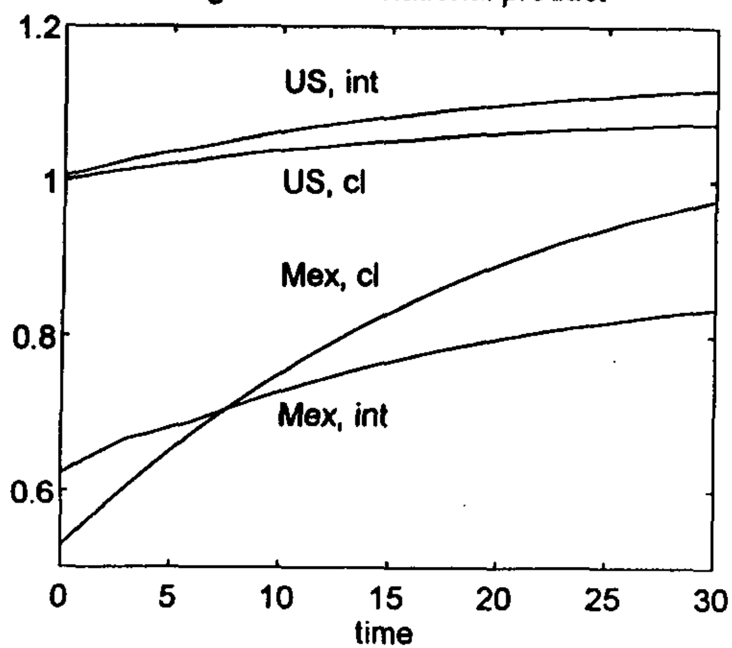


Figure 4d: consumption

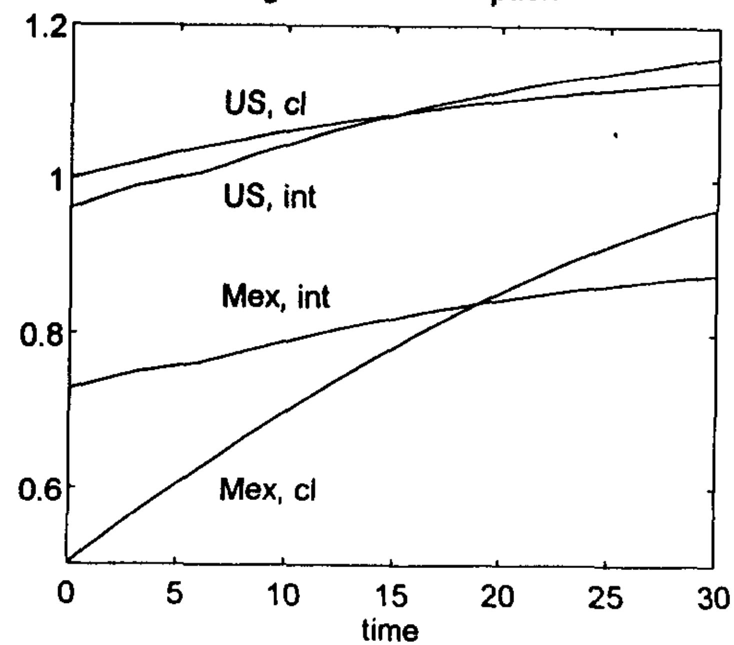


Figure 4e: skilled wage

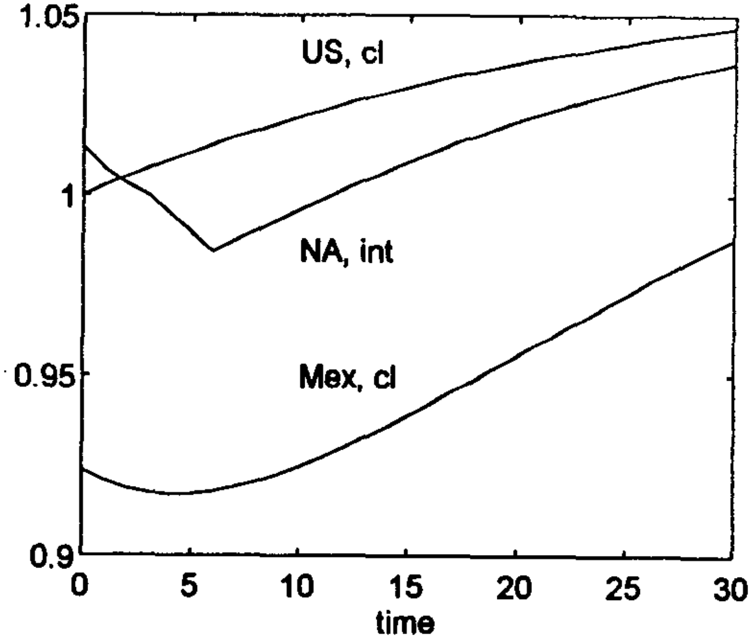


Figure 4f: unskilled wage

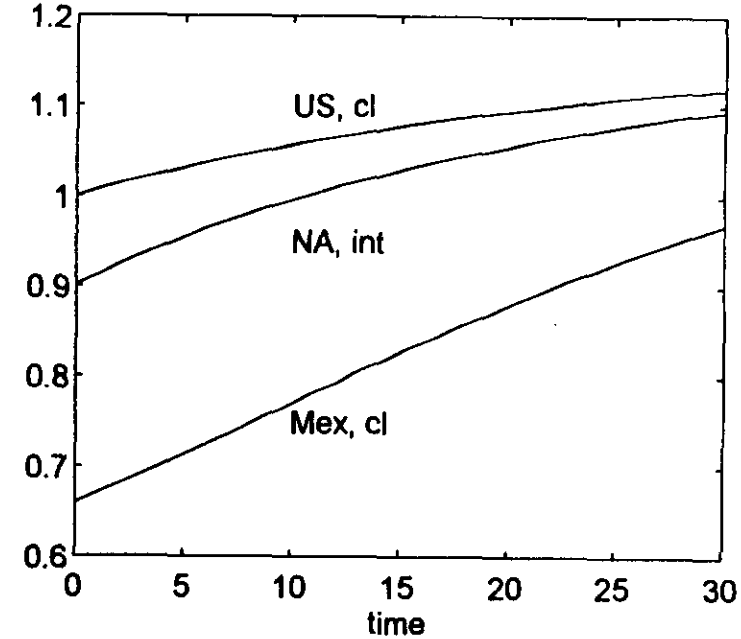


Figure 4g: wage gap

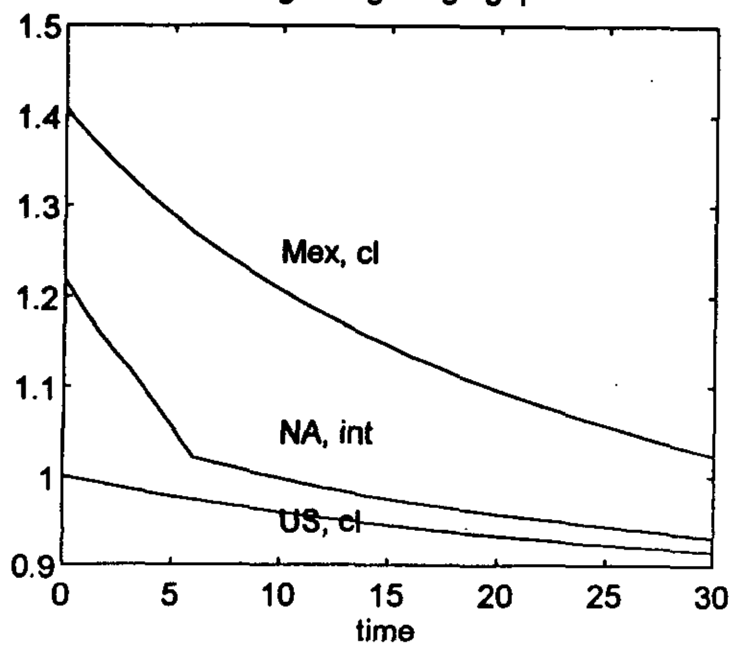
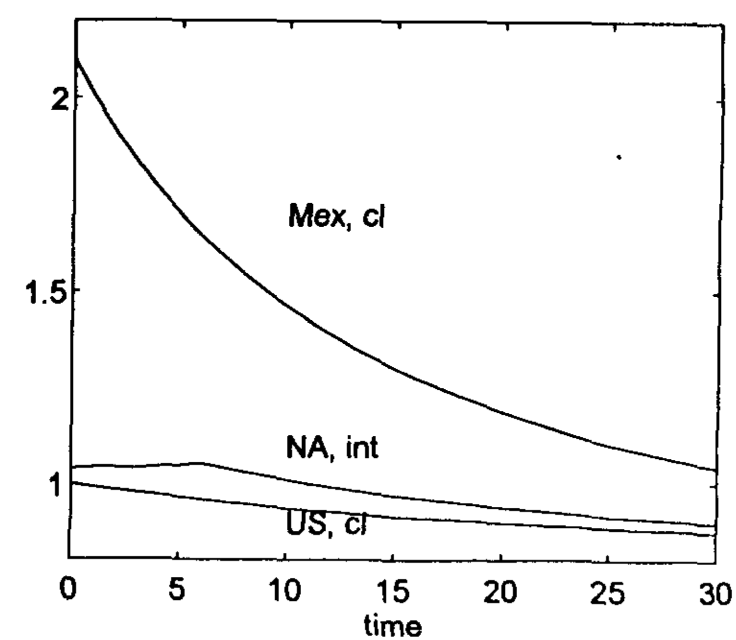


Figure 4h: interest rate



the Mexican consumption profile under integration is much flatter than under autarky. For the U.S., the slightly higher interest rate provides an incentive to do just the reverse: to increase capital accumulation, initially reducing consumption and later increasing it, resulting in a slightly steeper consumption profile.

The intuition for human capital accumulation is somewhat more complicated. As Figures 4e and 4f show, integration raises both wage rates in Mexico and reduces both in the U.S. The changes are much larger in Mexico than in the U.S., and in both countries are substantially larger for unskilled labor. The initial impact of integration in Mexico is to raise the skilled wage by about 10% and the unskilled wage by about 37%. Hence the wage gap in Mexico falls substantially, and the decline persists for a long period, as shown in Figure 4g. In the U.S. it has little effect on the skilled wage and reduces the unskilled wage by about 10%.

In Mexico, this lower return discourages investment in human capital. As we saw above, however, the return in Mexico on investment in physical capital also falls, and in fact it falls even more sharply than the return on human capital. This sharp decline in the interest rate makes investment in human capital comparatively attractive, which encourages such investments. The two effects tend to offset each other, resulting in the very modest rise in the rate of human capital accumulation shown in Figure 4a. In the U.S. the story is reversed but the net effect is similar.

As Figure 4c shows, NNP initially rises in both economies, as the efficiency gains from integration are realized. In Mexico the initial gain is eventually reversed, as physical assets grow in the closed economy and decline in the integrated one. In the U.S. the NNP gap continues to widen as returns from foreign investments flow into the integrated economy.

Integration initially raises consumption in Mexico, as the lower interest rate stimulates consumption smoothing. But since this smoothing is financed by decumulation of assets, in the long run Mexican consumption is lower under integration. In the U.S.

the effects are reversed.

For Mexico, the welfare gains from integrating, although smaller than those resulting from capital inflows, are still very substantial. The representative Mexican is indifferent between the consumption stream in the integrated economy and one that has the shape of the consumption stream in the closed economy but is 8.8% larger at evey date. (Recall the welfare gain from capital inflows, measured the same way, was 14.3%.) As before, much of the gain is from consumption smoothing. The welfare gain from consumption smoothing alone, induced by the lower interest rates in the integrated economy, is about 4.1% of initial consumption, while the increase in real income is about 4.6%. For the U.S., the gain from integrating is extremely small, less than 0.10% when measure relative to the consumption stream in the closed U.S. economy.

IV. THE EFFECTS OF NAFTA ON MEXICAN DEVELOPMENT

What, then, is the likely impact of NAFTA on Mexican development? Mexican investment in human and physical capital will depend on the rates of return on those assets, and these rates of return will depend on the relative supplies of all factors of production. Since both physical and human capital are relatively abundant in the U.S. and Canada, under NAFTA both factors will, in effect, flow into Mexico. These flows may be direct, in the form of capital flows and labor migration, or indirect, in the form of differences in the factor content of imports and exports.

In the first scenario above, only physical capital moved into Mexico; in the second, human capital as well as physical moved. In neither case were there any barriers to those capital flows. The actual impact of NAFTA is likely to combine elements of both these scenarios, but in less extreme form. That is, Mexico will experience inflows of both physical and human capital, but both will face substantial impediments. Moreover, human capital flows will face more serious barriers, since physical capital will have much greater opportunities for direct mobility.

Consequently, while the two scenarios above are unrealistic if taken at face value, they can be used to provide at least a rough indication of the likely effects of NAFTA over the next couple of decades. In terms of direction, the effects are likely to lie between these two cases, and in terms of magnitude, to be substantially smaller than either. Therefore, a rough estimate can be made by combining the two simulations above.

Figure 5 displays the first 30 years of transition paths for Mexico under all three regimes: as a closed economy, open to capital inflows, and integrated with the U.S. As before, all variables are measured relative to their current levels in the U.S. The first two panels display capital stocks, the next two show income and consumption flows, the next two display wage rates, and the final pair show returns to investments in human and physical capital.

Both opening to capital inflows and integrating with the U.S. have qualitatively similar predictions for capital stocks, income and consumption flows, wage rates, and the interest rate. The have rather different predictions for the skill premium, however. In addition, the conclusions for consumption and for physical capital accumulation ignore an important factor.

Compared with the closed economy, both the open and integrated ones display more rapid accumulation of human capital. For the open economy the change is very large, while for the integrated economy it is quite modest, as shown in Figure 5a. Thus, NAFTA is likely to accelerate human capital accumulation in Mexico, shifting it onto a path somewhere between those for the open and integrated economies.

Both the open and integrated economies predict higher wages for skilled and unskilled labor. Inflows of physical capital will tend to raise the skilled wage sharply, while inflows of human capital will tend to reduce it. Thus, the increase in the skilled wage is very dramatic in the open economy and rather modest in the integrated

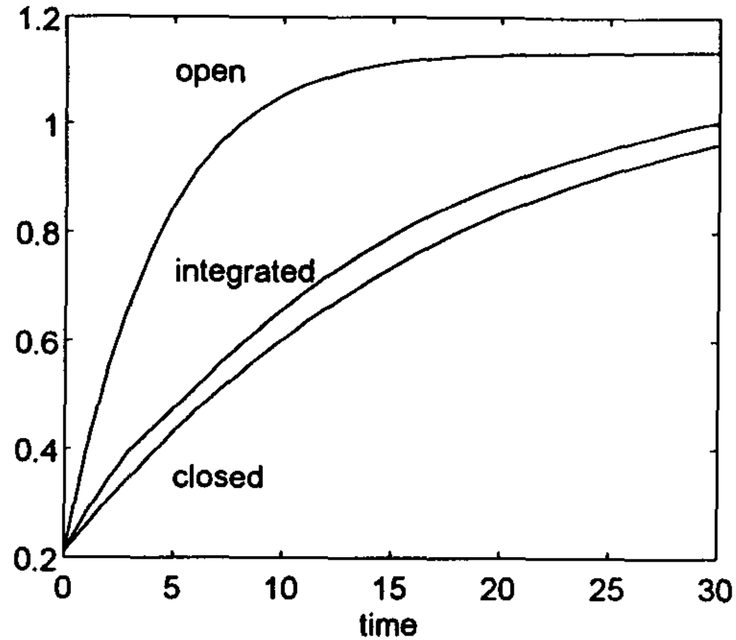


Figure 5a: proportion of skilled labor

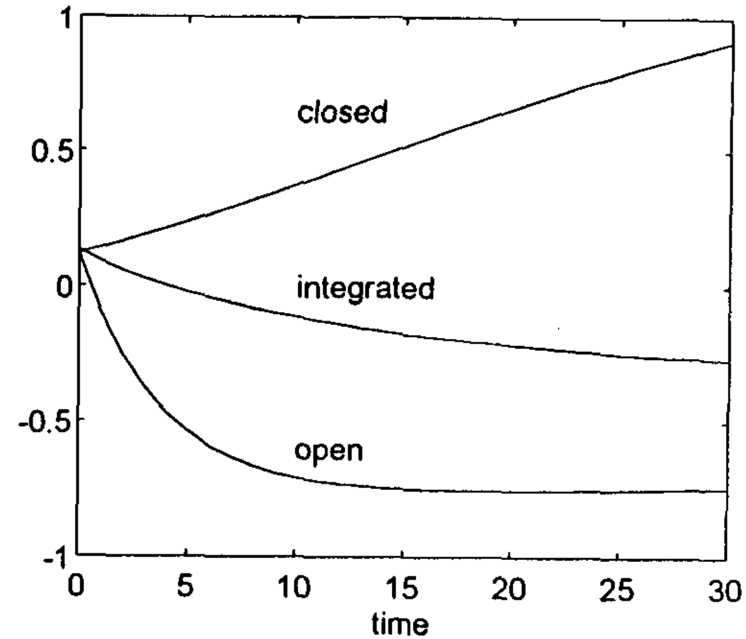


Figure 5b: domestic wealth

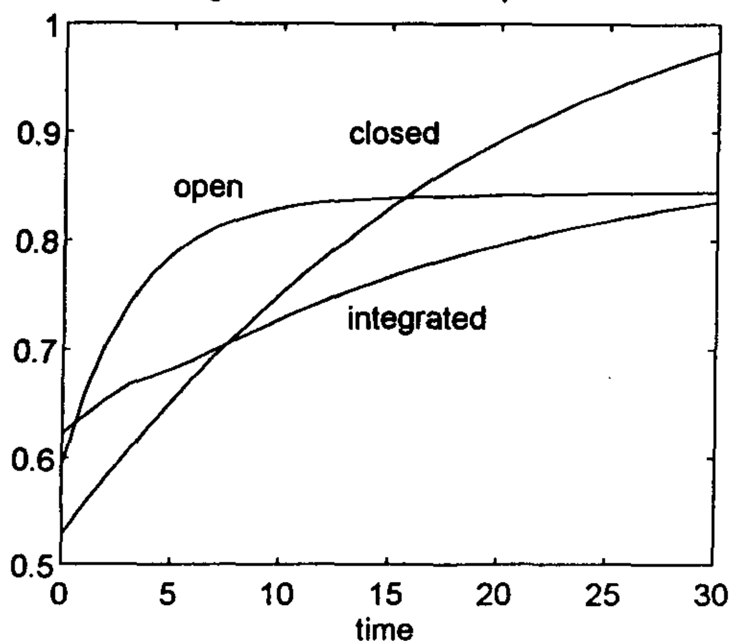


Figure 5c: net national product

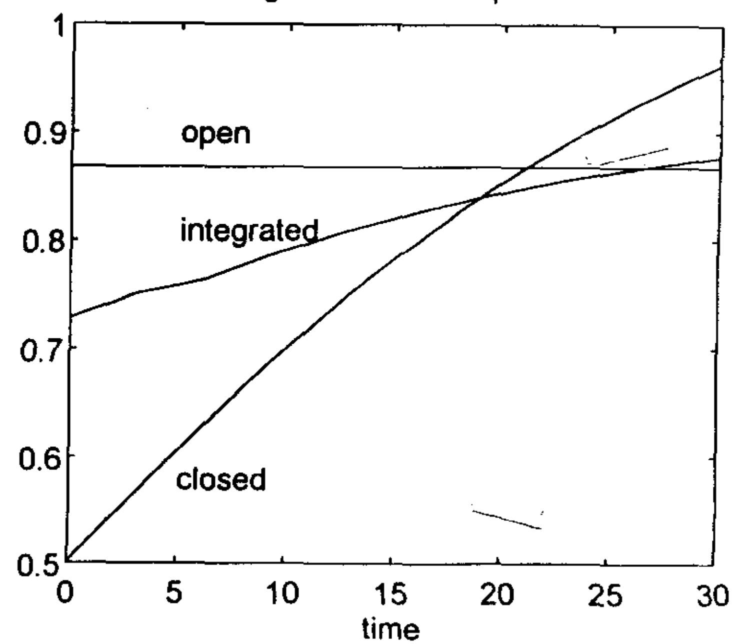


Figure 5d: consumption

Figure 5e: skilled wage

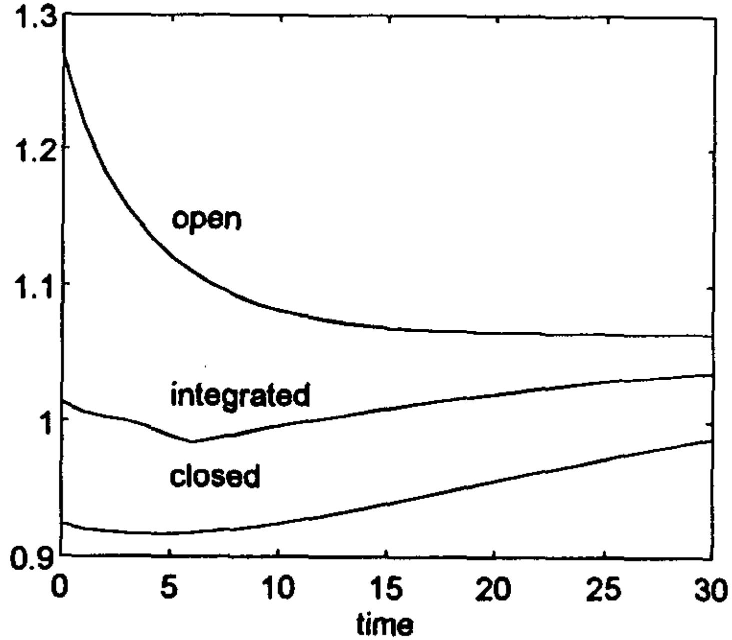


Figure 5f: unskilled wage

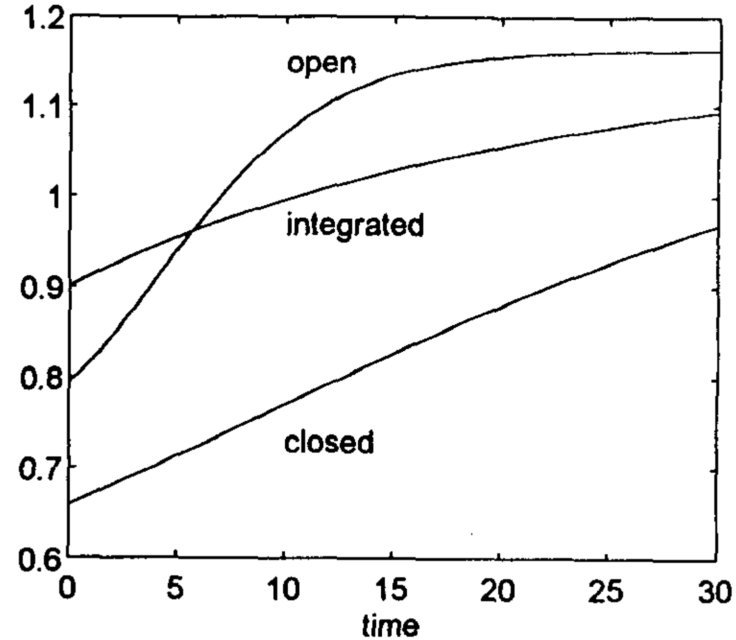


Figure 5g: wage gap

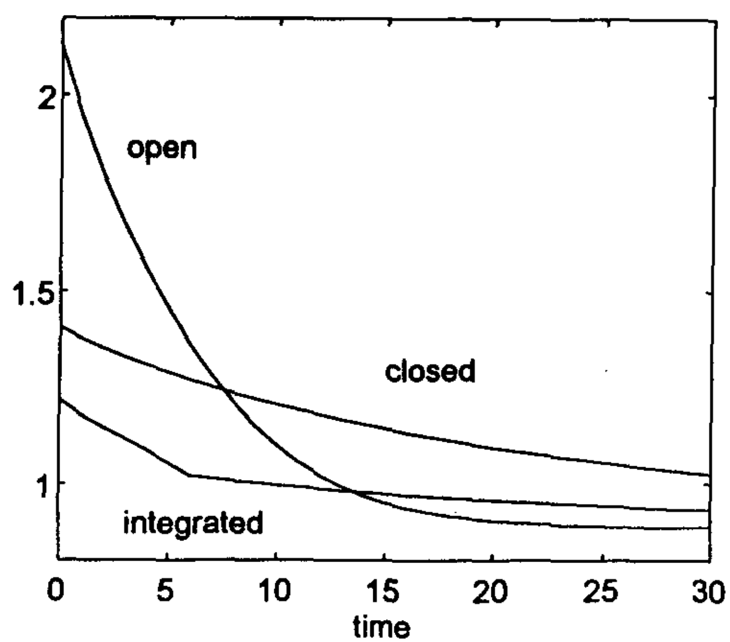
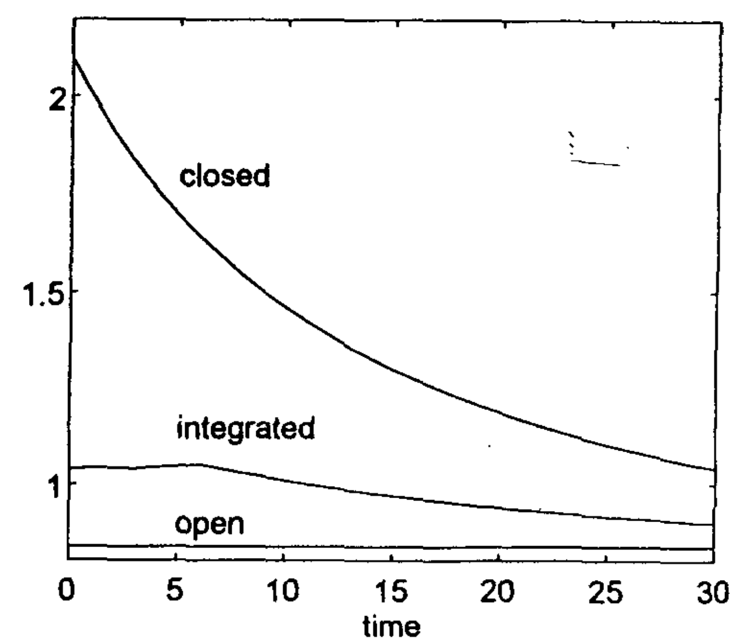


Figure 5h: interest rate



economy, as shown in Figures 5e. Both physical and human capital inflows tend to raise the unskilled wage, so the increase in the unskilled wage is quite substantial in both the open and integrated economies, as shown in Figure 5f. Thus, it seems clear that NAFTA will raise wage rates in Mexico for all kinds of labor. It is not clear, however, whether skilled or unskilled labor will enjoy the larger gain. Inflows of physical capital tend to widen the wage gap, while inflows of human capital narrow it, as shown in Figure 5g, and it is not clear which effect will dominate.

Similarly, the open and integrated economies both display an initial jump in net national product compared with the closed economy. The paths cross after 10 or 15 years, however, as factor returns and the proportion of skilled labor converge in all three economies, but the closed economy has a larger stock of domestically owned physical assets.

Figure 5b shows nonhuman wealth owned by Mexicans. (Note that this is different from the domestic capital stock, which includes assets owned by foreigners.) In the closed economy assets grow steadily, while in the integrated and open economies they shrink. In fact, assets become negative in both cases, and in the open economy the debt is quite large. The reason is apparent from Figures 5d and 5h. Compared with the closed economy, both the open and integrated scenarios have much lower interest rates. The model predicts that the lower interest rates lead Mexicans to choose much smoother consumption profiles, financed by the decumulation of assets. Moreover, since there are no *ad hoc* credit limits, net wealth can and does become negative.

Consumption loans of this magnitude seem implausible, although it is less obvious what the appropriate constraint should be. A negative asset position seems unlikely, although it is possible that NAFTA will slow accumulation of nonhuman wealth by Mexicans. Even this conclusion may be unwarranted, however.

The model here predicts that opening to capital inflows or integrating with the U.S. stimulates faster accumulation of human capital in Mexico but leads to *de*cumulation of physical capital. This conclusion rests on the assumption that foreigners can invest in physical capital in Mexico but cannot invest in human capital. This suggests that one might want to interpret "human capital" as including types of physical assets that are not amenable to foreign ownerships. Assets in this class might include those that, for moral hazard reasons, must be owner operated. Small businesses are one example.

The correct conclusion, then, is that investment by foreign firms in some types of capital will raise rates of return and stimulate domestic investment in *complementary* types of capital. The latter category includes human capital, but may include some types of physical capital as well. If it does, then the interest rate in Figure 5h should be interpreted as the rate of return on assets that are amenable to foreign ownership. The rate of return on assets that must be domestically owned is initially higher, and it is the latter that is the relevant for consumption decisions. Thus, Figure 5d substantially overstates the likely extent of consumption smoothing.

V. CONCLUSIONS

Most analyses of NAFTA have been static, focussing on its effects on relative prices, patterns of specialization, and trade flows, taking factor endowments as given. The approach here has been complementary to that one, focussing entirely on NAFTA's dynamic effects on interest rates, skill premia, and investments in human and physical capital.

Perhaps the main conclusion here is to confirm what several earlier studies have hinted at: that for Mexico the most important welfare consequences of NAFTA will come from its medium-run effects on factor returns and factor accumulation. As the simulations here show, these effects may be quite large, and the associated welfare gains for Mexico may be very substantial. For the two scenarios above, the gains were 14% and 9%. Even a half or a third of these numbers, which may be a more reasonable estimate, is a very large gain.

In addition, if NAFTA enhances technological "spillovers" from the U.S. to Mexico, the welfare gains may be even larger. The model above did not take account of technological differences between countries or technological change over time, so it ignored this source of efficiency gains. But one potential benefit of NAFTA to Mexico, and possibly a very important one, is the transfer of technology that may accompany the flow of manufacturing plants and engineers across the border.

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