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Productivity Growth and Organizational Learning

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Abstract

A new specification of the sources of productivity growth is offered. Motivated by the lack of innovation and technology adoption in backward economies, a third channel of growth related to organizational structure, work ethics, and discipline in the production process (for simplicity called organizational learning) is suggested. The suggested specification generates new insights about the dominating source of growth during the development process: organizational learning in backward economies, technology adoption in middle-income economies, and innovation in developed economies. This adds to the current understanding of development as a transition from technology adoption to innovation. Numerical simulations of the Thai catch-up process since 1965 illustrate the importance of organizational learning. A counterfactual experiment shows how investments in secondary education contribute to the move from organizational learning to adoption of more advanced foreign technology.

1. Introduction

The literature typically distinguishes between innovation and technology adoption as sources of productivity growth. According to the catching-up hypothesis (Nelson and Phelps, 1966), poor countries grow out of backwardness by adopting foreign technology. But this optimistic view of backwardness lacks empirical support.[1] The modern technology can be hard to take advantage of in poor countries due to inappropriateness (formalized by Basu and Weil, 1998). In a model with multiple convergence clubs, Papageorgiou (2002) argues that backward economies are not able to adopt foreign technology. Economies below a given threshold value of the technology gap are assumed to grow exogenously at a low rate, but the sources of growth are not specified. We offer a new specification of productivity growth that broadens the understanding of productivity improvements in backward economies. In addition to innovation and technology adoption, we model a third channel of growth related to better organization and production structures, improved work ethics and more discipline in the production process (for simplicity called organizational learning).

The productivity specification includes domestic and international barriers to growth, measured by the educational level of the labor force and the degree of openness, respectively. Productivity growth from organizational learning is determined by the degree of openness in the economy and the technological distance to the frontier. The understanding is that an open trade regime, inflows of foreign direct investment (FDI), and entry of multinational companies generate productivity improvements related to organizational structure and work ethics. Interaction with the rest of the world through trade and FDI also stimulates the transfer of foreign technology, which

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means that we separate between two channels of international productivity spillovers: adoption of highly advanced frontier technology and more basic productivity enhancing factors related to organizational learning. Consistent with the empirical analysis of Baumol et al. (1989) and the recent theoretical contribution by Vandenbussche et al. (2006) we assume that the ability to utilize foreign technology depends on the degree of secondary education in the labor force, while tertiary education is more important in R&D activities. The productivity specification generates multiple convergence clubs. Consistent with recent barrier models (Parente and Prescott, 2005; Ngai, 2004), there exists an endogenous critical value of the technology gap determining whether countries catch up towards the frontier or diverge. The threshold gap is endogenous and differs between countries and over time depending on the degree of barriers in the economy. The understanding is that countries below the threshold have not yet managed to start modern growth due to the high level of barriers.

In a recent theoretical investigation of the way out of backwardness, Acemoglu et al. (2006) distinguish between investment-based growth with adoption of foreign technology and innovation-based growth. They see economic development as a movement from adoption-oriented early stages to innovation-based growth later on. Our suggested productivity specification generates new insights related to the main source of growth during the development process. Consistent with the analysis of Acemoglu et al. (2006), economies experience a shift of focus from technology adoption to innovation as they approach the frontier. But productivity growth in backward economies is related to organizational learning, and not adoption of advanced frontier technology. As economies develop, technology adoption gradually takes over as the engine of growth. The dominating source of productivity growth during the development process is hence characterized by three stages: organizational learning in backward economies, technology adoption in middle-income economies, and innovation in developed economies. In this respect, our specification represents an extension of the two-stage development from adoption to innovation.

The second part of the paper investigates the empirical relevance of the suggested productivity specification, and focuses on the case of Thailand. Compared to other successful Asian economies, Thailand has a low-educated labor force and has specialized in low-tech labor-intensive industries. Even after four decades of high growth, about 60% of Thai workers have only primary education or less. To quantify the relative importance of organizational learning in the growth experience, we offer numerical simulations of the catch-up process. The productivity dynamic is put in a dynamic general equilibrium framework, and the model is calibrated to reproduce the main elements of the economic development during 1965–2005 and projected to 2015.

The simulations illustrate the changing sources of growth during the catch-up process. In the early stages, organizational learning accounts for about 70% of productivity growth. As the economy catches up and investment in secondary education increases, technology adoption gradually takes over as the engine of growth. The contribution from innovation is low during the entire period. To investigate the impact of recent investment in secondary education on future productivity dynamics and sources of growth, the calibrated Thai path is compared to a counterfactual path where the share of the labor force with secondary education is kept constant after 2000. The results show that investment in secondary education is important to manage the transition from basic productivity improvements to adoption of more advanced foreign technology.

The productivity dynamics is presented in section 2, while section 3 discusses the implications of the suggested specification for the sources of growth during the development process. Section 4 puts the productivity dynamics in a general equilibrium setting. Section 5 gives a brief characterization of the Thai growth experience, while section 6 applies the general equilibrium model to the case of Thailand and offers numerical simulations of the catch-up process. A counterfactual experiment illustrates the impact of recent educational investments on future growth. Section 7 concludes.

2. Productivity Dynamics

Innovation and technology adoption are typically regarded as the main sources of productivity growth, but in backward economies R&D activity is limited (Cameron, 1998) and the frontier technology can be hard to take advantage of due to inappropriateness. As argued by Papageorgiou (2002, p. 351), “it is doubtful that an Ethiopian farmer will benefit from the latest advances in animal genetics, or an Indian doctor from the latest innovations in laser surgery, or a Nepalese shopkeeper from the latest innovations in computerized inventory control”. Motivated by the lack of innovation and technology adoption in backward economies, we suggest a third channel of growth related to organizational learning.

The broad understanding of cross-country productivity differences is related to barriers and a large empirical literature has addressed the importance of barriers in economic growth. Cole et al. (2005) find a significant impact of domestic and international competitive barriers on Latin American productivity. Domestic barriers are linked to competitive restrictions such as entry barriers, inefficient financial systems, and subsidized state-owned enterprises. Benhabib and Spiegel (1994) emphasize the role of human capital as local barriers to growth. International barriers are typically measured by the degree of openness in the economy. Rodriguez and Rodrik (2001) criticize the empirical trade-growth literature due to methodological problems, and claim that the positive relationship is questionable. Harding and Rattsø (2005) address the endogeneity problem of openness and concentrate on tariff measures, while Lee et al. (2004) utilize a new methodology of identification through heteroskedasticity. Both analyses confirm the positive impact of openness on economic growth. We focus on the combined role of international and domestic barriers measured by the degree of openness and the human capital level, where the latter is related to the educational level of the labor force.

The understanding of organizational learning is related to basic productivity enhancing factors like organization of the production process, work ethics, motivation and discipline. Such productivity improvements are typically not skill-intensive, but are likely to benefit from international spillovers through foreign direct investments and entry of multinational companies, which bring with them their organizational structure, work ethics and effort demands. We hence relate organizational learning to the openness of the economy rather than the skill level of the labor force. In addition, we apply the Nelson–Phelps technology gap formulation, which implies that the growth potential from new organizational practices increases with the distance to the frontier. The technology gap is entered linearly (and not exponentially), which limits the advantage of relative backwardness.

The growth contribution from technology adoption is affected by both domestic and international barriers. More interaction with the rest of the world through trade and FDI stimulates the transfer of foreign technology, and the ability to take advantage of the new technology depends on the extent of secondary education in the labor force. While the catching-up hypothesis assumes a positive relationship between technology adoption and the distance to the frontier, we follow the formulation in Lau and Wan

(1993), where the technology gap has two opposite effects on the adoption of foreign technology. The learning potential increases with the distance to the frontier, but a larger technology gap also makes the modern technology less appropriate and harder to take advantage of for the domestic economy. The modern technology becomes more appropriate as the economy catches up, but the profitability of adoption is counteracted by gradual saturation of adoption opportunities. This gives a nonlinear relationship between adoption and the technology gap.

While the ability to adopt foreign technology is related to the degree of secondary education in the labor force, innovation and R&D activities typically depend on the level of tertiary education. In addition, the growth potential from innovation is assumed to increase as the economy approaches the frontier.

We define productivity growth ($\hat{A}$) as:

$$\hat{A} = f(h_i)\frac{A}{A^*} + g(h_a)k(o)\left[\frac{A}{A^*} - \left(\frac{A}{A^*}\right)^2\right] + l(o)\left(1 - \frac{A}{A^*}\right) \quad (1)$$

where h_i and h_a are the shares of the labor force with tertiary and secondary education, respectively, o is the degree of openness, A^* the productivity level at the technological frontier and A/A^* is the technology gap. The first term on the right-hand side is the contribution from innovation, the second term is the technology adoption function, and the last term represents productivity improvements from organizational learning. The functions $f(h_i)$, $g(h_a)$, $k(o)$, and $l(o)$ all have positive first derivatives.

The suggested productivity specification is consistent with multiple convergence clubs and technological divergence. As opposed to the catching-up hypothesis, middle-income economies have the best growth potential, and there exists a threshold value of the technology gap determining whether economies catch up or diverge relative to the frontier. The threshold gap for catch-up is endogenously determined by the level of barriers to growth, and varies across economies and over time. Countries at the same level of development may face different threshold values. The higher the educational level of the labor force and the higher the degree of interaction with the rest of the world through trade and FDI, the more backward the economy can be and still be able to catch up with the frontier. Assuming constant educational levels and degree of openness, the productivity dynamics are illustrated in Figure 1.[2]

The horizontal axis shows the relative position to the frontier, while the productivity growth rate is given on the vertical axis. The further to the left the economy is positioned, the larger is the technology gap. Productivity growth at the frontier is set exogenously equal to g. When the domestic productivity growth rate exceeds the growth rate of the frontier, the economy is catching up and the gap decreases. Equivalent, lower productivity growth rate than the frontier increases the gap, as illustrated by the arrows in Figure 1. A range of empirical studies of the pattern of economic growth are consistent with the assumed productivity dynamics in the model. Thorbecke and Wan (2004) document a nonlinear relationship between growth and GDP level with backward economies stuck in a poverty trap. The evidence implies increasing growth rate in the early stages of catching up with highest growth in middle-income economies.

The model generates increasing productivity differences over time, since some countries are catching up while others are stuck in a poverty trap with technological divergence. The timing and the degree of catch-up vary between countries depending on the level of barriers, consistent with the empirical analysis of Ngai (2004). Economies below the threshold gap have not yet managed to start modern growth because of high barriers to growth (applies to most of Sub-Saharan Africa today). The common

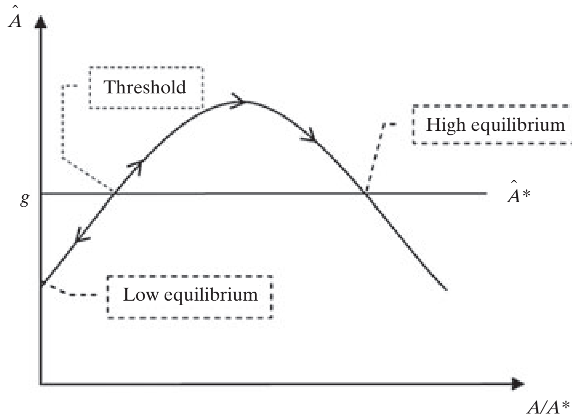

Figure 1. Productivity Dynamics (assuming constant educational levels and constant degree of openness)

understanding in the literature is that increasing productivity differences between countries are a transitional phenomenon. Growth miracles (or disasters) cannot last forever, and economies eventually return to world growth normals. Differences in growth rates are transitory, while differences in productivity levels are permanent (Acemoglu and Ventura, 2002). The model captures this long-run state through the endogenous nature of the threshold gap. Economies lagging behind can escape the poverty trap by investing in human capital or limiting international barriers. With a gradual reduction of barriers to growth the threshold gap asymptotically approaches zero, and most countries experience some degree of catch-up and converge to a common growth rate. But a shift from the low to the high convergence club does not necessarily generate a long period of high growth. The degree of catch-up depends on the level of barriers, and the economy may quickly reach the world growth rate with a permanent and large technology gap relative to the frontier.

3. Sources of Productivity Growth During the Development Process

Given our suggested productivity specification with organizational learning as an additional channel of growth, we investigate how the driving force of growth changes during the development process. Based on the productivity specification in equation (1), the three sources of growth are given as:

$$\hat{A}_I = f(h_i)\frac{A}{A^*}, \tag{2}$$

$$\hat{A}_A = g(h_a)k(o)\left[\frac{A}{A^*} - \left(\frac{A}{A^*}\right)^2\right], \tag{3}$$

$$\hat{A}_S = l(o)\left(1 - \frac{A}{A^*}\right), \tag{4}$$

where $\hat{A}_I$, $\hat{A}_A$ and $\hat{A}_S$ represent the growth contribution from innovation, technology adoption and organizational learning, respectively.

As illustrated in Figure 1, backward economies might get stuck in a poverty trap with technological divergence due to significant domestic and international barriers. Increasing technological distance to the frontier limits the growth potential from R&D, and makes the modern technology inappropriate and hard to take advantage of for the domestic economy. This implies that productivity improvements in backward economies are mainly generated through organizational learning. This result differs from the predictions of growth analysis in the Nelson–Phelps tradition, where backward economies catch up with the frontier by adopting modern technologies from abroad.

In economies above the threshold gap, the relative importance of the different sources of growth changes during the catch-up process. In the early stages organizational learning is an important factor of growth, but increasing degree of technological contact with the frontier gives lower costs of adoption as the economy catches up. Modern technologies become more appropriate to the local production process, and the driving force of productivity growth gradually shifts from organizational learning to technology adoption. Investment in secondary education may be crucial to manage the movement from simple organizational improvements to adoption of more advanced foreign technology (as illustrated by the numerical simulations in section 6). According to our suggested productivity specification, technology adoption is not highest in backward economies, but rather in middle-income economies. Eaton and Kortum (1997) document that about 80% of post-World War II growth in Germany, France, the United Kingdom, and Japan is due to foreign innovations, which supports the high importance of technology adoption in middle-income economies.

Later in the catch-up process, gradual saturation of adoption opportunities results in higher dependence on domestic innovation. This is consistent with the empirical analysis of the Japanese growth experience by Cameron (2005), who documents an increasing reliance on R&D as the economy approaches the frontier. During the period of study, Japan's productivity level relative to the US increases from about 0.5 in 1955 to 0.9 in 1989, and the shift towards innovation is most significant after the Japanese productivity level has exceeded about 80% of the US level. The higher degree of catch-up in the high equilibrium, the more dependent the economy is on innovation versus adoption in generating productivity growth. As documented by Eaton and Kortum (1997) more than 40% of growth in the US since 1950 is due to foreign innovations. This implies that even close to the frontier, economies use resources to adopt and learn from others in equivalent positions. Our analysis makes the simplifying assumption that productivity growth at the frontier (when $A = A^*$) is entirely driven by innovation through R&D activities. A more realistic specification of the frontier growth would only complicate the analytical solution and not change other results to a large extent.

The suggested productivity specification generates new insights about the relative importance of different sources of growth as the economy catches up with the technological frontier. The dominating force of growth during the development process is characterized by three stages: organizational learning in backward economies, technology adoption in middle-income economies, and innovation in developed economies (Figure 2).[3] This adds to the current understanding of development as a transition from

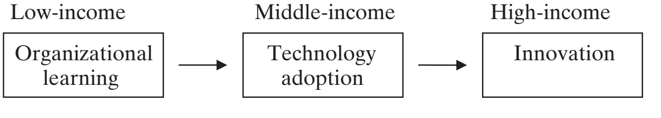

Figure 2. Main Source of Productivity Growth along the Development Process

technology adoption to innovation as suggested by Acemoglu et al. (2006), among others.

4. The Dynamic General Equilibrium Model

To capture the endogenous interaction between productivity growth, openness, and education, the productivity dynamics is put in a dynamic general equilibrium framework. We apply the model setup of Stokke (2004) as a benchmark, but offer a more disaggregated specification of the sources of productivity growth. We model the aggregate economy, and do not consider sectoral interactions. The economy faces a perfect capital market with the interest rate exogenously given from the world market. The representative household is forward looking and allocates its income to consumption and savings to maximize its intertemporal utility. Capital investments are based on intertemporal profit maximization, and can be financed through foreign borrowing. The decisions about savings and investment can therefore be separated, although with a long-run restriction on foreign debt. The model is consistent with neoclassical convergence driven by decreasing returns to capital. The long-run growth rate is exogenously given, while transition growth is endogenous. Adjustment costs of investments, imperfect substitution between domestic and foreign goods, and endogenous productivity growth contribute to prolonged transition dynamics. The complete model description and calibration of parameters are given in a separate appendix, while the productivity specification is discussed below.[4]

Value added production (X_t) is a Cobb–Douglas function of capital (K_t) and labor (L_t):

$$X_t = A_t^{\alpha} L_t^{\alpha} K_t^{1-\alpha}, \tag{5}$$

where A_t is labor augmenting technical progress. Total factor productivity (tfp_t) is defined as:

$$tfp_t = A_t^{\alpha}, \tag{6}$$

which gives the following relationship between the rate of labor augmenting technical progress and the total factor productivity growth rate:

$$\hat{tfp}_t = \alpha \hat{A}_t. \tag{7}$$

Compared to equation (1), we assume specific functional forms, and measure the degree of openness by total trade as share of GDP, which is endogenous in the model. The rate of labor augmenting technical progress is hence specified as:

$$\hat{A} = b_1 h_i^{\gamma_1} \frac{A}{A^*} + b_2 h_a^{\gamma_2} \left(\frac{Trade}{GDP}\right)^{\gamma_3} \left[\frac{A}{A^*} - \left(\frac{A}{A^*}\right)^2\right] + b_3 \left(\frac{Trade}{GDP}\right)^{\gamma_4} \left(1 - \frac{A}{A^*}\right), \tag{8}$$

where A^* is the productivity level at the technological frontier, A/A^* the technology gap, h_i and h_a are the shares of the labor force with tertiary and secondary education, respectively, while b_1, b_2, and b_3 are positive constants. The transitional and long-run properties of the assumed productivity specification are consistent with the dynamics in Figure 1. The educational shares are exogenous, and are calibrated based on historical data (as documented in section 6). The elasticity of innovation-driven productivity growth with respect to h_i is given by γ_1, while γ_2 is the elasticity of technology adoption with respect to h_a. The elasticities of technology adoption and organizational learning with respect to the trade share are given by γ_3 and γ_4, respectively. The chosen values of these elasticities are based on available empirical estimates.

In the long-run equilibrium the growth rate of the capital stock and the foreign debt approaches a constant rate given by $g + n$, where g is the long-run growth rate of labor augmenting technical progress (which equals the frontier growth rate) and n is the labor supply growth rate. This means that a long-run position below the threshold gap for catch-up represents an unstable equilibrium in the present model.

5. Empirical Relevance of the Productivity Specification: Case Study of Thailand

Thailand achieved remarkably high growth from 1960 until the Asian crisis in the late 1990s with an average annual GDP growth rate of almost 8%. It is a common understanding that the growth was driven by a combination of investments and productivity (Diao et al., 2005). An open trade regime with large inflows of foreign direct investments combined with entry of multinational companies is an important factor in the growth success. But the traditional separation between innovation and technology adoption as sources of productivity growth does not give a good description of the Thai experience. Investments in human capital and R&D activities do not characterize the catch-up process. Productivity growth is certainly related to openness and international spillovers, but is not driven by adoption of highly advanced frontier technology. Thailand has typically specialized in low-tech labor-intensive industries. We argue that a broader view of the sources of productivity growth, taking into account the importance of organizational learning, can contribute to the understanding of the Thai growth experience.

Both export and GDP composition indicate that Thailand has specialized in relatively less technologically sophisticated industries than other high growth countries in Asia. The economy has been highly dependent on agricultural production, and food exports accounted for more than half of total merchandise exports until the mid 1980s. Manufacturing exports are increasing over time, but are dominated by typically low-tech labor-intensive industries such as textile and food manufacturing (at least until the mid 1990s). The importance of high-tech exports during 1975–2003 is illustrated in Table 1.[5] The share of high-tech exports in total manufacturing exports was low in the 1970s and early 1980s. It has increased since the mid 1980s, but is still significantly lower than in Singapore and Malaysia and about equal to the average share for the East Asian region as a whole (World Bank, 2006).

Table 1. Thai High-Tech Exports as Share of Total Manufacturing Exports

	%
1975	1.8
1980	1.0
1985	5.7
1990	17.7
1995	26.7
1998	33.4
2003	30.2

Table 2. Composition of the Labor Force according to Educational Level in the late 1980s

	No education	*Primary*	*Secondary*	*Tertiary*
Thailand	7%	83%	2%	8%
Hong Kong	5%	44%	37%	14%
Japan	2%	29%	47%	22%
Malaysia	13%	59%	20%	8%
Singapore	20%	29%	31%	20%
South Korea	27%	19%	39%	15%

Table 3. Composition of the Thai Labor Force according to Educational Level, 1988 and 2005

	No education	*Primary*	*Secondary*	*Tertiary*
1988	7%	83%	2%	8%
2005	4%	57%	26%	14%

The importance of low-tech production is reinforced when we consider the educational level of the labor force. Thailand is characterized by an extremely high share of workers with only primary education and a similarly low share of workers with secondary education. As seen from Table 2, about 90% of Thai workers had only primary education (or no education at all) in the late 1980s.[6] The 1960s and 1970s were dominated by investment in primary education. The primary enrollment ratio increased from 78% in 1965 to almost 100% in the mid 1980s, while enrollment in secondary education remained low and was among the lowest in the Asian region (17% in 1970). In 1991 the secondary enrollment ratio in Thailand was 31%, which is still well below that of other high growth Asian countries and also lower than the region average. But significant investments in secondary education during the 1990s resulted in a rate of 85% in 2001. The tertiary enrollment ratio increased from 32% to 41% during 1999–2004, and is relatively high compared to other East Asian countries.

As seen from Table 3, even after four decades of high growth, about 60% of Thai workers have only primary education or less.[7] This indicates that the growth process has been characterized by low-tech production with basic productivity improvements related to organizational learning rather than adoption of advanced foreign technologies.

Today, Thai public spending on education (both as share of GDP and as share of total public expenditures) is higher than the average share in the region, and also higher than most of the other high growth East Asian economies. The educational reform of the late 1990s raised compulsory education from six to nine years and introduced twelve years of free education. Expenditure on research and development, on the other hand, is close to zero (as a share of GDP). Similarly, the number of researchers in R&D (per million people) is lower than the average for the East Asia and Pacific region, and well below countries such as Hong Kong, Japan, South Korea, and Singapore. This indicates that innovation-based growth is still not relevant for the Thai economy.

Several policy studies (World Bank, 2000; 2001) identify lack of skills and education as a major obstacle to global competitiveness and future growth. Since Thailand is gradually losing its comparative advantage in low-tech labor-intensive production (partly due to the entry of China), sustainable growth in the future requires adoption of more advanced technologies. In this respect, the recent investments in secondary and tertiary education are important. The rapid expansion of secondary enrollment ratios in the 1990s has increased the educational level of the labor force, but the process is slow and the majority of Thai workers still have only primary education or less.

6. Sources of Growth in the Thai Catch-up Process and Impact of Educational Investments

As documented in the previous section, specialization in low-tech labor-intensive industries together with a low-educated labor force distinguishes Thailand from other successful Asian countries. Based on the general equilibrium model described in section 4 we offer numerical simulations of the Thai growth experience. First, we calibrate the model to reproduce the main elements of the economic development during 1965–2005 (but ignoring the Asian crisis), and analyze the sources of productivity growth during the catch-up process. Second, we apply a counterfactual experiment to investigate the importance of recent educational investments on future growth.

The economic growth of the period under study is of transitional character, but is consistent with a long-run growth path. The steady state growth rate is set to 5.2% (2.7% technological progress rate and 2.5% labor growth). The initial level of the capital stock is assumed to be below the long-run path, and labor supply and foreign debt are adjusted down accordingly. The initial technology gap is set so as to reproduce the observed total factor productivity (TFP) growth rate in Thailand. The scaling back serves as an exogenous shock that takes the economy outside the equilibrium long-run path in 1965, and economic growth is driven by endogenous adjustment back to equilibrium growth.

To reproduce the Thai catch-up process, the development of educational shares in the labor force is calibrated based on available data. The share of the labor force with secondary education increased from 2% in 1988 to 26% in 2005 (Table 3). We reproduce this path in the model simulations by assuming a constant share of 2% during 1965–88, which gradually increases to 26% in 2005. Based on significant investments in secondary education during the 1990s we project a further increase in the secondary share of the labor force to about 45% in 2015. Similarly, the share of workers with tertiary education is calibrated to increase from 2% in 1965 via 8% in 1988 to 14% in 2005, consistent with available data. Due to recent increases in the tertiary enrollment ratio the share is expected to increase further, and in the numerical model the share of the labor force with tertiary education increases to about 20% in 2015.

Economic growth and productivity dynamics are affected by the degree of openness in the economy. 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. The tariff rate (relative to import) decreases from about 25% in 1965 to 3% in 2005. In the long run, tariffs are assumed to remain constant at the 2005 level.

The model generates an average annual GDP growth rate during 1965–2005 equal to 7.1%, which is consistent with the observed average growth rate in the data (excluding the crisis years of 1997–98 with negative growth). The model captures the trend growth and does not represent the cyclical factors affecting the actual growth. The high growth period is driven by a combination of capital investments and productivity growth. Initially, high marginal returns to capital stimulate capital growth. The gradual opening of the economy contributes to productivity improvements, which increases the profitability of capital investments and counteracts the decreasing returns to capital. The productivity–investment interaction generates prolonged high growth above the steady state level. More comprehensive analysis of aggregate growth in Thailand is offered by Diao et al. (2005, 2006) and Stokke (2004). The focus of the present analysis is on the productivity dynamics and the sources of productivity growth during the catch-up process.

The model productivity path during 1965–2005 is broadly consistent with available data. Hall and Jones (1999) estimate the productivity level in Thailand to be 37% of the US level in 1988, corresponding to a technology gap of 0.37. Data from Heston et al. (2002) indicates significant catching up in terms of PPP-adjusted real GDP per capita relative to the US, increasing from 0.09 in 1965 to 0.24 in 1996 before falling back to 0.21 after the Asian crisis. To generate a consistent development in relative productivity we assume an initial technology gap to the frontier of 0.3. Given the initial trade and educational levels, the economy is above the threshold value for catching up with a labor augmenting technical progress rate of 3.6%. Driven by the gradual opening of the economy, a profitable technology gap relative to the frontier, and (at least in the last part of the period) investments in human capital, the growth rate of technical progress increases over time to 6.8% in 2005. The growth path corresponds to a movement along the increasing part of the curve in Figure 1, starting out above the threshold gap and increasing towards the maximum point. In the growth projections to 2015 the growth rate reaches the peak and starts declining. Exceeding the rate of productivity growth at the frontier, technological catch-up and reduction of the gap is observed. Relative productivity increases from the initial value of 0.3 to 0.54 in 2005 and further to 0.78 in the projection for 2015. The point estimate of 0.37 for 1988 is reproduced. The relationship between TFP growth and the rate of labor augmenting technical progress is given by equation (7) in section 4. Based on a labor share of 0.35 (consistent with Thai data) the average annual TFP growth rate during 1965–2005 equals 1.5%. This is consistent with conventional TFP calculations for Thailand offered by Collins and Bosworth (1996), among others.

Initially, productivity improvements are mainly driven by organizational learning, which accounts for about 70% of aggregate productivity growth. Lack of secondary education in the labor force and the large technological distance to the frontier hold back adoption of advanced foreign technology. As the economy catches up, the importance of technology adoption as a source of growth gradually increases. Rapid investments in secondary education since the late 1980s contribute to this development. As illustrated in Figure 3, the growth contribution from organizational learning starts to decrease in the early 1990s and accounts for about 25% in 2005. The relative importance of technology adoption in productivity growth increases from about 30% during 1965–85 to 68% in 2005. Gradual investment in tertiary education stimulates R&D activities, but due to the large technology gap, innovation remains an insignificant source of productivity growth during the entire period of study (accounting for about 0–5% of total growth).

To illustrate the impact of recent investments in secondary education on future productivity dynamics and sources of growth, the calibrated Thai path is compared to a counterfactual path where the educational share of the labor force remains constant after 2000. This implies that the rapid increase in secondary enrollment ratios since the early 1990s is not taken into account. The share of the labor force with secondary education equals 13.5% during 2000–15 instead of gradually increasing to 45%. The results illustrate the importance of educational investments to manage the shift from basic productivity improvements through organizational learning to adoption of more

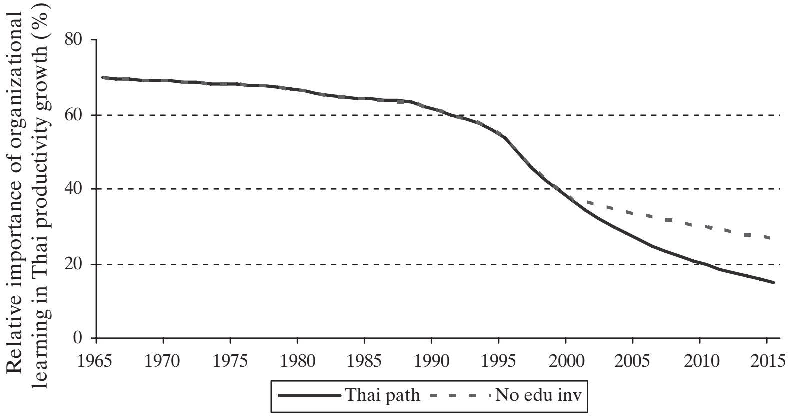

Figure 3. Share of Productivity Growth due to Organizational Learning. Calibrated Thai Path 1965–2015 versus Counterfactual Path without Recent Investments in Secondary Education

advanced foreign technology. Without recent investments in secondary education, the growth contribution from technology adoption is held back, while organizational learning continues to play a significant role in productivity growth. As seen from Figure 3, at the end of the period studied the share of growth coming from organizational learning is about 12 percentage points higher in the counterfactual scenario than along the calibrated Thai path. Lack of investment in secondary education affects not only the sources of productivity growth, but also the actual growth rate and the degree of catch-up. In the base scenario, the average rate of labor augmenting technical progress equals 6.5% during 2000–15, which corresponds to 2.3% TFP growth. In the counterfactual scenario, the average TFP growth rate equals 1.9% in the same period. The degree of catch-up with the frontier is held back, and relative productivity increases to 0.66 compared to 0.78 in the base scenario.

The numerical simulations document the importance of organizational learning in the Thai catch-up process. In this respect, the suggested productivity specification with three sources of growth contributes to the understanding of the growth success in Thailand. While investments in tertiary education is typically regarded as an important factor to manage the shift from adoption to innovation as sources of growth, we emphasize the importance of secondary education in the transition from basic productivity improvements through organizational learning to adoption of more advanced foreign technology. The counterfactual experiment shows that investments in secondary education are crucial for middle-income economies like Thailand to continue the catch-up process.

7. Concluding Remarks

We offer a new specification of productivity growth, which broadens the understanding of productivity improvements in backward economies. Motivated by the lack of innovation and technology adoption in poor countries, we suggest a third channel of growth related to better organizational structure, improved work ethics, and more discipline in the production process (for simplicity called organizational learning). Such basic productivity improvements are typically related to the degree of interaction with the rest of the world through trade, foreign direct investments and entry of multinational companies. The suggested productivity specification generates new insights about the main source of growth during the development process: organizational learning in backward economies, technology adoption in middle-income economies, and innovation in developed economies. This represents an extension of the two-stage development from technology adoption to innovation as suggested by Acemoglu et al. (2006), among others.

The second part of the paper investigates the empirical relevance of the productivity specification, and focuses on the case of Thailand. Compared to other Asian success countries, Thailand has a low-educated labor force and has specialized in low-tech labor-intensive industries. The standard separation between innovation and technology adoption as sources of productivity growth does not give a good description of the Thai experience. Productivity growth is certainly related to openness and international spillovers, but is not driven by adoption of highly advanced frontier technology. To quantify the relative importance of organizational learning we offer numerical simulations of the catch-up process. The productivity dynamic is put in a dynamic general equilibrium framework, and the model is calibrated to reproduce the main elements of the economic development during 1965–2005 and projected to 2015.

The simulations illustrate the changing sources of growth during the catch-up process. In the early stages, organizational learning accounts for about 70% of productivity growth. As the economy catches up and investment in secondary education increases, technology adoption gradually takes over as the engine of growth. The new productivity specification with organizational learning contributes to the understanding of the growth success in Thailand, and the mechanisms involved are likely to be relevant in other developing countries as well. A counterfactual experiment investigates the impact of recent educational investments on future productivity dynamics and sources of growth. The results show that investments in secondary education are important to manage the transition from basic productivity improvements to adoption of more advanced foreign technology.

Since Thailand is gradually losing its comparative advantage in low-tech labor-intensive production (partly due to the entry of China), sustainable growth in the future requires adoption of more advanced technologies. In this respect, the recent educational investments are important. The rapid expansion of secondary enrollment ratios in the 1990s has increased the educational level of the labor force, but the process is slow and the majority of Thai workers still have only primary education or less. A successful movement from low-tech production to adoption of more advanced technology requires further investments in education, and is a future challenge for Thailand.

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Notes

1. Evidence on multiple convergence clubs is provided by Quah (1997), among others. The importance of productivity in explaining large income differences is supported in several empirical studies, for instance Hall and Jones (1999).
2. The necessary conditions for multiple equilibria are outlined in an appendix available at the author's webpage (http://www.svt.ntnu.no/iso/Hildegunn.Stokke/default.htm).
3. Documentation of the results and necessary parameter restrictions are given in an appendix available at the author's webpage (http://www.svt.ntnu.no/iso/Hildegunn.Stokke/default.htm).
4. The model appendix is available from the author's webpage (http://www.svt.ntnu.no/iso/Hildegunn.Stokke/default.htm).
5. Data for 1975–98 is calculated based on Input–Output tables available from the National Economic and Social Development Board in Thailand (http://www.nesdb.go.th/), while data for 2003 is from World Bank (2006). The Input–Output tables include 180 sectors. We define manufacturing as sectors no. 42–134. The following sectors are defined as high-tech: Office equipment & machinery (116), Electrical industrial machinery & appliances (117), Radio, television set & communication equipment (118), Other electric appliances (119), Ship building (123), Railway equipment (124), Aircraft (128), and Scientific equipments (129). This is broadly consistent with the classification of high-tech industries applied by the World Bank, and the calculated share of high-tech exports for 1990, 1995, and 1998 is consistent with similar data offered by the World Bank (2006) during 1989–2003.
6. The data is based on World Bank (2006), and the specific year depends on data availability and varies between 1987 and 1991, with 1988 for the case of Thailand.
7. Data for 1988 is from World Bank (2006), while data for 2005 is from the Report of the Labor Force Survey, National Statistics Office, Thailand.