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International spillovers, productivity growth and openness in Thailand: an intertemporal general equilibrium analysis

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Abstract

Thailand has experienced economic growth well above world averages from 1960 to the recent crisis. While the controversy over Thailand and East Asian growth has discussed the role of capital accumulation versus productivity, we analyze the general equilibrium interaction between productivity and investment in an intertemporal growth model. The high growth is understood as a prolonged transition path with gradual tariff reduction and endogenous productivity driven by foreign spillover feeding capital investment. Counterfactual analyses show how protection would have reduced growth with productivity and investment slowdown, while shock liberalization would have raised immediate growth with faster convergence to steady state.

JEL classification: O41; O47; O53

Keywords: Intertemporal growth modeling; Endogenous productivity growth; Foreign technology spillover; Trade and growth; Thailand

1. Introduction

Income differences across countries cannot be understood only as a result of different availability of production factors. The empirical evidence that capital stocks per worker

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explain limited part of the income differences among nations now is widely accepted. The attention therefore is turned to productivity and technology and productivity differences between countries are substantial, as documented by Hall and Jones (1999). Acemoglu and Ventura (2002) find that the world income distribution is remarkably stable over time. It follows that differences in income levels are permanent, while differences in growth rates are mostly transitory. A corollary to this is that miracle growth countries cannot produce miracles over long periods. Growth rates will decline again to world normals.

The sources of the remarkable growth in Thailand and East Asia have been controversial and empirical studies have constructed a horserace between factor accumulation and productivity growth. While the conventional view has recognized high productivity growth associated with openness as part of the explanation (Klenow and Rodriguez-Clare, 1997), both empirical (Young, 1994) and theoretical (Baldwin and Seghezza, 1996) studies have argued that capital accumulation has been the main driving force. This debate is hard to understand from a general equilibrium point of view, since both factor accumulation and productivity are endogenous. The conventionally calculated residual underestimates the productivity effect when productivity improvements contribute to higher capital accumulation. Hulten (2001) shows how this induced capital accumulation effect can be calculated. He reports that this measure of the productivity effect accounts for about 50% of output growth in the East Asian economies studied by Young.

The present paper addresses the growth process of Thailand in this context. We suggest that the interplay between accumulation and productivity is investigated in an intertemporal general equilibrium framework. Openness and trade policy are assumed to be important for productivity spillover and cost of capital goods. The focus is on endogenous productivity growth in transition towards long-run balanced growth. Thailand has had economic growth of about 6–8% and well above world averages from 1960 to the recent crisis, in transformation from a ‘rice economy’ to industrialization with labor-intensive exports.

The literature on endogenous productivity growth points to the role of research and development and innovation. But these sources of productivity growth do not seem to be of great relevance for Thailand. Resource input to research and development is concentrated to the most developed countries of the North. Innovation is the result of R&D and certainly requires advanced skills, again not characterizing the local growth process. Human capital development and skill accumulation are important ingredients in recent models of endogenous growth. While education and skill levels have been rising in Thailand, the low-tech labor-intensive industries do not indicate that this is a major growth factor. Our analysis addresses productivity growth generated by learning by doing, technology adoption and foreign technology spillover. Based on recent econometric evidence for Thailand, our understanding is that productivity growth has been related to the increased openness of the economy. Greenaway et al. (2002) supply broader evidence about openness and growth.

Thailand’s growth experience is analyzed as an interaction between endogenous productivity growth and capital accumulation with increased openness of the economy. This mechanism explains the extended transition growth above long-run balanced growth rates. To investigate the transition path and the role of openness, we have developed an intertemporal, general equilibrium model with productivity dynamics that allows counterfactual analysis. The model describes an economy with macroeconomic stability, full employment of resources and flexible allocation of resources between sectors according to profitability. The assumptions are heroic, but then Thailand has enjoyed an impressive growth record with the ability of holding macroeconomic balance and reasonably full utilization of resources.

The model calibration is based on the combination of a social accounting matrix (SAM), econometric evidence and stylized facts of the Thailand economy. The calibration reproduces a transition growth rate above the assumed steady-state growth rate of 5.5% for the period 1960–1995. The establishment of the transition path explains the prolonged growth of the economy above world normals, and gradual reduction of tariff barriers is an important ingredient. Based on the transition path, we analyze counterfactual developments of the economy that can throw light on the growth process. Since the role of openness is assumed essential for the productivity growth, we look at both a protectionist alternative and shock liberalization. Reduced openness has a negative impact on the overall growth rate due to reduced learning from foreign spillover. Shock liberalization in 1960 would have raised the immediate growth, but the convergence to steady state would have been faster.

Imperfect substitution is assumed between domestic and foreign goods. The substitution possibilities of the economy affect the growth paths. In experiments using higher and lower substitution elasticities in both exports and imports compared to the calibrated transition growth, we show how increased substitution possibilities strengthen the incentive to take advantage of cheaper capital goods in the future with gradual tariff reductions. When there is high substitution between domestic and foreign goods, immediate growth is lower, but the growth gradually picks up with cheaper capital goods and endogenous productivity growth with more trade.

Section 2 puts the analysis in the context of the recent literature on productivity growth, and discusses empirical studies of the growth process in Thailand. Section 3 outlines the productivity dynamics and Section 4 describes the full intertemporal model. Calibration of the prolonged transition is explained in Section 5 and the sources of growth are decomposed. Section 6 offers counterfactual analyses of openness, protection and shock liberalization, while Section 7 investigates the substitution effects on growth slowdown towards steady state. Concluding remarks are collected in Section 8.

2. Productivity and foreign spillovers

The shift of focus from long-run growth rate to income and productivity level implies that the choice of technology is at the forefront. The standard neoclassical Hecksher–Ohlin–Samuelson model assumes common technology and therefore concentrates on factor allocation. Investment levels explain differences in per capita income. In the context of development and growth, it seems more productive to assume limited international mobility of technology, as argued by Eaton and Kortum (1999). Adoption of technologies from abroad then is the main determinant of technological progress in countries like Thailand.

Our approach is inspired by the learning by doing literature innovated by Arrow (1962), the technology gap dynamics introduced by Nelson and Phelps (1966) and the emphasis on technology diffusion associated with international trade suggested by Krugman (1979). In a separation between North and South, he assumes innovation in the North and imitation in the South. This is an early contribution with a long-run equilibrium where North and South have the same growth rate, but permanent income differences. The South can improve its position by raising the ability to imitate. Technological differences are expected to be very important without trade since the South hardly can produce the 'new' goods innovated in the North. Modern authoritative treatments of foreign spillovers are Grossman and Helpman (1992) and Aghion and Howitt (1998).

Technology spillovers as discussed above represent an important explanation for convergence of economic growth across countries. All countries can take benefit of the growth of the world technology frontier, albeit in different degrees and speeds. Parente and Prescott (1994) suggest that productivity differences are the result of different barriers to technology adoption. They look at technology as a production factor, and investment in technology explains productivity. The improvement in productivity depends on the distance to the exogenous world technology frontier, and investment is needed to benefit from the world technology. The costs of investment come out as a key determinant of productivity and the authors see these costs mainly as the result of distortions created by policy. We concentrate on trade barriers as a constraint on technology adoption, based on the econometric evidence about the relationship between openness and productivity.

The sources of total factor productivity (TFP) growth have been addressed in an extensive literature with a focus on international spillovers. Edwards (1998) investigates the effect of alternative measures of openness on TFP growth in a dataset of 93 countries. He concludes that more open economies indeed have experienced faster productivity growth. The broad empirical background for our analysis is the study of Coe et al. (1997) using a dataset for 77 countries during 1971–1990. They conclude that 'a developing country can boost its productivity by importing a larger variety of intermediate products and capital equipment embodying foreign knowledge'. The estimates document a substantial spillover effect of foreign R&D and that spillovers are linked to trade. The conclusion is reinforced in a study of East Asian countries by Frankel et al. (2000) taking into account the endogeneity of foreign trade.

The controversy over the Asian miracles has focused on the fact that growth rates have not declined quickly even with high investment level. They are expected to run fast down the decreasing return to capital. We agree with Ventura (1997) that Asian economies probably have been able to meet the diminishing returns through increased international trade. He emphasizes the shift from labor-intensive to capital-intensive industry along with the capital accumulation. This mechanism seems less relevant for Thailand, since manufacturing and exports have not had a clear shift towards capital-intensive products. Howitt (2000) argues that convergence to a common growth rate with different productivity levels is consistent with a Schumpeterian model. While this certainly may be important generally, the underlying assumption of endogenous innovations in R&D firms is not characterizing the industrial structure in Thailand.

Growth accounting analyses of Thailand have been abundant as part of the controversy over the broader East Asian experience. Young (1994) argues in an influential article that the Asian economies have rapid growth due to rapid capital accumulation and not as a result of extraordinary productivity growth. Klenow and Rodriguez-Clare (1997) challenge the conclusions of Young, and their analysis gives more room for productivity effects. We emphasize the interaction between endogenous productivity growth and capital accumulation.

Even Young (1994) estimated TFP growth in Thailand of approximately 2% and is supported by the analysis of Collins and Bosworth (1996) for a longer time period. Tinakorn and Sussangkarn (1998) report from 10 studies where TFP growth estimates vary from 0.5% to 2.7%. They relate annual aggregate TFP growth in Thailand 1981–1995 to the openness of the economy and the sectoral allocation of employment. The effect of the variables can be interpreted as learning by doing driven by domestic factors and foreign spillover and they all are of statistical significance. Urata and Yokota (1994) find that TFP growth in manufacturing increases with trade liberalization (measured by effective rates of protection).

Rattsø and Stokke (2003) apply the method and the disaggregated data of Tinakorn and Sussangkarn (1998) for agriculture and industry to investigate more closely the dynamics of productivity and foreign spillover. The estimates consistently show a clear long-run relationship between measures of foreign trade and TFP. Interestingly, the qualitative and quantitative effect of foreign trade on productivity is similar in both agriculture and industry. Both sectors seem to enjoy foreign spillover and are equally able to take benefit of them. The quantitative effects are of economic importance. In their preferred equation, Rattsø and Stokke (2003) conclude that the long-run elasticity of productivity with respect to foreign trade is about 0.2 in both agriculture and industry. When foreign trade goes up by 10%, sectoral productivities go up by 2%. Since growth of foreign trade has been higher than the overall economic growth in Thailand, this seems to be the major determinant of productivity growth.

3. Productivity dynamics

Our framework to analyze productivity growth looks at the balance between agricultural and industrial growth, with industry covering the 'rest of the economy'. In this section we show the endogenous productivity relationships that are integrated in the full intertemporal general equilibrium model. The sectoral production functions are defined as:

$$X_{\mathrm{M}} = \tilde{A}_{\mathrm{M}} L_{\mathrm{M}}^{\alpha} K_{\mathrm{M}}^{1-\alpha} \tag{1}$$

$$X_{\mathrm{A}} = \tilde{A}_{\mathrm{A}} L_{\mathrm{A}}^{\beta_1} LD^{\beta_2} K_{\mathrm{A}}^{1-\beta_1-\beta_2} \tag{2}$$

where $\tilde{A}_i$ is TFP for sector i. Subscript M is for industry and A for agriculture. L indicates labor, LD land and K capital, and $0<\alpha<1$, $0<\beta_1$, β_2, $\beta_1+\beta_2<1$. Labor and capital are mobile across sectors, while land is a sector specific input only for agriculture. Moreover, the supply of the land is fixed in the economy over time. For this reason, together with different capital intensity across the two sectors, we need different growth rate for TFP across sectors in order to have a balanced growth path. We introduce labor augmenting technical progress A, which is equal in the two sectors, and land augmenting technical progress A_D:

$$\tilde{A}_M = A^{\alpha} \tag{3}$$

$$\tilde{A}_A = A^{\beta_1} A_D^{\beta_2} \tag{4}$$

It follows that the growth paths of the sectoral TFP are as follows:

$$\frac{\dot{\tilde{A}}_M}{\tilde{A}_M} = \alpha \frac{\dot{A}}{A} \tag{5}$$

$$\frac{\dot{\tilde{A}}_A}{\tilde{A}_A} = \beta_1 \frac{\dot{A}}{A} + \beta_2 \frac{\dot{A}_D}{A_D} \tag{6}$$

In the case of Thailand, and similar for many developing countries, industry is more capital intensive than agriculture. For this reason, the balanced growth path requires that TFP in agriculture grows more rapidly than in industry.

In accordance with the theoretical literature and econometric evidence discussed in Section 2, we relate labor augmenting and land augmenting productivities to the level of international trade. Compared to Nelson and Phelps (1966), we do not explicitly introduce the technology gap, assuming that Thailand is well below the world technology frontier for the whole period under study. Compared to Young (1991), we do not explicitly take into account possible decline in learning over time, since we emphasize transition growth. The chosen formulation accommodates the steady-state conditions of the model. Labor augmenting and land augmenting productivities are simply related to total trade, which is scaled by the labor force for labor augmenting productivity:

$$A = m \frac{T}{L} \tag{7}$$

$$A_D = dT \tag{8}$$

where T is total trade, L labor supply, and m and d are positive constants. Given the proportional relationship between foreign trade and technological progress, and taking into account the sectoral labor shares and the land constraint in agriculture, the elasticities of TFP with respect to trade are broadly consistent with the estimates of Rattsø and Stokke (2003).

With this setup, the sectoral productivity growth rates are consistent with a steady-state growth path defined by the exogenous long-term growth rate for the country's overall technical progress g, and the exogenous labor supply growth rate n:

$$\frac{\dot{X}_M}{X_M} = \alpha \left(\frac{\dot{T}}{T} - \frac{\dot{L}}{L} \right) + \alpha \frac{\dot{L}_M}{L_M} + (1-\alpha) \frac{\dot{K}_M}{K_M} = g + n \tag{9}$$

$$\frac{\dot{X}_A}{X_A} = \beta_1 \left(\frac{\dot{T}}{T} - \frac{\dot{L}}{L} \right) + \beta_2 \frac{\dot{T}}{T} + \beta_1 \frac{\dot{L}_A}{L_A} + (1-\beta_1-\beta_2) \frac{\dot{K}_A}{K_A} = g + n \tag{10}$$

4. The intertemporal general equilibrium model

We model a small open economy that faces a perfect international capital market. The economy is small in the sense that its capital accumulation and growth do not influence the world interest rate, which we therefore assume to be exogenously given. A small open economy model with exogenous interest rate and no imperfections in the capital market gives immediate adjustment of the capital stock to its steady-state level if the model is calibrated to an out of steady-state (SS) path. The economy will take advantage of the foreign borrowing opportunity to finance the investments to fully exploit the profit opportunities along the steady state. Consistent with this, the consumption path is unaffected. Introducing adjustment costs in investment is a common way of creating interesting dynamics in such a model. Moreover, as shown by Diao et al. (1998), imperfect substitution between domestic and foreign goods through an Armington composite system also constrains the speed of return to SS. We apply both approaches in this paper. The alternative would be to look into constraints and risks at international capital markets, which represents a future challenge for this kind of models.

To have a consistent basis of growth analysis, we assume intertemporal saving and investment decisions. The representative household is forward looking with rational expectations. The household allocates consumption and saving to maximize an intertemporal utility function, while capital is allocated based on the intertemporal profit maximization. Since investment can be financed through foreign borrowing, the decisions about savings and investment can be separated. Domestic savings and investments do not have to be equal in every period, but a long-run restriction on foreign debt exists. We apply the model setup of Diao et al. (1998) as a benchmark with endogenous determination of sectoral total factor productivities as the main extension. In addition, the adjustment costs are introduced for investment, and land is specified as an input in agricultural production. Full documentation of the intertemporal general equilibrium model is given in a separate appendix available from the authors.

4.1. The household and consumption/saving

The representative household allocates income to consumption and savings to maximize its intertemporal utility. There is no independent government sector so public tax revenues (import tariffs and sales taxes) are transferred to the household lump sum. In addition, it receives income through the primary factors, while interest payments on its foreign debt are subtracted. We consider an infinite horizon model, and utility is maximized subject to an intertemporal budget constraint, which says that discounted value of total consumption cannot exceed discounted value of total income. With intertemporal elasticity of substitution equal to one, we have the well-known Euler equation for optimal intertemporal allocation of consumption:

$$\frac{E_{t+1}}{E_t} = \frac{1+r}{1+\rho} \tag{11}$$

where r is the exogenous world interest rate, ρ is the positive rate of time preference and E_t is total consumption spending in period t. The growth of consumption spending depends on the relationship between the interest rate and the time preference rate. Higher interest rate and lower time preference rate motivate more savings and thereby higher consumption spending growth.

4.2. Investment and capital stock

The aggregate capital stock is managed by an independent investor who decides on investment and passes net profits to the household. Adjustment costs of the investment, φ_t, are assumed to be a convex function of investment (I) over existing capital stock (K):

$$\varphi_t = aP_{\mathrm{M},t}\frac{I_t^2}{K_t} \tag{12}$$

where a is constant and $\mathrm{P}_{\mathrm{M},t}$ composite price of the industrial good.

The investor chooses an investment path so as to maximize the present value of future profits over an infinite horizon, subject to the capital accumulation constraint. First order conditions for labor and land equilibrate marginal return and unit cost of the representative factor. Differentiating with respect to I gives:

$$q_t = \mathrm{PI}_t + 2P_{\mathrm{M},t}a\frac{I_t}{K_t} \tag{13}$$

where PI_t is the unit cost of the investment that eventually forms the capital equipment. This relationship says that investment will equilibrate the marginal cost of investment, which is given on the right hand side, and the shadow price of capital, q_t. Differentiating with respect to K_t gives us the well-known no-arbitrage condition:

$$rq_{t-1} = Rk_t + P_{\mathrm{M},t}a\left(\frac{I_t}{K_t}\right)^2 - \delta q_t + \dot{q}_t \tag{14}$$

which states that marginal return to capital has to equal the interest payments on a perfectly substitutable asset of size q_{t-1}. The first term on right-hand side of the equation (Rk_t) is the derivative of capital in the production function, while the second term is the derivative of capital in the function for investment adjustment cost. The marginal return to capital also has to be adjusted by the depreciation (δ) and capital gain ($\dot{\mathrm{q}}$).

4.3. Foreign sector and foreign debt

We assume imperfect substitution between domestic and foreign goods, so the model operates with two composite goods, one agricultural and one industrial. Imports are endogenously determined through the Armington functions, while exports are determined through the constant elasticity of transformation (CET) functions. As discussed earlier, this is a way to create transitional dynamics in a small open economy model facing a perfect international capital market and exogenous interest rate given from the world market.

If domestic investments exceed domestic savings, the gap is financed through foreign borrowing. Increase in the foreign capital inflows (i.e., trade deficits) in the current period, together with interest payments on existing debt, augments foreign debt in the next period.

4.4. Equilibrium

In each period (intratemporal equilibrium), the following conditions must be fulfilled: (1) in each sector domestic demand plus export demand equal total output, (2) factor demand equals factor supply, (3) investments equal domestic savings and foreign borrowing.

The steady-state equilibrium requires that capital stock and foreign debt (DEBT) grow at a constant rate given by $g+n$:

$$I_T = (\delta + g + n)K_T \tag{15}$$

$$\mathrm{FSAV}_T = (g + n - r)\mathrm{DEBT}_T \tag{16}$$

where FSAV is the trade deficit. Finally, the shadow price for the capital becomes constant, as does the marginal return to capital:

$$Rk_T - aP_{\mathrm{M},T}\left(\frac{I_T}{K_T}\right)^2 = (r + \delta)q_T \tag{17}$$

The subscript T represents the time periods of the steady state.

5. Calibration of transition growth path

Thailand's growth experience is a puzzle as seen from standard growth theory. How can the country stay above a realistic long-run steady-state growth rate and above world growth normals for such an extended period? The actual growth rate has been 7.8% during 1961–95. The background of the growth process is discussed in a broad literature (see the overview of Jansen, 2001 with references). Our approach is more narrow to investigate the mechanisms of transition growth related to recent growth theory.

The intertemporal general equilibrium model is calibrated to a steady-state equilibrium with a balanced growth path. The assumed steady-state growth rate is 5.5% (2.8% labor growth and 2.7% technological progress rate). The quantification of the underlying steady-state growth is debatable, but the exact numerical representation is less important when we concentrate on the transition. With the balanced growth assumption, all other endogenous variables, such as capital stock and investment, savings and consumption, sectoral outputs and trade, have to grow at this rate along the steady-state path. Parameters in the numerical model are calibrated from a 1995 SAM, as documented in the appendix.

The first step of the analysis is to calibrate a transition path that is close to the growth experienced during 1960–1995. Establishing this transition is a challenge in an intertemporal model with assumptions of small open economy and open capital markets, because it is known that in its most flexible form, the capital stocks will immediately adjust to steady state by foreign borrowing. As will come clear, the endogenous productivity growth related to the openness of the economy and interacting with the investment contributes to continued high transition growth. We calibrate the gradual reduction of the tariff barriers over the period that gradually increases the openness of the economy. In addition to this, slow convergence to the steady state follows from imperfect substitution between domestic and foreign goods and convex adjustment costs in investment. The first assumption introduces two 'home' goods with endogenous prices, while the second assumption holds back the adjustment speed in capital accumulation.

Starting from the base year 1995, the transition growth serving as reference path is calibrated backwards. To reproduce the actual GDP of 1960, the initial level of the capital stock is reduced to about 4% of the base year level. The levels of labor supply and sectoral TFP are reduced by their constant annual growth rates of n and g, respectively. The balance between the state variables, capital stock and foreign debt, is important for the out of steady-state position and foreign debt is adjusted to reproduce the initial year. As shown in the IMF study of Kochhar et al. (1996), Thailand did not liberalize trade quickly (partly due to limited public finances), but rather implemented gradual trade liberalization. This is captured in the calibration by a gradual reduction of import tariffs along the transition path based on historical data. Both agricultural and industrial tariff rates (relative to import) fall gradually from 30% in 1960 to about 12% in 1995. The paths of real GDP for both actual data and the calibrated transition are shown in Fig. 1.

Given the initial 1960 economy, the calibration generates an intertemporal equilibrium growth path, and does not capture economic fluctuations experienced. When the economy is brought down below the steady-state path in 1960, increased marginal return to capital generates investment growth above 5.5% (though converging to the steady-state rate in the long run). As seen from Fig. 2, capital growth rate along transition is more than 8% in the beginning of the period.

Our productivity formulation assumes learning by doing generated by spillovers from abroad, where the TFP growth rates depend on the growth in total trade. The initial expansion of capital accumulation raises the need for imports, which causes more foreign technology spillovers and increases productivity growth. Fig. 3a–b shows an initial TFP growth rate of 3.5% in agriculture and 1.3% in industry, compared with 2.7% and 0.9%, respectively, in steady state.

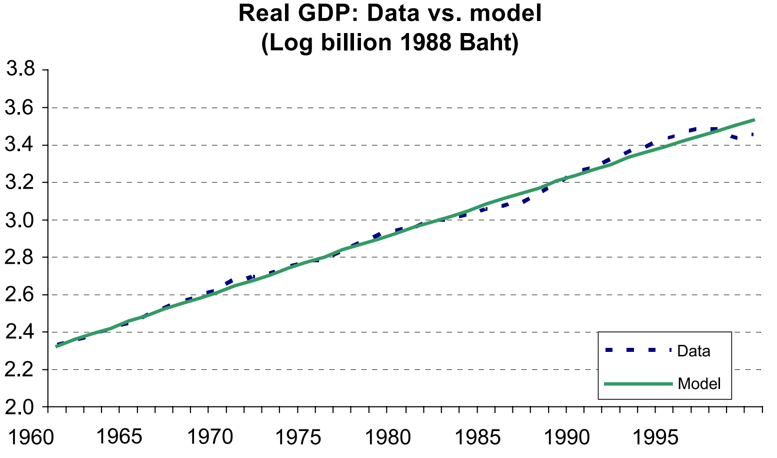

Fig. 1. Real GDP: data vs. model's transitional path.

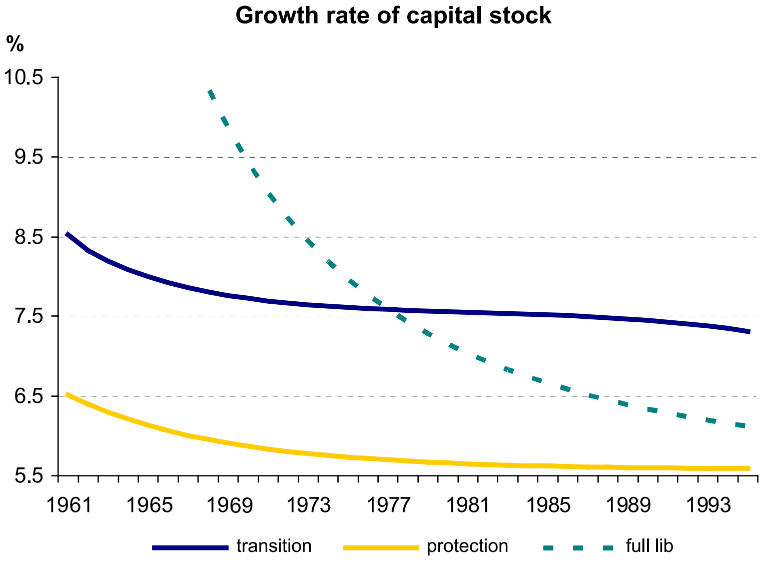

Fig. 2. Growth rate of capital stock, transition, protection and full liberalization.

The productivity–investment interaction, together with the gradual opening of the economy, generates high and prolonged transition growth well above the steady-state growth rate. Real GDP growth during the calibrated transition is initially close to 8% and stays above 7% for the entire period studied (Fig. 4). When import tariffs are gradually reduced, growth in total trade is kept above 7% per year. The growth in total trade feeds the productivity growth. This certainly contributes to the rapid growth of the economy and also stimulates capital accumulation by increasing the profitability of investment. Decreasing returns to capital gives an initial fall in the investment growth rate, but this is counteracted by high productivity growth and gradually less expensive capital goods from abroad. High capital growth again implies more imports and further stimulates productivity growth. In a counterfactual assuming exogenous (SS level) productivity growth (not reported), overall economic growth is reduced by close to 2% during the whole period.

Decomposing the transitional growth process shows clearly how endogenous improvement in TFP generates more capital accumulation. When the economy is brought down to the 1960 level, the accumulation of capital is the immediate dominating growth factor, and investment explains 75% of the growth in industry and 50% in agriculture. Productivity growth quickly picks up, driven by foreign spillovers related to trade. In the medium-run along the transition, improvement in productivity represents about 50% of growth in agriculture (as land productivity growth has to be high) and 20% of growth in industry, up from 40% and 10%, respectively, at the beginning of the period. Capital accumulation is always the dominating source of growth in industry (about 65% in the medium run). The decomposition consequently is in accordance with the general view that capital accumulation has been the major growth factor (Young, 1994 and followers), but clarifies the background importance of endogenous productivity. Since the labor supply grows

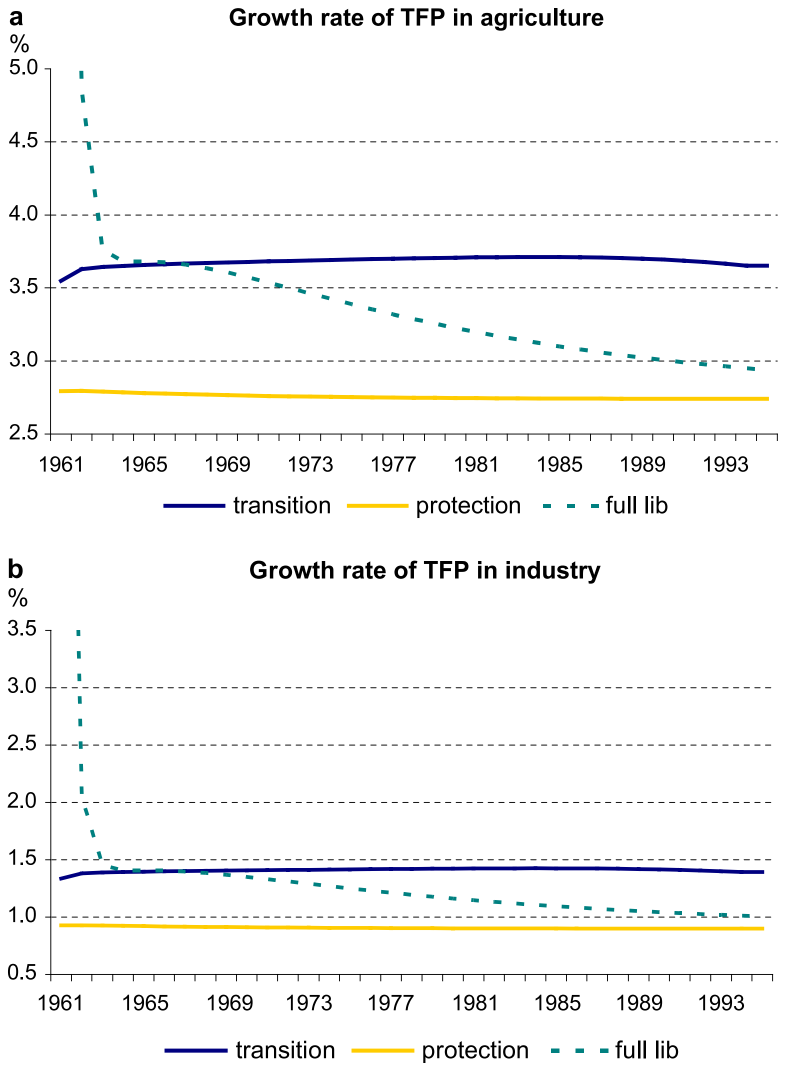

Fig. 3. (a) Agricultural TFP growth rate, transition, protection and full liberalization. (b) Industrial TFP growth rate, transition, protection and full liberalization.

exogenously at 2.8%, both sectors enjoy expansion of the employment, which contributes to 10–15% of growth.

The macroeconomics of the transition path shows the role of the open capital market assumed. With a smoothing consumption path, foreign capital inflows become important for the growth process. More than 80% of investment has to be financed by foreign inflows during the early years along the transition, up from 20% along the steady-state path. As the investment expansion needs more imports, the early inflows have to be financed by future export earnings. Of course, with the new production capacity and

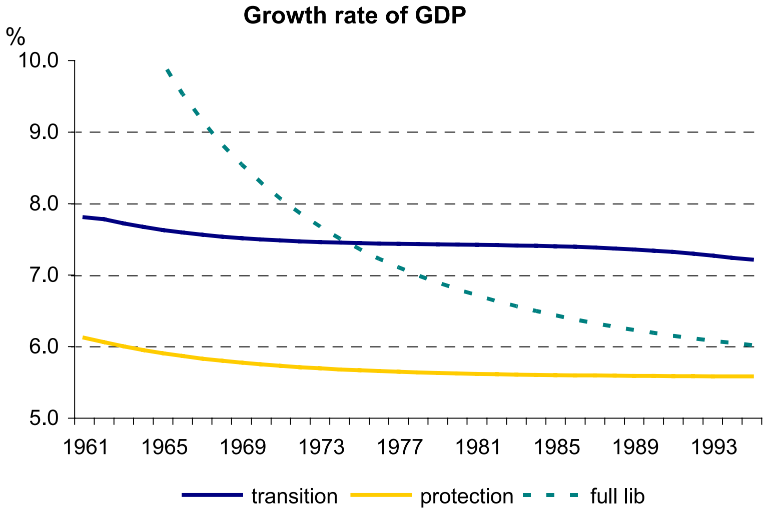

Fig. 4. GDP growth paths, transition, protection and full liberalization.

higher productivity, more exports are generated in the future. The handling of this intertemporal trade balance is the key to development success or failure. The model presented here and the Thailand application obviously tells the success version.

6. Counterfactual analysis of trade policy

The Thai economy has been outward oriented, and most analysts have attributed the growth performance to gradual trade liberalization and the access to foreign capital and technology (Karunaratne, 1999; Kochhar et al., 1996 in an IMF study). To evaluate the importance of openness for growth, two counterfactual experiments are constructed. In the first scenario ('protection'), the consequences of reduced openness are investigated assuming constant tariffs equal to the 1960 level for the entire period. In the second scenario ('full lib'), we analyze the growth implications of immediate reduction of tariffs to the 1995 level compared to the observed gradual reduction in tariffs. While others have studied trade liberalization in a static general equilibrium framework for Thailand (notably Karunaratne, 1999), we can offer an analysis of the dynamic consequences.

The direct effect of continued high tariff barriers is to raise the cost of investments as imports of capital goods become more expensive. Depressed investments, together with the reduction in imports, feed back to affect the productivity. The consequent drop in productivity growth strengthens the negative effect on investment profitability. Thus, the dynamic effects of protection are further augmented. While the initial tariff rates are equal to the transition path, the investment share of GDP immediately falls by 4 percentage points (from 56% in transition to 52% with protection). The drop in investment follows from intertemporal adjustment with perfect foresight, since expected lower tariffs in the future keep up investments with gradual tariff reductions. The consequences for the growth of the capital stock as well as GDP are significant. As shown in Figs. 2 and 4, the growth rates drop about 2 percentage points compared to the transition path.

The reduction of the growth rate creates a large income gap over time. The income gap due to protection is about 33% of real GDP after 20 years and widens to 50% at the end of the period (Fig. 5). Even though the growth rates in both scenarios-calibrated transition and protection-converge to the same steady-state growth rate (of 5.5%), i.e., even though the rapid growth is transitory, the loss in the national income due to protection is permanent. Thus, if we treat these two cases as two countries, Thailand, the more open economy, and one of the other developing countries which is less open, the protection adopted by the other country will produce a permanent income gap between this country and Thailand, unless the country changes its policy, opening up to the world and have more rapid growth.

The protectionism also has a detrimental effect on productivity. As discussed above, imports fall with the lower investment level and export growth is also reduced. The growth rate in total trade drops from 7% to 5.6%, which causes the spillovers to contract and growth in TFP to slow down (Fig. 3a–b). While the trade share increases from 50% to about 56% of GDP in transition, it falls to below 50% with protectionism, resulting in TFP growth slowdown. Fig. 3a–b implies that the TFP growth driven by high investment and high imports is missed out with protection. Along the new path, the TFP growth rate in industry is about 0.9%, while TFP growth in agriculture is far below 3%.

The dynamic productivity and growth effects in the protectionist alternative should be understood as an interaction between investment and learning by doing from the spillovers. The immediate reduction of investment with more expensive imports of capital goods affects the structure of the economy so that it is less adaptable to foreign technology spillover. The consequent drop in productivity growth strengthens the negative effect on investment profitability. The model offers a lesson about how the dynamics of productivity and investment may accumulate to serious income level effects over time. The conclusion

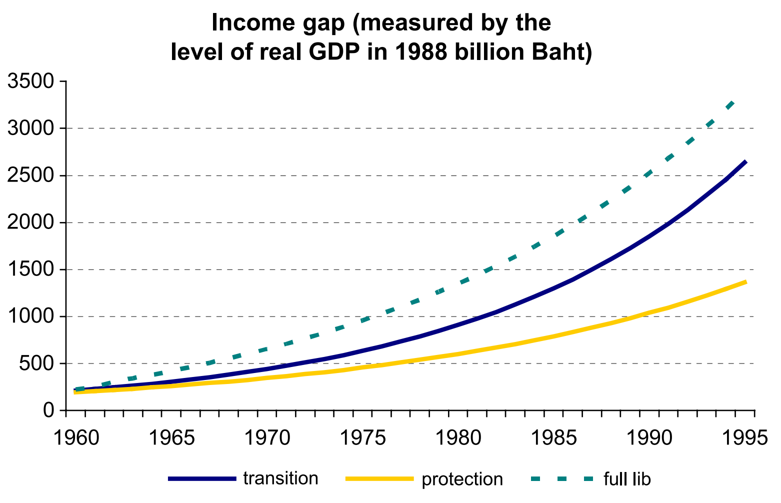

Fig. 5. Income gap between transition, protection and full liberalization.

is at odds with the literature arguing that protection gives room for manufacturing industries with productivity growth. The higher costs of imported capital and trade as channel for foreign spillover explain our result.

In the second counterfactual experiment, we compare gradual reduction of tariffs (as along the transition path) with immediate reduction of tariffs in 1961 from 30% to the 1995 level of 12%. The shock liberalization implies an economic development very different from the gradual transition. The reduction of tariffs generates an immediate and large increase in marginal return to capital, and the capital growth rate initially is almost 15%. Higher imports, especially of capital goods, and more exports generate very high productivity growth in both sectors the first couple of years. But after the immediate economic expansion, when the trade share of GDP is constant and capital accumulation decreases with marginal returns, the productivity growth falls below the transition rates already after 5–10 years (Fig. 3a–b). The decreasing returns to capital are not counteracted by productivity growth and, as seen from Fig. 2, the capital growth rate falls below the transition rate already in the mid-1970s.

The GDP growth rate under the 'full liberalization' scenario follows a similar pattern (Fig. 4). High growth initially is due to high capital accumulation and productivity growth, but it falls quickly over time with decreasing returns to capital and lack of growth of foreign spillovers. The extreme high growth rates in the early years generate an income gap in favor of the full liberalization scenario, but after the mid 1970s the gap is decreasing.

The counterfactual experiments illustrate the important role of gradual trade liberalization for Thailand's prolonged high growth path. Without the increased openness resulting from lower tariff barriers, the economic growth would have suffered, in particular because of less learning by doing from foreign spillovers. Immediate shock trade liberalization in the early 1960s would have led to higher income level even after 35 years, but the growth rates would have declined more quickly.

7. The role of substitution possibilities and relative prices

The growth process involves changes in relative prices reflecting the structure of the economy. Acemoglu and Ventura (2002) argue that terms of trade adjustment explain the decline and convergence of growth rates by high growth economies. Specialization in varieties forces the countries to run down demand curves at the world market. In our setup, the varieties are restricted, the world market demand is perfectly elastic, and the terms of trade are fixed in nominal terms. But the assumption of imperfect substitution between domestic and foreign goods allows an investigation of changes in relative prices driven domestically. The composite (imported and domestically produced) agricultural and industrial goods are applied for consumption and investment, and also the composite (exports and domestically consumed) exportables good adjusts to domestic prices. The Armington functions determine the variety composition of domestic goods and imports, while the CET (constant elasticity of transformation) functions determine exports versus domestic use.

We start out by comparing the benchmark transition path with the assumption of a 3.0 elasticity of substitution rate (between imports and domestic goods and between exports and goods produced for domestic markets) with two other paths in which a low (1.5) and high (6.0) elasticity of substitution is employed. As expected, the dynamic growth paths are seriously affected by the different possibilities for substitution. The model partially captures the Acemoglu–Ventura effect although the world prices are fixed.

When the elasticity of substitution is higher, the incentive to postpone current investment in order to take advantage of less expensive capital goods in the future is strengthened. As seen from Fig. 6a–b, the initial capital growth rate is lower in the high elasticity alternative. Over time the effect of gradual tariff reduction (both directly and via productivity growth) is stronger, and the growth rate of capital accumulation increases. The standard decreasing return to capital effect is dominated by the positive impact of less expensive capital goods and higher productivity growth, and the capital growth rate increases to almost 8%. The productivity effect follows from more foreign spillovers with better substitution between domestic and foreign goods. Increased capital accumulation over time raises the need for imported capital goods and further stimulates productivity growth. The expansion of production generates higher export growth and, hence, over time TFP growth is higher when substitution possibilities are better, driven both by export and import growth.

The consequences for the GDP growth rate follow from the effects on capital accumulation and TFP explained above. With high elasticity, we hence observe increasing growth rate over time, since decreasing returns to capital is avoided and TFP growth rates increase. With low elasticity (half of the base value), it is harder to take advantage of less expensive import goods in the future. The incentive to postpone current investment is weaker and we observe higher capital growth initially. Decreasing returns to capital is not counterbalanced by the endogenous productivity effect, and capital accumulation and GDP growth fall more rapidly than in the transition benchmark.

The faster convergence to steady state with low elasticity of substitution is a puzzle compared to the standard understanding of the small open economy. In the case of low elasticity, domestic and export goods are like different goods for the producer. The domestic demand pressure under early transition and the following increase in the relative price of domestic goods have little effect for export production. When exports are kept up during early transition, the dynamic foreign constraint allows for large investment and high foreign savings. Exports are independent of the domestic market, and the country can take more immediate benefit of trade and capital markets. The development looks like the small open economy, but here this follows when the substitution possibilities between domestic and export goods are small in supply.

The standard understanding is that the small open economy with perfect capital market implies high growth transition quickly returning to the steady state. The global market is no constraint on prolonged high growth because the economy can expand along perfectly elastic export demand curves. Acemoglu and Ventura (2002) show how price-response at the world market under specialization leads to decline in growth rates. The Thailand model offers insight about another mechanism related to relative prices and exports adjustment. When there is high substitution between domestic and export goods supply, similar to the small open economy, resources are easily shifted out of exports to satisfy domestic demand under early transition. The worsening of the exports growth path will reduce early transition growth. The medium run consequences depend on the productivity dynamics.

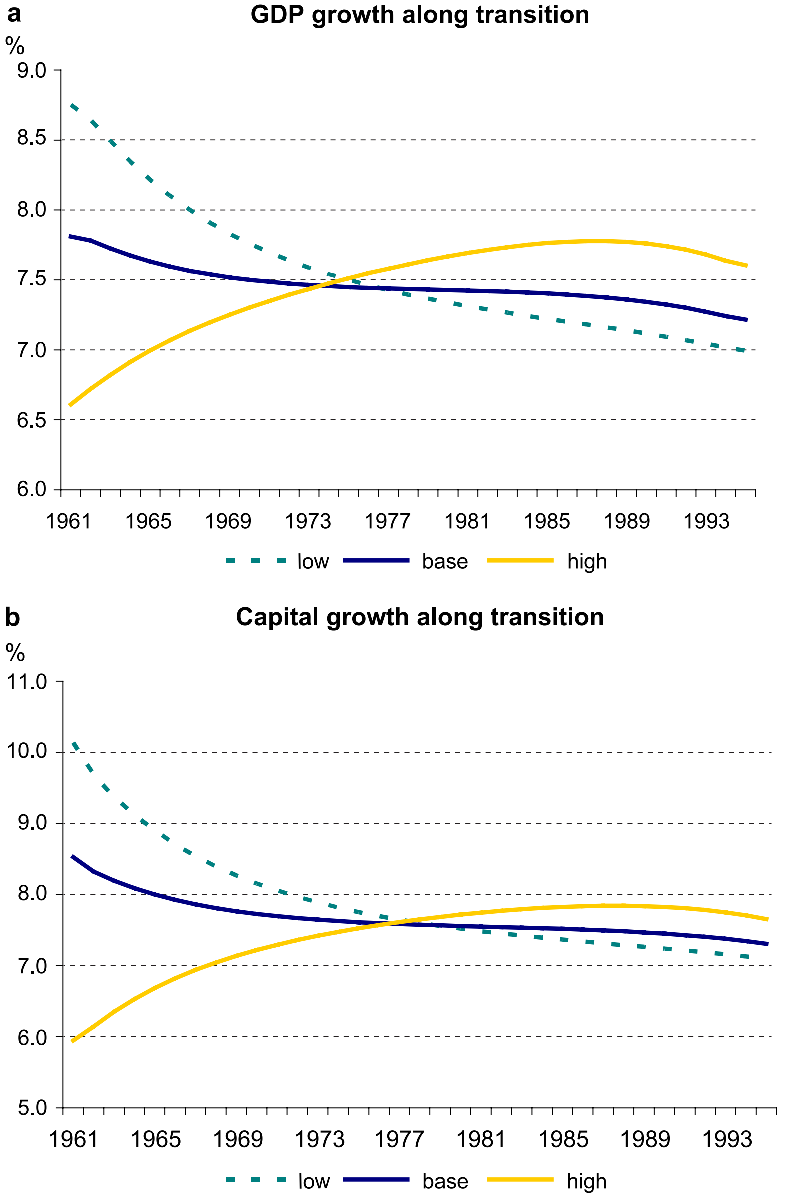

Fig. 6. (a) GDP growth rate along transition with different elasticities of substitution. (b) Capital growth rate along transition with different elasticities of substitution.

With the endogenous response of productivity to openness assumed here, gradual expansion of exports will raise productivity over time and keep up transition growth.

8. Concluding remarks

Thailand has experienced economic growth well above world averages from 1960 to the recent crisis. It is a challenge to understand the sources of this high growth path, and in particular why growth has not slowed down with assumed decreasing returns to capital. We develop an intertemporal general equilibrium model separating between agriculture and industry, and with open capital market and endogenous productivity growth to analyze the underlying adjustment mechanisms. Foreign technology spillover embodied in trade is assumed to be the driving force of the productivity growth, consistent with available econometric evidence. The high growth experience is understood as a transition path with interaction between productivity growth, openness and capital investment. Gradual reduction of tariffs is a key factor explaining prolonged transition. Counterfactual analysis shows how protection may have had serious detrimental effect on the growth rate due to productivity and investment slowdown with less foreign spillovers. On the other hand, shock liberalization would have raised initial growth and income level during the period studied, but would have given less stimulus to productivity growth over time.

The substitution possibility of the economy affects the growth path. In experiments using higher and lower substitution elasticities in both exports and imports compared to the calibrated transition growth, we show how increased substitution possibilities strengthen the incentive to take advantage of cheaper capital goods in the future with gradual tariff reductions. The standard understanding is that the small open economy with perfect capital market implies high growth transition quickly returning to the steady state. When there is high substitution between domestic and export goods supply, similar to the small open economy, resources are easily shifted out of exports to satisfy domestic demand under early transition. The worsening of the exports growth path will reduce early transition growth. The medium run consequences depend on the productivity dynamics. With the endogenous response of productivity to openness assumed here, gradual expansion of exports will raise productivity over time and keep up transition growth.

Our analysis contributes to the literature evaluating short and long-run effects of trade liberalization. Diao et al. (1999) show how trade liberalization may give short-run welfare gain, but long-run welfare loss in Japan. Their explanation is that liberalization gives domestic industrial expansion, but then crowds out foreign spillovers over time. Compared to Japan, Thailand's trade protection has concentrated more on industry than agriculture. Rauch (1997) finds that trade liberalization in Chile gives short-run growth decline, but long-run welfare gain. In his model, trade liberalization gives specialization in traded goods with productivity growth, but immediate contraction in the non-traded sector. In this Thailand model, industry and growth is hurt by protectionism in the short and the long run, over time the effect is driven by the relationship between openness and productivity growth. It is a challenge to investigate more closely the dynamics of the productivity relations assumed here and factors affecting technology adoption and learning from abroad. An alternative dynamic formulation with multiple equilibria is analyzed by Stokke (2004).

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Appendix A. Calibration

The parameters in the production, demand and trade functions are set according to the method adopted in most static computable general equilibrium models and are based on a 1995 SAM. The original SAM is provided by the National Economic and Social Development Board (NESDB) in Thailand and includes 180 production sectors, which are aggregated into two sectors (agriculture and industry). The domestic savings rate is about 40% and investment accounts for 50% of GDP. Domestic savings finance 80% of investment, while the other 20% is financed through foreign capital inflows. The agricultural value-added accounts for 12% of GDP, while industry represents the remaining 88%. The indirect taxes in agriculture and industry are 0.8% and 8.3% of GDP, respectively. The elasticity of substitution in both the Armington and CET functions are assumed to be 3. These elasticities represent substitution possibilities between domestic and foreign goods (Armington), and between sales to domestic markets versus export markets (CET).

The parameters determining the intertemporal equilibrium path follow from the steady-state conditions (5.5% growth rate) given a few key assumptions. The domestic interest rate is set to 0.09 based on IMF (2000) and the depreciation rate is set to 0.10. The initial capital stock and investment are derived from the steady-state condition (15) using data from the SAM. Eqs. (13) and (17), together with the depreciation rate and the marginal return to capital (0.14), are used to calibrate the shadow price of capital, q, and the coefficient, a, in the capital adjustment cost function. The initial level of foreign debt is calibrated from Eq. (16) given the data about trade deficit/surplus in the SAM, given the chosen interest rate and long-run growth rate. The time preference rate is the residual from the Euler Eq. (11) and is 0.032. Gradual tariff reductions are based on the NESDB SAMs for 1975 and 1998 and a tariff path is interpolated for the period 1960–1995. Tariffs are set to 30% in 1960, decreasing gradually to 12% in 1995, and this is broadly consistent with other data (World Bank Tables).

The levels of TFP by sector and the relationships between TFP and foreign trade in Eqs. (7) and (8) are also calibrated from the SAM and based on the econometric evidence discussed in Section 2. The foreign spillover effect of trade is assumed proportional to both labor augmenting and land augmenting technological progress, but to be consistent with the steady-state foreign trade is scaled by labor supply for labor augmenting technical progress. Given the labor share in industry, the elasticity of industrial TFP with respect to trade is 0.3. The calibration of the agricultural TFP path is harder, since the model assumes fixed land while the TFP calculations are based on increased land input. The area of cultivated land in Thailand has been about constant over time, but the share of the land irrigated has increased from 15% to 28% during the period of study (World Bank, 2001). A large part of the agricultural productivity growth results from increased irrigation. Given the fixed land assumption of the model, the elasticity of technological spillover from

Appendix Table 1
Values of selected parameters and variables (initial value for endogenous variables)

Definition	Symbol in the model	Value
Parameters		
Share of labor in agriculture	β_1	0.21
Share of labor in industry	α	0.34
Share of capital in agriculture	$1-\beta_1-\beta_2$	0.39
Share of capital in industry	$1-\alpha$	0.66
Share of land in agriculture	β_2	0.40
Distribution parameter Armington function for agriculture	ma_{A}	0.32
Distribution parameter Armington function for industry	ma_{M}	0.42
Distribution parameter Armington function for agriculture	mc_{A}	0.64
Distribution parameter Armington function for industry	mc_{M}	0.61
Coefficient in adjustment cost	a	0.79
Elasticity in Armington function	σ_{m}	3.00
Elasticity in CET function	σ_{e}	3.00
Time preference rate	ρ	0.032
Depreciate rate	δ	0.10
Elasticity of spillover in agriculture		0.6
Elasticity of spillover in industry		0.3
Exogenous variables		
Steady-state growth rate	$n+g$	5.5
Growth rate of labor	n	2.8
Growth rate of technology	g	2.7
World interest rate	r	0.09
Endogenous variables		
Marginal returns to capital	$Rk+aP_{\mathrm{M}}(I/K)^2$	0.16
Marginal product of capital	Rk	0.14
Derivative of adjustment cost w.r.t. capital	$-aP_{\mathrm{M}}(I/K)^2$	−0.02
Shadow price of capital	q	0.84
Adjustment cost per unit of investment	$aP_{\mathrm{M}}I/K$	0.12
TFP in agriculture	$\tilde{A}_{\mathrm{A}}$	2.97
TFP in industry	$\tilde{A}_{\mathrm{M}}$	1.19
Labor-augmenting technical progress	A	1.67
Land-augmenting technical progress	A_{D}	11.57

foreign trade in the agricultural TFP function is adjusted up and set to 0.6. Overview of the calibrated parameters and initial values of the intertemporal variables are shown in the appendix table below.

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