Does Agriculture Lead the Economy's Growth?: A Quantitative Analysis of Asian Countries after the Green Revolution

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Abstract

The role of agriculture on economic growth is investigated using a two sector dynamic general equilibrium model. People facing subsistence food consumption initially stagnates in a low agricultural and low manufacturing production. A change of agricultural technology using more capital and less land leads the economy start a rapid growth through manufacturing growth. The simulation results of Thailand and India after the Green Revolution are consistent with the actual data.

Keywords: The Green Revolution, Economic growth, Thailand, India, Subsistence level

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1 Introduction

Although development of poor regions with poverty reduction is a world's priority, the role of agriculture on which most poor people in the region rely is still ambiguous. The effect of agricultural productivity growth on the economic growth has been investigated for a long time in the agricultural and development economics. One of the well known observations often mentioned is that before the Industrial Revolution UK experienced Agricultural Revolution, which was a phenomenon of rise in labor productivity of agricultural production (Johnson (2000)). The observation is mere description of a correlation, it is said that the rise in agricultural labor productivity is one of the necessary conditions for subsequent industrial growth (Johnson (2000), Johnston and Mellor (1961)). If we casually look on the recent Asian countries, we see a similar story, namely before the "Miracle," Asian countries experienced the Green Revolution. The object of this paper is to model the effect of a change in agricultural production technology on the country's growth and to test it with simulation framework, focusing on two Asian countries, Thailand and India, 1960-2000. Two main questions we inquire are very simple; (1) Why did some Asian countries suddenly start rapid growth from low income and low income growth after 1960s? (2) What is the role of the agriculture on the economy's growth?

In the history of the world, the phenomena resemblance with Agricultural Revolutions usually preceded in incident as the Industrial Revolutions in today's developed regions (Hayami (2001)). Most East Asian countries become the middle incomes today and South Asia has started to grow but Sub-Sahara Africa is still in poverty, but all the regions suffered miserable poverty a half century ago. Moreover, 50 years ago world had worried incoming world wide food shortage. Especially, Asian countries would have be thought facing serious famine because of rapid population increase and stagnating food production (Evenson (2004), Otsuka (2000)). But Asian food crisis was not realized. The conclusive answer in agricultural economics of the reason is it is because of the Green Revolution (e.g., Ruttan (2002), Hayami (2001)). Continuous application of modern technology on agricultural production made it possible to yield higher amount of crop after late 1960s. Not only the crises have never happened but also Asian countries have experienced period of rapid economic growth, so-called "the Miracle". The implication of the Green Revolution on the economy as a whole is, however, unfairly overlooked in the literature focusing on the East Asian Miracle (e.g., World Bank (1993)[1]).

One reason for this ignoring is that although agricultural production increase comes first, the economy grows mainly due to growth of non-agricultural sector. Figure 1 is path of per worker GDPs in selected Asian countries. The horizontal axis is year and the vertical axis is the level of GDP per worker from Penn World Table. Thailand and India are countries we will analyze more precisely in subsequent sections.[2] As heavily referred to, after 1970s

[1] There are several views of the engine of the Miracle. A benchmark is World Bank (1993), which focuses on the institutions and the role of the government. In this report, they scarcely refer to the role of agriculture.

[2] Contrary to our simulation section, we use data from Penn World Table to depict this graph in order to

Southeast Asia has grown rapidly and South Asia follows in a decade after. By what is this rapid growth realized? That is by non-agricultural sector and the contribution of agricultural GDP becomes smaller as a country grows. The answer is one of the stylized fact and also clears from Figure 2. The various lines are the ratio of agricultural GDP to total GDP in each area. As time goes by, the magnitude of agriculture decreases. Thus, a straightforward conclusion is agriculture has no impact on the economy's growth and think about manufacturing is crucial.

We argue, however, agriculture kicks off the growth of manufacturing. The key is initial capital accumulation. Contrary to approach paying attention to the institutions and the role of government by World Bank (1993), Krugman (1994) argued the main source of GDP rise in East Asia is capital accumulation. Moreover, he continued that as simple Solow model predicts, rapid growth would end in the near future as growth of Soviet Union had been temporal phenomenon. Hayami (2001) criticize that even the US the starting period of the economic growth was mainly due to capital accumulation rather than TFP rise. We do not pursue the generality of this observation further, but the point here is that the starting period, the economy needs several amount of capital accumulation. But as already mentioned, Asian countries were worried incoming starvation 50 years ago. Is it possible for an economy facing famine to accumulate enough amount of capital? It may not be impossible but it is, of course, difficult. If people are poor, it is difficult to save. Christiano (1989) explains Japanese high saving rate but initially (just after the World War II) low saving rate under the reconstruction hypothesis of an implication of neo-classical framework. A famous fact that Japanese saving rate was high compared with US during post World War II period. Neo-classical growth model is able to explain high saving rate as return period to the steady state. A shortcoming of the theory is it is unable to explain initial low saving rate. According to the theory, saving rate should be highest in the initial period. Christiano's hypothesis is that people was too poor to save while the initial low saving rate period. The situation before the Green Revolution is similar. People had been too poor to save, but the Green Revolution changed the situation and the country started to grow. In other wards, our hypothesis is that a change in agricultural technology enables capital accumulation, then input accumulation increases manufacturing production, which stimulates rapid economy growth.

The basic idea is, in fact, not new one. The role of agriculture on the economy's growth is studied for a long time and is one of the classical controversies in development and agricultural economics. There are two issues; (1) Whether development of agriculture contributes whole economy's development? (2) What are the effects of the agriculture? The answer to the first question is usually yes. Without supplying substantial amount of food, the economy is not sustainable even if non-agricultural production would be highly proficient.[3] For the second

hold international comparability.

[3] If we consider a world with international trade, the discussion is not so straightforward. We do not pursue open economy framework following Hansen and Prescott (2002), Gollin et al. (2002) and Restuccia et al. (2004). A justification, which is summarized in Gollin et al. (2002), is for the developing countries, import of food is very low.

question, Johnston and Mellor (1961) lists roles of agriculture in the economy's development as (1) to feed the growing population in the manufacturing sector, (2) to release labor for manufacturing employment, (3) to increase the domestic demand on manufacturing goods, (4) to accumulate capital, (5) to enlarge agricultural exports. When we think listed five roles, we find that all of the statements are under a unified story. Owing to agricultural production growth, people escaped from stagnated poverty with low saving to high consumption of manufacturing goods with high saving economy. In this process, exporting of agricultural goods helps speed of accumulation and labor transition leads higher manufacturing production. The story is, in a sense, very straightforward and similar to ours.

Model based analyses were also attempted. Lewis (1954) proposed so-called "Dual-Economy" model and analyze the transition from agriculture to manufacturing through a shift of surplus labor using a simple two-sector model. But his assumptions of surplus labor paid subsistence level wage was empirically rejected by Schultz (1964). Jorgenson (1961) contructed a two-sector model without that assumption. Model based empirical studies were, however, few as long as we know. One reason was that empirical studies with two-sector model focused mainely on migration and labor shifting. Another reason is data limitation of developing countries. Recently, however, development of dynamic macroeconomics and computational methods relights this field of research. Matsuyama (1992) and Eswaran and Kotwal (1993) revise theoretical framework of two sector growth models. Furthermore, simulation method provides empirical test of the framework. For example, Hansen and Prescott (2002) uses two sector growth model with a switch from agricultural ("Malthus", in their term) sector to manufacturing ("Solow") sector and succeeds to simulate historical UK economy after the Agricultural Revolution. Gollin et al. (2002) constructs a two sector framework with two goods model and traces UK history after the Agricultural Revolution. Echevarria (1997)'s model has three sectors and replicate stylized facts on the development: intersectoral labor share changes. She furthermore succeeded to replicate the facts using developed countries' data with international trade (Echevarria (1995)). Tamura (2002) describes very long history, over 2000 years, of the world based on endogenous human capital accumulation and production technology change. For the history of Japan after *Meiji* Restoration, Murata (2002) replicates the trajectory of intermediate goods usage of the agricultural production.[4] These listed literature usually has at least two production technologies. An important difference among them is the number of consumption goods in each model. One consumption good model by, for example, Hansen and Prescott (2002) and Tamura (2002) has a shortcoming if we consider our story. This type of the model treats structural change as a switch from agricultural production to manufacturing. In this case, exogenous rise in agricultural productivity delays switch from agriculture to manufacturing. Our message is opposite. For this reason, the model we will construct has two consumption goods as Matsuyama (1992), Eswaran and Kotwal (1993), Eswaran and Kotwal (2001), Gollin et al. (2002) and others.

[4] Other studies belong to two sector model are Eswaran and Kotwal (2001), Lagerlöf (2003) and Laitner (2000)

Actually, our basic story is similar to Matsuyama (1992)'s closed economy case.

Contrary to recent accumulation of studies focusing on long history of the world, application of this type of the models on recent experiences of Asia is surprisingly thin. Scarcity should not be due to the unimportance. Studying Asian experiences is beneficial for the development in other regions. There are two studies focusing on recent history using dynamic framework. One is Gollin et al. (2001). They set a two sector model to study the implication of the Green Revolution on the prevailing cross country income differences. Their basic message is that different start of modern agricultural production explains today's cross country income differences. The other is Restuccia et al. (2004), which has the same motivation that a change in agricultural production can make cross country income difference. The crucial point is the existence of barrier of using intermediate input in agricultural production. Before one day, there had been an institutional barrier to use capital input in agricultural production and the afterwards the barrier disappears and the agricultural production rises. Then, the economy started to grow and international income difference emerges depending on the timing of barrier disappearances. Our approach is similar to them, but is different from the reason of capital using for exogenous technology change.

Contrary to these two papers, the focus of this paper is narrower. We do not pursue cross country income differences but just focus on each country's growth trajectory as precisely as possible. Thus, this paper is a special case of Gollin et al. (2001) and Restuccia et al. (2004) in this sense. In another context, however, our approach is general version of them. They conduct simulations without using capital stock data despite mentioning its importance. The reason is data availability. Capital stock data in developing countries is missing in international comparable data set as Penn World Table (Heston et al. (2002)), World Development Indicators, FAOSTAT, and OECD data set.[5] Paying the cost of limiting countries to Thailand and India, we can utilize available resource of capital stock data. Then, we conduct standard growth accounting for both agriculture and manufacturing sectors. By this, we can trace the growth path more precisely as comparable to actual data. Thus, a contribution of this paper is model based analysis and simulation of the growth facts on the Asian countries.

Composition of the rest of the paper is follows. In the next section, we summarize basic facts about the Green Revolution through existing literature and construct basic intuition of the agricultural production. Section three introduces the model. In section four, we test our hypothesis using simulation method based on the model. Finally we conclude and propose possible extensions in section 5.

[5] First three do not have capital stock data. Last one, OECD, has capital stock data but the data is only for developed countries.

2 The Green Revolution

The Green Revolution is the term describing development and widespread adoption of high yielding varieties or modern varieties of primary crops accompanies by use of capital input starting late 1960s in developing countries, mainly in Southeast and South Asia, and South and Central America (Evenson and Gollin (2003), Otsuka (2000)). When we consider about the Green Revolution and its impact on the whole economy, we have to note following four facts. The first is that the Green Revolution is basically exogenous technological change. Secondary, labor and land productivity are incredibly rise. The third is that it is mainly due to introduction of new varieties and coincident capital using. Finally, total factor productivity does not notably rise.

The fundamental source of the Green Revolution is development and application of modern varieties into developing countries. Central role of the research is conducted by international institutions. This is because agricultural production technology is difficult to keep in secret. Other than genetically modified seeds, crop seeds spread rapidly. Knowledge about production is also easily imitated. In this sense, agricultural production technology is a public goods (Hayami (2001)). At the same time, however, agricultural technology is difficult to diffuse over regions. Since agricultural production technology is location specific, inter-country technology diffusion is difficult. For these reasons, in 1950s, international research institutions were constructed (Otsuka (2000), Evenson and Gollin (2003), Evenson (2004)). Then, the institutions have released several types of crop seeds, related input and production technique for several conditions. Of course, country specific investment as canal and road has important role too. The fundamental change was, however, owing to newly available technology and then farmers responded this change rationally (David and Ostuka (1994),Otsuka (2002)). In this sense, we think the change as exogenous.

The spread of modern agricultural technology, increases land and labor productivity of agriculture substantially.[6] Hayami and Ruttan (1985) did seminal research of increases of labor productivity and land productivity. According to them, the direction of technical change depends on available resource. If an economy has relatively rich land but few labors, direction of increase is mainly directed to labor saving and land using, and vice versa. Asian countries commonly face limited land. So, the direction of technical change is land saving. That is, land productivity rises much and labor productivity rises moderately.[7]

Another feature of the Green Revolution is capital use accompanied by the application of the modern varieties. Capital input has become used for the whole process of the agricultural production. The most evident change is application of fertilizer, pesticide and herbicide. As summarized in Otsuka (2000) and Evenson (2004), the varieties before the Green Revolution, traditional varieties, are not fertilizer responsive and are difficult to use large size machineries.

[6] Land productivity is agricultural production per land, and labor productivity is per labor.

[7] Actually, Thailand is an extreme case. Uncultivated land is relatively large in Thailand compared with other Asian countries (David and Ostuka (1994)). But the level is not comparable to that of South America (Hayami and Ruttan (1985)).

Contrary to the traditional varieties, modern varieties are fertilizer responsive and can be used machinery harvesting, so that input of capital has grown rapidly. Pesticide and herbicide are vital for the first generation of the modern varieties because they are intolerance.[8] Mechanization is also notable. From tractor to harvesting thresher, several agricultural machineries become used. The mechanization, heavy use of capital input on agricultural production, is accompanied by the introduction of modern varieties.[9] In this sense, the Green Revolution enabled farmers to use capital inputs more.

There is vast amount of attempts to estimate agricultural production function and total factor productivity. A broad survey is in Hayami and Ruttan (1985) and Mundlak (2000). One well-known "puzzle" of the Green Revolution is that although it seems rapid exogenous technical progress, empirical studies cannot to find high TFP growth (e.g., Suhariyanto and Thirtle (2001), Rosegrant and Evenson (1992), Mundlak (2000)). This is mainly because of high growth rate of capital input. If we decompose growth of agricultural production through growth accounting methods, dominance of capital factor growth diminishes the residual or total factor productivity.

Following and simplifying these facts, we suppose the Green Revolution as an exogenous change of agricultural production technology, and then, farmers respond the change as a result of the maximization. More precisely, we assume that people own agricultural technology and the technology changes at the initial period. In the next section, we construct our model including discussed agricultural production.

3 The Model

In this section, we set a two sector general equilibrium model to test the hypothesis that agricultural production change leads rapid economic growth.

3.1 Basic Environment

Our aim is to investigate the relationship between agricultural production change and economic growth. At time 0, the agricultural production technology changed, and the economy began to go a steady state. To focus on growth facts the model is perfect foresight with no uncertainty. We also drop the effect of international trade following Hansen and Prescott (2002). There is a representative household who owns unit of farmland and agricultural production technology. The land is endowed and cannot be sold nor lent.[10] There are two kind of goods in the world: one is agricultural good or food, the other is non-agricultural good or manufacturing good.[11] Time is discrete and population growth is exogenously de-

[8] Tolerance become rise in later generations released 70s. Further discussion is in Evenson and Gollin (2003).

[9] More detail discussion and its implication for the income distribution are in David and Ostuka (1994)

[10] As clear from this specification we also assume a homogenous economy. Heterogeneous land holdings and its implication on the income distribution is another interesting topic.

[11] We use "non-agriculture" and "manufacturing" interchangeably.

termined, n_t (> 0). Thus, we also omit fertility choice[12] . The representative household with N_t population maximizes infinite sum of discounted period utility as

$$\sum_{t=0}^{\infty} \beta^t N_t u(c_{at}, c_{mt}), \quad u(c_{at}, c_{mt}) = \sigma \ln(c_{at} - \alpha) + (1 - \sigma) \ln c_{mt} \tag{1}$$

where $\sigma \in (0, 1)$ and $\alpha > 0$. The household consumes agricultural good, c_{at} , and manufacturing good, c_{mt} in each period. Lower case letters are per capita values whereas uppercase letters are aggregate values (that is, $C_{at} = N_t c_{at}$, for example). β is the discount factor. She gets no utility from leisure. Period utility function is addilog with the exogenously determined constant subsistence level, α, because Atkeson and Ogaki (1996) and Ogaki and Zhang (2001) report subsistence level has not negligible effect in developing countries. Essential property of this form of utility function is that if the household has low income, it is difficult to save.

The household faces following constraints:

$$p_t C_{at} + C_{mt} + K_{t+1} \leq p_t Y_{at} + w_t N_{mt} + r_t K_{mt} + (1 - \delta) K_t \tag{2}$$

$$N_{at} + N_{mt} \leq N_t \tag{3}$$

$$Y_{at} = A_{at} K_{at}^{\phi} N_{at}^{\psi} (Land)^{1-\phi-\psi} \tag{4}$$

$$K_{at} + K_{mt} = K_t \tag{5}$$

where $A_{at} = A_{a0}\chi^t$, $Land$ is normalized to 1 and $\phi, \psi, \phi + \psi \in (0, 1)$. The household has agricultural production technology and land so that the household is assumed to be a farmer, which represents the economy of developing countries.[13] First constraint is the household budget constraint. p_t is relative price of agricultural good. Income of the household is sum of the sales of agricultural production, Y_{at}, return of capital investment on the manufacturing sector with r_t return rate, wage payment in the factory, where wage rate is w_t, and not depreciated part of capital stock. Depreciation rate is δ. The household expenditure divides total consumption of food, C_{at} manufacturing good, C_{mt}, and capital investment, K_{t+1}. The second constraint is labor endowment. The household is endowed a unit of labor and divides it into working on farm, N_{at} and manufacturing sector, N_{mt}. Since each person endowed a unit of labor, labor ratio of each sector is expressed as n_{at} ($\equiv N_{at}/N_t$) and n_{mt} ($\equiv N_{mt}/N_t$). The third constraint is farming technology. Cobb-Douglas farm production requires capital input, labor, and land. A_{at} is total factor productivity of the agricultural production with constant growth rate χ[14] . Since land is constant over time, agricultural production is decreasing returns to scale with respect to capital and labor. An implicit assumption of the household problem is that the household can save through capital investment but not borrow. In this

[12] Tamura (2002) and Lagerlöf (2003) treat fertility choice more.

[13] Under the conditions we specify, the allocation is the same when farm production is owned by competitive firms with suitably defined price system and transfer of land return to the household.

[14] We will assume $\chi = 1$, no TFP growth, in the simulation section.

sense, credit market is imperfect. This assumption is, to some extent, justified when we think about farmers' economy described in Ogaki and Zhang (2001). The household maximizes its utility controlling the sequences of $\{c_{at}, c_{mt}, k_{at}, k_{mt}, n_{at}, n_{mt}, k_{t+1}\}_{t=0}^{\infty}$.[15] As is clear from maximization problem, all inequality constraints can be reduced to equality constraints.

The manufacturing sector has standard Cobb-Douglas production technology and maximizes its profit:

$$Y_{mt} - w_t N_{mt} - r_t K_{mt} \tag{6}$$

$$\text{s.t.} \qquad Y_{mt} = A_{mt} K_{mt}^{\theta} N_{mt}^{1-\theta}, \qquad \theta \in (0,1). \tag{7}$$

Y_{mt} is the amount of manufacturing good, K_{mt} is capital input, and N_{mt} is labor input. A_{mt} is total factor productivity and its growth rate is defined as $A_{mt+1}/A_{mt} = \gamma_t^{1-\theta}$, $(\gamma_t > 0)$. The firms face constant returns to scale production, so they earn zero profit and we can normalize the number of firms as one.

The economy is closed, so the appropriate resource constraints are

$$C_{at} = Y_{at} \tag{8}$$

$$C_{mt} + K_{t+1} = Y_{mt} + (1-\delta) K_t. \tag{9}$$

The first one is for food whereas the second is for manufacturing good. Note that manufacturing good can be used as capital input for both sector as well as a consumption good but agricultural good is only for consumption. Under this environment, the competitive equilibrium can be defined as

Definition 1 *A* ***Competitive Equilibrium*** *of the economy is a sequence of prices* $\{p_t, w_t, r_t\}_{t=0}^{\infty}$ *and associated quantities* $\{C_{at}, C_{mt}, N_{at}, N_{mt}, Y_{at}, Y_{mt}, K_{at}, K_{mt}, K_{t+1}\}_{t=0}^{\infty}$ *given exogenous values* $\{A_{mt}, A_{at}, N_t\}_{t=0}^{\infty}$ *and initial value* K_0 *such that, for all* t,

i) the household maximizes the utility as prices given;

ii) the firm maximizes the profit as prices given;

iii) resource constraints are satisfied.

3.2 Transformation and Equilibrium Conditions

Solving the household and the firm optimization problem and the resource constraints give a set of equilibrium conditions, which is in the Appendix. To check the properties around the steady state, we detrend some of the endogenous variables as

$$\tilde{c}_{mt} = \frac{C_{mt}}{A_{mt}^{1/(1-\theta)} N_t}, \quad \tilde{k}_{mt} = \frac{K_{mt}}{A_{mt}^{1/(1-\theta)} N_t}, \quad \tilde{k}_{at} = \frac{K_{at}}{A_{mt}^{1/(1-\theta)} N_t}$$

[15] But some of them are co-state variables, actually.

and

$$\tilde{c}_{at} = \frac{C_{at}}{A_{at}A_{mt}^{\phi/(1-\theta)}N_t^{\phi+\psi}}.$$

Define manufacturing capital labor ratio as:

$$x_t = \frac{\tilde{k}_{mt}}{n_{mt}}.$$

Finally, we define

$$\alpha_t \equiv \frac{\alpha}{A_{at}A_{mt}^{\phi/(1-\theta)}N_t^{-1+\phi+\psi}}.$$

Since all right hand variables are exogenously determined, α_t is exogenous, too. Then, we get a set of competitive equilibrium conditions for the Transformed Economy. From equilibrium conditions of the original problem, derived conditions of the Transformed Economy are

$$\tilde{c}_{mt} + \tilde{k}_{t+1}n_t\gamma_t = \tilde{k}_{mt}x_t^{\theta-1} + (1-\delta)\tilde{k}_t \tag{10}$$

$$\tilde{c}_{at} = \tilde{k}_{at}^{\phi}n_{at}^{\psi} \tag{11}$$

$$\frac{\gamma_t}{\beta}\frac{\tilde{c}_{mt+1}}{\tilde{c}_{mt}} = \theta x_{t+1}^{\theta-1} + 1 - \delta \tag{12}$$

$$\theta x_t^{\theta-1} = \frac{\sigma\phi}{1-\sigma}\frac{\tilde{c}_{mt}}{\tilde{c}_{at}-\alpha_t}\frac{\tilde{c}_{at}}{\tilde{k}_{at}} \tag{13}$$

$$(1-\theta)x_t^{\theta} = \frac{\sigma\psi}{1-\sigma}\frac{\tilde{c}_{mt}}{\tilde{c}_{at}-\alpha_t}\frac{\tilde{c}_{at}}{n_{at}} \tag{14}$$

$$1 = n_{at} + n_{mt} \tag{15}$$

$$x_t = \frac{\tilde{k}_{mt}}{n_{mt}} \tag{16}$$

$$\tilde{k}_t = \tilde{k}_{at} + \tilde{k}_{mt} \tag{17}$$

The first equation is from the resource constraint on manufacturing good. (11) is from resource constraint for agricultural good and its production technology. (12) is the Euler equation. (13) and (14) are marginal conditions on capital and labor in each production technologies, respectively. (15) is labor supply constraint. (16) is the definition of x_t, capital labor ratio for manufacturing. The last one, (17) is the capital supply equality. Given this conditions, we define the Asymptotic Steady State.

Definition 2 *The Transformed Economy is at the* ***Asymptotic Steady State*** *where all transformed endogenous values are asymptotically constants.*

We express the Steady State as Asymptotic because of the existence of α. When $\alpha = 0$, the values become exactly constants. Hereafter, for simplicity, we call the Asymptotic Steady State and the Steady State interchangeably. In order to all endogenous values being constants, we make an assumption

Assumption 1 *As $t \to \infty$, $n_t \to n$ and $\gamma_t \to \gamma$.*

The assumption requires n_t and γ_t become constants. As it is clear from the discussion above, the condition for the economy having the steady state is that α_t is asymptotically 0. Formally,

Proposition 1 *The Transformed Economy has a steady state if and only if*

$$\alpha_t \to 0 \text{ as } t \to \infty.$$

From the definition of α_t and the assumption, we can also say the condition as

Remark 1 *The Transformed Economy has a steady state if and only if*

$$\chi\gamma^{\phi/(1-\theta)}n^{-1+\phi+\psi} > 1.$$

Because the value of α_t affects other values, the agricultural production technology represented by ϕ, ψ and χ is a crucial source of the allocation. For example, if ϕ is small, α_t is large by definition. Then, the economy needs more food (or $\tilde{c}_{at}$) to satisfy non-negativity of $\tilde{c}_{at} - \alpha_t$.[16]

3.3 System of Difference Equations

To calculate the sequence of endogenous variables, we derive a system of difference equations and using shooting algorithm a la Judd (1998). Solving the system, we derive two inter-temporal equations and four intra-temporal equations. Two dynamic equations are:

$$\tilde{c}_{mt+1} = \frac{\beta}{\gamma_t}[\theta x_{t+1}^{\theta-1} + 1 - \delta]\tilde{c}_{mt} \tag{18}$$

$$\tilde{k}_{t+1} = \frac{\tilde{k}_{mt}x_t^{\theta-1} + (1-\delta)\tilde{k}_t - \tilde{c}_{mt}}{n_t\gamma_t} \tag{19}$$

Four static equations are:

$$x_t = \frac{\theta\psi}{(1-\theta)\phi}\tilde{c}_{at}^{-1/\psi}\tilde{k}_{at}^{1+\phi/\psi} \tag{20}$$

$$\tilde{k}_{mt} = (1 - \tilde{c}_{at}^{1/\psi}\tilde{k}_{at}^{-\phi/\psi})x_t \tag{21}$$

$$\tilde{c}_{mt} = \frac{(1-\theta)(1-\sigma)}{\sigma\psi}x_t^{\theta}\tilde{c}_{at}^{-1+1/\psi}(\tilde{c}_{at} - \alpha_t)\tilde{k}_{at}^{-\phi/\psi} \tag{22}$$

$$\tilde{k}_t = \tilde{k}_{at} + \tilde{k}_{mt} \tag{23}$$

Substituting four static equations into dynamic system, we can reduce the system into two variables non-linear difference equations of $(\tilde{c}_{at}, \tilde{k}_{at})$. Under the suitable parameter values, this system has a saddle around the steady state (discussed more in the Appendix).

[16] Not only through this channel, but also directly parameters change the allocation as clear from the equilibrium conditions.

4 Data and Calibration

In the next section, some simulations are presented to support the hypotheses. Before going ahead the results of the simulation, we explain data and model parameterization.

4.1 What Country Is Tested?

Since our hypothesis focuses on the growth facts, the model is constructed standard two sector type. The cost of the specification is relatively high requirement of the data. A common problem when we study developing countries is limited data availability. In this paper, we limit the number of countries we simulate because of data availability. The data used the simulations are of official statistics of India and Thailand complementing with several estimations of existing literature. As mentioned in the first section, a problem using developing countries' data is luck of capital stock. Widely used data set as World Development Indicators and Penn World Table has no capital stock data. Our study goes back country level data and fully utilizing existing estimations. For this reason, it is difficult to analyze wide range of countries but we focus on just two countries. More precise explanation about the data is in the Appendix. It is hard to justify perfect validity of analysis for other Asian countries, but we can think partial validity because representativity of these two countries for other Asian countries ensured by Figure 1 and 2.

4.2 Model Parameters and Calibration

We have a set of parameters and exogenous variables. Although there are several parameters, available data is limited to calibrate all the model parameters. Consequently, most of the parameters are arbitrary given from several studies. We explain in order.

Parameters related to utility function are σ, α, and β. σ is asymptotic expenditure share of food consumption. We set this 0.4 for India and 0.2 for Thailand, which are approximately actual shares of food expenditure to GDP in 2000. α is the subsistence level of food consumption. Ogaki and Zhang (2001) estimates subsistence level of India and Pakistan using micro level data. According to their results, the average of food subsistence level is 40 to 50 % of food consumption. So, α is set 45% of Agricultural GDP in the year.[17] We set discount factor, β as 0.95 following standard assumption. Agricultural production technology parameters are share parameter of capital, ϕ, share of labor, ψ, and growth of TFP, χ. As we discussed in Section 2, the values of them are key to development. As a baseline model, we set 0.4 for ϕ, 0.5 for ψ, and 1.00 for χ. Share parameters come from rough average of literature reviewed in Hayami and Ruttan (1985).[18] As discussed in Section 2, TFP growth in agriculture is unclear, so we set $\chi = 1.00$, no growth.

[17] We assume food consumption is equal to agricultural GDP in the model. The assumption is roughly observed in the acutal data.

[18] More precisely, input in several estimations are not necessarily only capital, labor and land, but mostly including labor and land. Rough average of labor parameter is 0.5 and that of land is 0.1. If we assume constant returns to scale with respect to all the input, capital share is the residual, 0.4.

n_t, population growth rate is set actual value up to 2000. After 2000, set the value of 2000, that is, the long run value of n is one that of 2000. Initial population is normalized to one.

Capital stock data is based on several estimations. In these estimations, δ is set 0.05 for Thailand and 0.046 for India, so we set the same. Remaining two parameters are related to non-agricultural production. Since there is no information to calibrate the share parameter of capital input in the manufacturing, θ, we use commonly used value, one third. We estimated γ_t through growth accounting for the manufacturing under the share parameter θ. Then, it gives each country's TFP growth as residuals. We get and use actual values of γ_t from 1960 to 1996 in Thailand and to 2000 in India. This is because we have capital stock data for Thailand only by 1997. Long run values of γ is set the average of last 10 years to avoid cyclical movement. That is, since it misses information during Asian crises, the trace of Thai economy during Asian Crisis may be worse. The used parameter values are summarized in the Table 1.

5 The Results of the Simulation

Given actual value of K_0, Table 1 parameters and exogenous values, we calculate model values of endogenous variables. The Steady State values are summarized in Table 2. We also include the eigenvalues in the Table 2 in order to confirm the existence of saddle path (discussed in the Appendix). Figure 3 and 4 are the results of the baseline simulations for Thailand and India, respectively. Solid line is the actual values of manufacturing (non-agricultural) GDP per worker, dash-dotted line is the model values of that, dotted line is the actual values of agricultural GDP per worker, and line with x is that of the simulated values. Model performance is fairly good especially for India. Since we set actual TFPs for manufacturing production, the values are mostly traced. As we explained in the last section, trace of Thai economy during the Asian Crisis is bad, where the model shows counter movement. But in general, the long run trends are mostly replicated. The GDPs are initially low both manufacturing and agriculture. Then, manufacturing goes up but agriculture remains at the same level.

Figure 5 and 6 are ratio of agricultural GDP per worker to total GDP per worker, the data and simulation values. These figures are comparble to Figure 2. The performance is not bad. Basic fact of the reduction of agricultural ratio is partly replicated in the figures although the decreasing speed is slower in the model than in the actual values. Before going ahead, we check the source of the results. We set actual values of manufacturing TFPs and population growth rate. Does the result crucially depend on these trends? To check this, we calculate detrended values and the results are Figure 7 and 8. Without trend, tractability becomes worse. But the level facts are mostly simulated. That is, the results do not crucially depend on the trend.

So far we checked our model performance. Now, we conduct a counterfactual experiment.

Our hypothesis is a change of agricultural production technology that more capital using and land and labor productivity rising starts the economy's growth. From the facts about the Green Revolution, we do not want to change agricultural total factor productivity. What we do is a change of the share parameter of the agricultural production. More precisely, we change only the capital share, ϕ to 0.25 in the counterfactual experiment. That is, we assume before the Green Revolution, the share is much lower than that of after the Green Revolution.[19] We do not change other than ϕ even for the agricultural production parameters but accordingly it changes the share of land as summarized in Table 3.

The results of the counterfactual experiment is in Figure 9 to 14. We describe the same pictures as baseline case. Contrary to baseline case, the impact of manufacturing does not rise in both countries as clear from Figure 11 and 12. Figure 9 and 10 describe the economy heavily depends on the agricultural production and consumes food for a long period. So the ratio of agricultural GDPs were initially very high and decrese littel as shown in Figure 11 and 12. The weak magnitude becomes more vivid in detrended values. As Figure 13 and 14 show, the importance of manufacturing is far less than the actual level for the all period. Conclusively, these experiments show that the technical change influences the path of the economies.

6 Conclusion

In this paper, we construct a two sector growth model and test it with simulation using Thailand and India data. The model is a standard two sector type having both agriculture and manufacturing. People face a subsistence level of food consumption. We found that the validity of the two sector model, i.e., it explains basic facts of the growth that structural change and high economic growth in Thailand and India. Furthermore, we found that the Green Revolution or a change of agricultural production technology has an essential role of the subsequent economic growth. In the Introduction we raised two questions: the reason of Asian growth and the role of agriculture. The answer to the questions is clear. A change in agricultural technology, which stands the Green Revolution, enables people to accumulate capital, and then, it increases manufacturing production.

The finding has an implication for future development of other regions. Although Asia has started to grow, Sub-Sahara Africa countries are still stagnated. Although we did not investigate African countries, our counterfactual experiment suggests that one of the reasons is stagnation of agricultural technology. Actually, implementation of the Green Revolution to Africa was hardly observed (Evenson and Gollin (2003), Evenson (2004)). It is natural because agricultural production technology is location specific. Even if the technology reached to Asia and Latin America, it does not necessarily mean the success in Africa. An implication of our results is that the agricultural development may kick off the economy's

[19] The timing of the start period of the Green Revolution depends on the country. It was at around 1970 for some countries. We choose zero period change because of simulation simplicity.

growth. Agricultural production technology is, however, still unreached to Africa (Johnson and Evenson (2000)). What is worse, although agricultural technology is public goods, public investment has decreased last decades (Hayami (2001), Ruttan (2002)). Our results suggest more investment of agricultural technology aiming Sub-Sahara Africa is an effective way to grow the economy and to reduce poverty.

Our framework has several shortcomings. First of all, we assume the manufacturing total factor productivity growth as exogenous. If we take recent development of endogenous growth literature into account, it may be a problem to use the shortcut theoretically. Moreover, not only theoretical growth models but also recent empirical literature emphasizes development process through human capita accumulation (Foster and Rosenzweig (1996), Godo and Hayami (2002)). Thus, an extension capturing technological progress through endogenous human capital investment is worth to consider in recent Asia.

Another important caveat is the assumption of closed economy. As mentioned in the Introduction, the property of the model is in common with the closed economy version of Matsuyama (1992). An implication of importance of agriculture under a closed economy with subsistence level is very natural. His extension to open economy implies, however, that the effect of agricultural growth is ambiguous. An open economy may grow but may stagnate through specialization in agriculture together with international trade. But as we notified, even in real economy, import of food is few in developing countries. Understanding this fact is also our future task.

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Appendices 1: Data Description

Data used in quantitative analysis is basically taken from each country 's official statistics. Capital stock data and labor supply data are incomplete in both, so we use available estimations and calculate.

- Thailand
  National Income of Thailand 1951-1996 edition, Office of The National Economic and Social Development Board, Office of The Prime Minister, Bangkok, Thailand (1999)
  National Income of Thailand, various years edition, Office of The National Economic and Social Development Board, Office of The Prime Minister, Bangkok, Thailand (various years)

- India
  National Accounts Statistics Back Series, 1950-51 – 1992-93, Central Statistical Organization, New Delhi, India (2001)
  National Accounts Statistics, various years, Central Statistical Organization, New Delhi, India (various years)
  National Income Statistics January 2004, Center for Monitoring Indian Economy, Mumbai, India (2004)

Supplementary we use World Bank's World Development Indicators (World Bank (2003)) and FAOSTAT by FAO (2004).

Y_t **(GDP):** Real GDP from each country's National Income Statistics.

Y_{at} **(Agricultural GDP):** Real GDP for agriculture (including forestry and fishery) from each country's National Income Statistics.

Y_{mt} **(Manufacturing GDP):** $Y_t - Y_{at}$.

N_t **(Total Labor Age Population):** Population who are 15-64 years olds from WDI.

N_{at} **(Total Labor for Agriculture):** Economically active people in agriculture from FAOSTAT. Since values for 1960 are missing, they are calculated with linear extension. Official statistics of India misses this information and of Thailand misses values before 1980. So, we use estimation by FAO.

N_{mt} **(Total Labor for Manufacturing):** $N_t - N_{at}$.

K_t **(Capital Stock), India** National Accounts Statistics, Government of India. Capital stock data is available only after 1981. Before 1980, calculate the data using gross capital formation at 93-94 prices (I_t) series using $K_{t+1} = (1-\delta)K_t + I_t$ with $\delta = 0.046$.

K_{at} **(Capital Stock for agriculture), India** The same as aggregate capital stock.

K_t **(Capital Stock), Thailand:** We use Limskul (1988)'s estimation for 1985 capital stock as a benchmark and estimate using the same method for India but depreciation rate is assumed to be $\delta = 0.05$ following Limskul (1988).

K_{at} **(Capital Stock for agriculture), Thailand** Shintani (2003).

K_{mt} **(Capital Stock for manufacturing)** $K_t - K_{at}$.

Appendices 2: Solution Procedure

In this appendix we describe solution procedures precisely.

Derivation of the Difference System

From the household maximization problem, we have

$$\begin{aligned}
p_t &= \frac{u_{1t}}{u_{2t}} \\
\frac{1}{\beta}\frac{u_{2t}}{u_{2t+1}} &= r_{t+1} + 1 - \delta \\
r_t &= p_t \phi A_{at} K_{at}^{\phi-1} N_{at}^{\psi} \\
w_t &= \psi p_t A_{at} K_{at}^{\phi} N_{at}^{\psi-1}.
\end{aligned}$$

where subscripts of u as partial derivative with respect to each good. Firm's first order conditions are

$$\begin{aligned}
w_t &= (1-\theta) A_{mt} k_{mt}^{\theta} N_{mt}^{-\theta} \\
r_t &= \theta A_{mt} K_{mt}^{\theta-1} N_{mt}^{1-\theta}.
\end{aligned}$$

These equations and resource constraints (8) and (9) conform the equilibrium conditions of the original problem. Then, replacing the values to transformed values gives the equilibrium conditions of the Transformed Economy described (10)–(17).

Next, we derive from (10)–(17) to (18)–(23). From (12) to (18) and (10) to (19) are straightforward. (23) is the same as (17). From (11),

$$n_{at} = \tilde{c}_{at}^{1/\psi} \tilde{k}_{at}^{-\phi/\psi}. \tag{24}$$

Connecting this with (15) gives

$$n_{mt} = 1 - \tilde{c}_{at}^{1/\psi} \tilde{k}_{at}^{-\phi/\psi}. \tag{25}$$

Deviding (13) by (14) for each side gives

$$\frac{\theta}{1-\theta}\frac{1}{x_t}=\frac{\phi}{\psi}\frac{n_{at}}{\tilde{k}_{at}}$$

or

$$x_t=\frac{\theta\psi}{(1-\theta)\phi}\tilde{k}_{at}n_{at}^{-1}.$$

Substituting (24) into above equation gives (20).
From (16) with (25),

$$\begin{aligned}\tilde{k}_{mt} &= n_{mt}x_t\\ &= (1-\tilde{c}_{at}^{1/\psi}\tilde{k}_{at}^{-\phi/\psi})x_t.\end{aligned}$$

This is (21).
From (14),

$$\tilde{c}_{mt}=\frac{(1-\theta)(1-\sigma)}{\sigma\psi}x_t^{\theta}\tilde{c}_{at}(\tilde{c}_{at}-\alpha_t)n_{at}.$$

Substituting (24) into this gives (22).

The system (18)–(23) can be reduced to the bi-variate difference system. Substituting (20) into (21) and (22) gives

$$\tilde{k}_{mt}=(1-\tilde{c}_{at}^{1/\psi}\tilde{k}_{at}^{-\phi/\psi})\frac{\theta\psi}{(1-\theta)\phi}\tilde{c}_{at}^{-1/\psi}\tilde{k}_{at}^{1+\phi/\psi}\equiv k_m(\tilde{c}_{at},\tilde{k}_{at})$$
$$\tilde{c}_{mt}=\frac{(1-\theta)(1-\sigma)}{\sigma\psi}(\frac{\theta\psi}{(1-\theta)\phi}\tilde{c}_{at}^{-1/\psi}\tilde{k}_{at}^{1+\phi/\psi})^{\theta}\tilde{c}_{at}^{-1+1/\psi}(\tilde{c}_{at}-\alpha_t)\tilde{k}_{at}^{-\phi/\psi}\equiv c_m(\tilde{c}_{at},\tilde{k}_{at}).$$

We also express

$$x_t=\frac{\theta\psi}{(1-\theta)\phi}\tilde{c}_{at}^{-1/\psi}\tilde{k}_{at}^{1+\phi/\psi}\equiv x(\tilde{c}_{at},\tilde{k}_{at}).$$

Then, substituting all the static equations into two dynamic equations (18) and (19) becomes

$$c_m(\tilde{c}_{at+1},\tilde{k}_{at+1})=\frac{\beta}{\gamma_t}[\theta(x(\tilde{c}_{at+1},\tilde{k}_{at+1}))^{\theta-1}+1-\delta]c_m(\tilde{c}_{at},\tilde{k}_{at})$$
$$\begin{aligned}&\tilde{k}_{at+1}+k_m(\tilde{c}_{at+1},\tilde{k}_{at+1})\\ &\quad=\frac{1}{n_t\gamma_t}[k_m(\tilde{c}_{at},\tilde{k}_{at})(x(\tilde{c}_{at},\tilde{k}_{at}))^{\theta-1}+(1-\delta)(\tilde{k}_{at}+k_m(\tilde{c}_{at},\tilde{k}_{at}))-c_m(\tilde{c}_{at},\tilde{k}_{at})].\end{aligned}$$

This is the two variable difference system. The system gives path of $\{\tilde{c}_{at+1},\tilde{k}_{at+1}\}_{t=0}^{\infty}$ given $(\tilde{c}_{a0},\tilde{k}_{a0})$. Once the path of $\tilde{c}_{at}$ and $\tilde{k}_{at}$ is derived, all other endogenous varibles are calculated using (20)–(23) and (24), (25).

Steady State Values

From the equilibrium condition of the transformed economy we can derive stedy state values. By the assumptions, $\alpha_t = 0$, $n_t = n$, and $\gamma_t = \gamma$. We omit tilde for the notational simplicity.

$$
\begin{aligned}
&k_{mss} x_{ss}^{\theta-1} = c_{mss} + k_{ss} n\gamma + (1-\delta) k_{ss} \\
&c_{ass} = k_{ass}^{\phi} n_{ass}^{\psi} \\
&\frac{\gamma}{\beta} \frac{c_{mss}}{c_{mss}} = \theta x_{ss}^{\theta-1} + 1 - \delta \\
&\theta x_{ss}^{\theta-1} = \frac{\sigma\phi}{1-\sigma} \frac{c_{mss}}{c_{ass}} \frac{c_{ass}}{k_{ass}} \\
&(1-\theta) x_{ss}^{\theta} = \frac{\sigma\psi}{1-\sigma} \frac{c_{mss}}{c_{ass}} \frac{c_{ass}}{n_{ass}} \\
&1 = n_{mss} + n_{ass} \\
&x_{ss} = \frac{k_{mss}}{n_{mss}} \\
&k_{ss} = k_{ass} + k_{mss}
\end{aligned}
$$

From the system, directly

$$
x_{ss} = \left(\frac{\frac{\gamma}{\beta} - 1 + \delta}{\theta}\right)^{1/(\theta-1)}
$$

After some calculation,

$$
\begin{aligned}
&c_{mss} = B x_{ss} / (1 + AB + C) \\
&k_{ass} = A c_{mss} \\
&k_{mss} = \frac{\phi\sigma}{(1-\sigma)\theta} x_{ss}^{1-\theta} c_{mss} \\
&k_{ss} = k_{ass} + k_{mss} \\
&n_{mss} = k_{mss} / x_{ss} \\
&n_{ass} = 1 - n_{mss} \\
&y_{ass} = c_{ass} = k_{ass}^{\phi} n_{ass}^{\psi} \\
&y_{mss} = k_{mss} x_{ss}^{\theta-1}
\end{aligned}
$$

where

$$
\begin{aligned}
&A = \sigma\psi x^{-\theta} / (1-\sigma)(1-\theta) \\
&B = x^{\theta-1} - n\gamma + 1 - \delta \\
&C = \frac{\sigma\phi}{(1-\sigma)\theta} x^{1-\theta} (n\gamma - 1 + \delta).
\end{aligned}
$$

Simulation Method via Shooting Algorithm

At the initial period, calculate $\tilde{k}_0$ from given actual value k_0. And we guess $\tilde{c}_{a0}$. Connecting (20), (21) and (23) gives

$$0 = \frac{\theta\psi}{(1-\theta)\phi}\tilde{c}_{a0}^{-1/\psi}\tilde{k}_{a0}^{1+\phi/\psi} + (1 - \frac{\theta\psi}{(1-\theta)\phi})\tilde{k}_{a0} - \tilde{k}_0$$

This is a nonlinear equation of $\tilde{k}_{a0}$ for given $\tilde{k}_0$ and guessed $\tilde{c}_{a0}$. We can solve the equation with respect to $\tilde{k}_{a0}$ using Newton-Raphson's method.

Once we get both $\tilde{c}_{a0}$ and $\tilde{k}_{a0}$, we can calculate path of $\{\tilde{c}_{at+1}, \tilde{k}_{at+1}\}_{t=0}^{\infty}$ using two variables difference system. Since the system has a saddle (as discussed below), we search appropriate initial value of $\tilde{c}_{a0}$ as the economy goes to the Steady State using the shooting algorithm a la Judd (1998).

Log-linearized System

A (log-) linearization makes it possible to analyze properties of the system around the steady state. Let $\hat{z}_t = \ln(z_t/z_{ss})$ where $z_t = (\tilde{c}_{at}, \tilde{k}_{at}, \tilde{c}_{mt}, \tilde{k}_{mt}, x_t)$. At around the steady state $\alpha_t \approx 0$. Then, using a matrix notetion, the log-linearized system is

$$A\hat{X}_{t+1} = B\hat{X}_t, \qquad \hat{X}_t = (\hat{c}_{at}, \hat{k}_{at})'$$

where A and B are matrices of exogenous variables and steady state values.

$$V^{-1}\hat{X}_{t+1} = DV^{-1}\hat{X}_t$$

where D is a matrix of eigenvalues and V is matrix of corresponding eigenvectors.

$$Z_{t+1} = DZ_t$$

with $Z_t = V^{-1}\hat{X}_t$. The property around the steady state is described by this eigenvalue matrix. Precisely, log-linearized transformed equilibrium conditions are:

$$\hat{c}_{mt+1} - \frac{\beta}{\gamma}\theta x_{ss}(\theta-1)\hat{x}_{t+1} = \hat{c}_{mt}$$
$$n\gamma k_{ss}\hat{k}_{t+1} = k_{mss}x_{ss}^{\theta-1}\hat{k}_{mt} + k_{mss}x_{ss}^{\theta-1}\hat{x}_t + (1-\delta)k_{ss}\hat{k}_t - c_{mss}\hat{c}_{mt}$$
$$\hat{x}_t = -\frac{1}{\psi}\hat{c}_{at} + \frac{\psi+\phi}{\psi}\hat{k}_{at}$$
$$k_{mss}\hat{k}_{mt} = (1 - c_{ass}^{1/\psi}k_{ass}^{-\phi/\psi})x_{ss}\hat{x}_t - c_{ass}^{1/\psi}k_{ass}^{-\phi/\psi}x_{ss}\frac{1}{\psi}\hat{c}_{at} + c_{ass}^{1/\psi}k_{ass}^{-\phi/\psi}x_{ss}\frac{\phi}{\psi}\hat{k}_{at}$$
$$\hat{c}_{mt} = \theta\hat{x}_t + \frac{1}{\psi}\hat{c}_{at} - \frac{\phi}{\psi}\hat{k}_{at}$$
$$k_{ss}\hat{k}_t = k_{ass}\hat{k}_{at} + k_{mss}\hat{k}_{mt}$$

Matrices A and B are 2×2, and thier elements are

$$\begin{aligned}
A_{11} &= 1 - \theta + \frac{\beta}{\gamma}\theta x_{ss}^{\theta-1}(\theta - 1) \\
A_{12} &= -\phi + (\phi + \psi)(\theta - \frac{\beta}{\gamma}\theta x_{ss}^{\theta-1}(\theta - 1)) \\
A_{21} &= -n\gamma x_{ss} \\
A_{22} &= n\gamma(k_{ss}\psi + x_{ss}\phi) \\
B_{11} &= 1 - \theta \\
B_{12} &= \theta(\psi + \phi) - \phi \\
B_{21} &= -c_{mss}(\psi + \phi) - x_{ss}^{\theta} + (1 - \delta)x_{ss} \\
B_{22} &= \psi(1 - \delta)k_{ss} + \psi x_{ss}^{\theta-1}k_{mss} + \phi x_{ss}^{\theta} + \phi(1 - \delta)x_{ss} - c_{mss}(\theta(\psi + \phi) - \phi)
\end{aligned}$$

This system has one predetermined variable, $\hat{k}_{at}$ and the other is non-predetermined, $\hat{c}_{at}$. Under plausible set of parameters, one element of D is absolutely less than 1 and the other is absolutely greater than 1. That is, the system has one saddle (at least around the steady state).

Table 1: Baseline Model Parameters

	Thailand	India
n	1.010	1.019
γ	1.041	1.046
θ	1/3	
δ	0.050	0.046
χ	1.00	
ϕ	0.40	
ψ	0.50	
β	0.95	
σ	0.20	0.40
α	$y_{a1960} \times 0.45$	

n and γ are long-run values.
Actual values are used before 2000.
(Actual γ is up to 1996 for Thailand.)

Table 2: Steady State Values and Eigenvalues of the Simulations

	Baseline		Counterfactual	
	Thailand	India	Thailand	India
c_{ass}	0.2910	0.5368	0.2802	0.4773
c_{mss}	0.9569	0.7097	0.9779	0.7460
y_{ass}	0.2910	0.5368	0.2802	0.4773
y_{mss}	1.3320	1.1489	1.3281	1.1307
k_{ss}	3.6988	3.8818	3.4529	3.4003
k_{ass}	0.6558	1.2838	0.4189	0.8435
k_{mss}	3.0430	2.5979	3.0340	2.5569
x_{ss}	3.4529	3.4003	3.4529	3.4003
n_{ass}	0.1187	0.2360	0.1213	0.2481
n_{mss}	0.8813	0.7640	0.8787	0.7519
eigenvalues	0.7101	0.7130	0.7545	0.7525
	1.3511	1.2946	1.3462	1.2992

Table 3: Counter factual experiment

	"Baseline"	"Counter factual"
Capital Share (ϕ)	0.40	0.25
Labor Share (ψ)	0.50	0.50
Land Share ($1-\phi-\psi$)	0.10	0.25

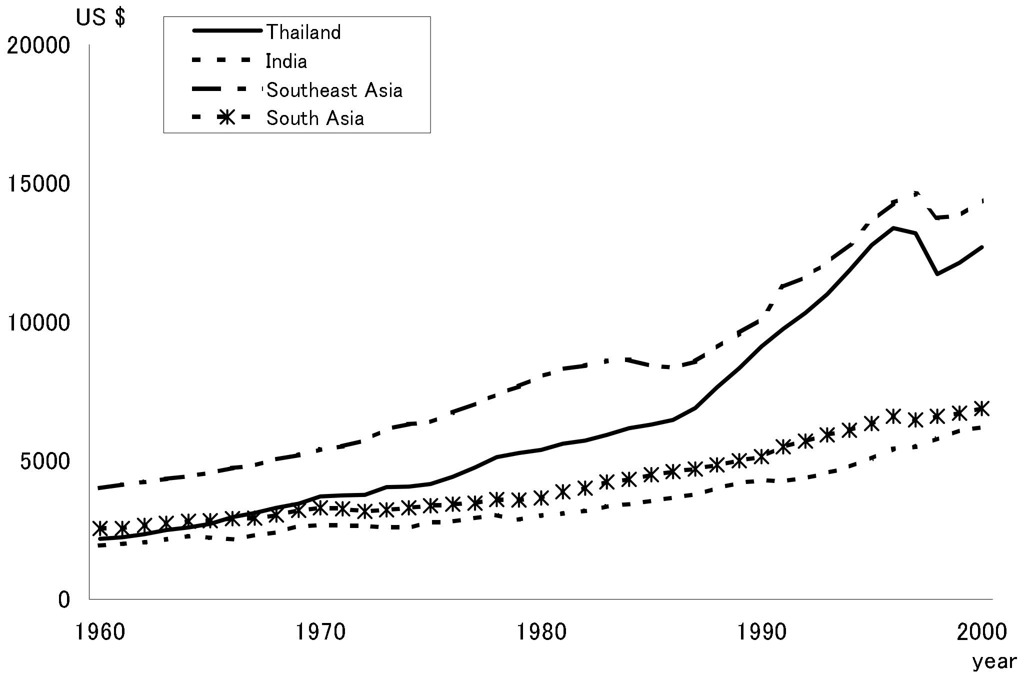

Figure 1: Real GDP per worker, Selected Asian countries 1960-2000

Source: Penn World Table version 6.1 (Heston et al. (2002)). "Southeast Asia" is the arithmetic average of Thailand, Indonesia, Malaysia and Philippines. "South Asia" is that of India, Bangladesh, Sri Lanka and Pakistan.

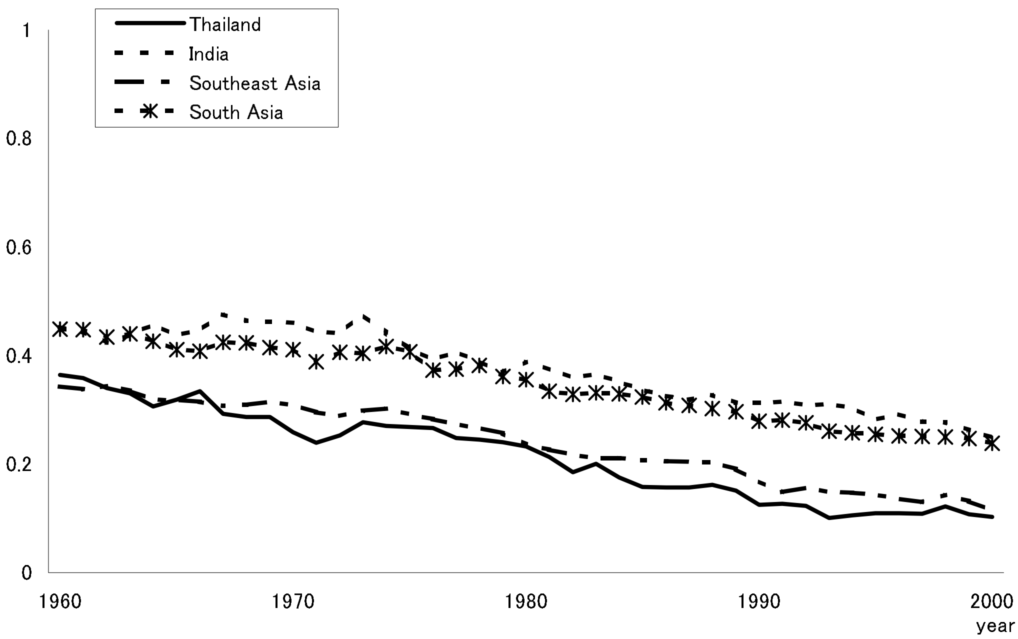

Figure 2: Ratio of Agriculture GDP, Selected Asian countries 1960-2000

Source: World Development Indicators 2003. "Southeast Asia" is a weighted average of Thailand, Indonesia, Malaysia and Philippines. "South Asia" is that of India, Bangladesh, Sri Lanka and Pakistan. The wight is GDP per worker used in Figure 1.

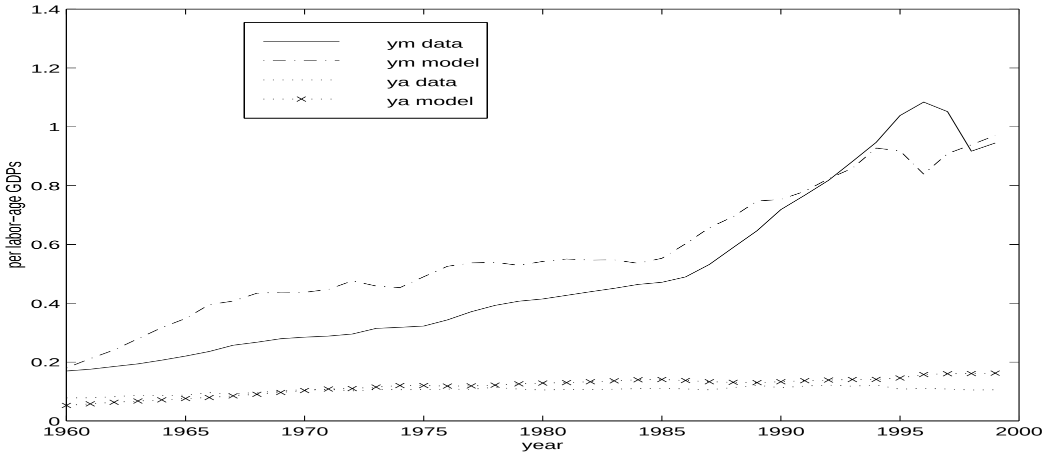

Figure 3: Actual and Model GDP per labor age population, Thailand 1960-2000, total GDP in 1988=1

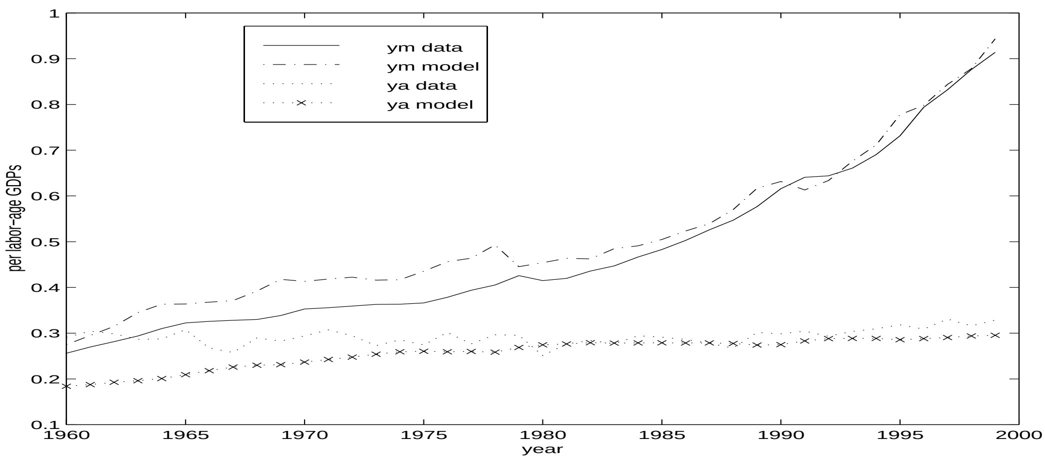

Figure 4: Actual and Model GDP per labor age population, India 1960-2000, total GDP in 1993=1

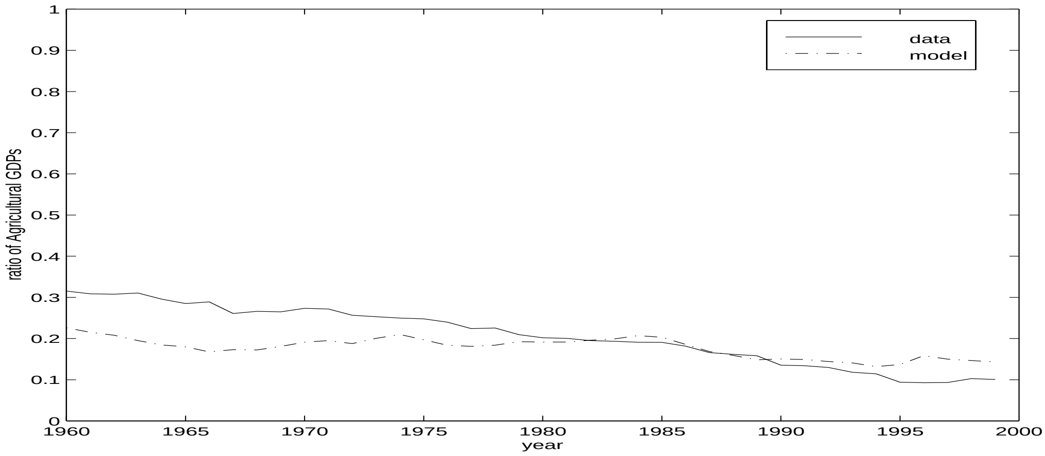

Figure 5: Actual and Model Ratio of Agricultural to total GDP per labor age population, Thailand 1960-2000

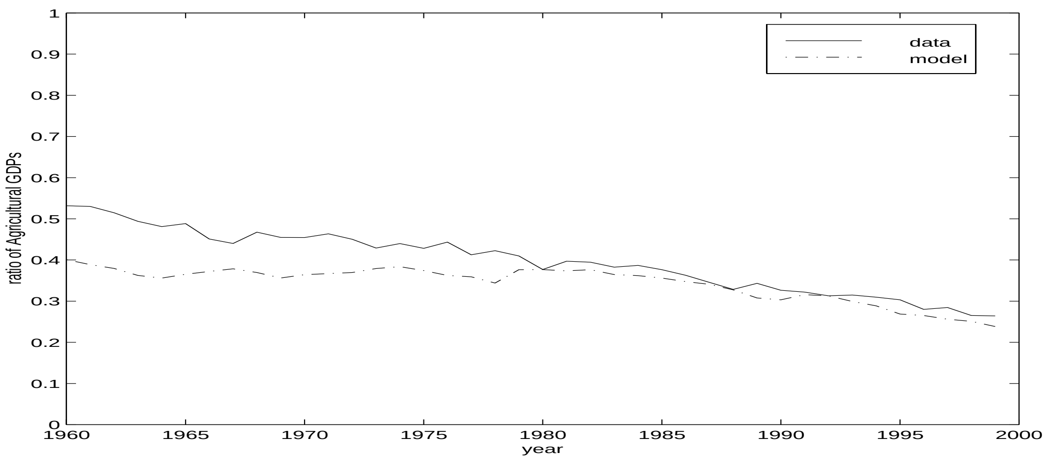

Figure 6: Actual and Model Ratio of Agricultural to total GDP per labor age population, India 1960-2000

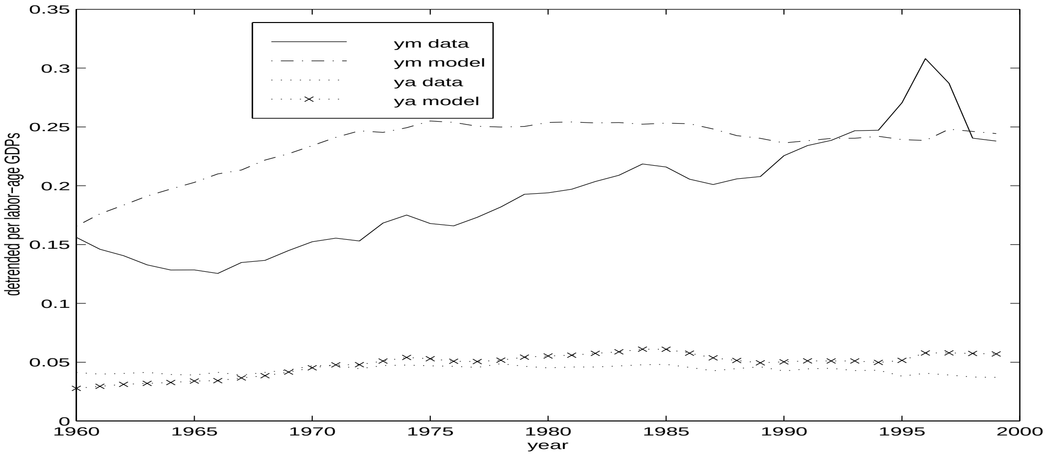

Figure 7: Deterended Actual and Model GDP per labor age population, Thailand 1960-2000

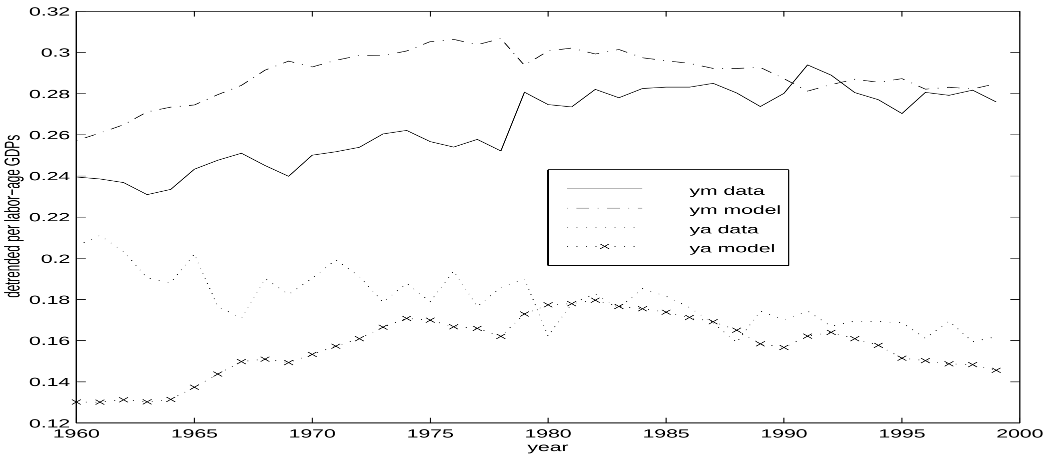

Figure 8: Deterended Actual and Model GDP per labor age population, India 1960-2000

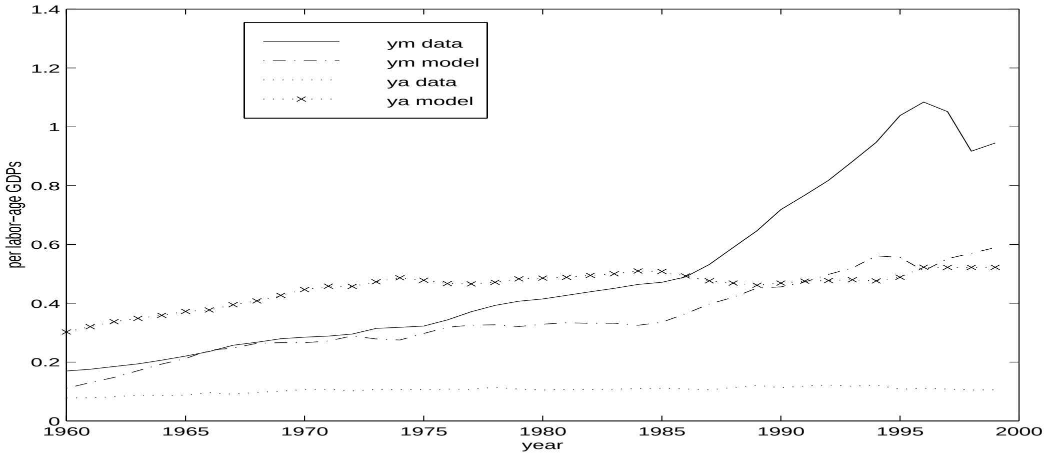

Figure 9: Actual and Counterfactual Model GDP per labor age population, Thailand 1960-2000, total GDP in 1988=1

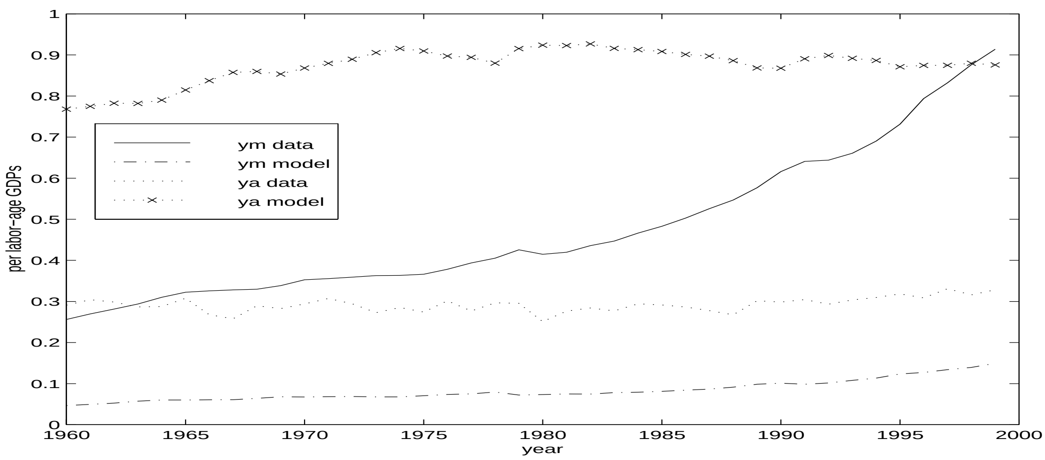

Figure 10: Actual and Counterfactual Model GDP per labor age population, India 1960-2000, total GDP in 1993=1

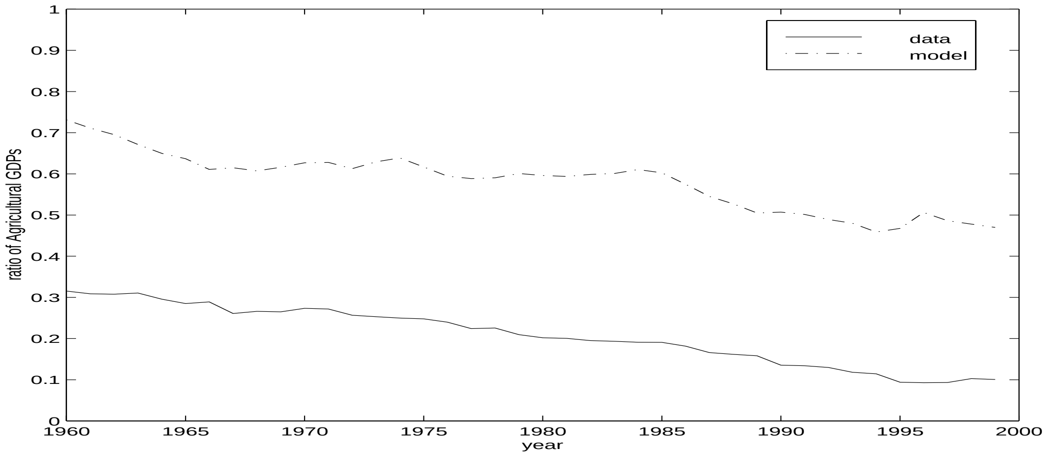

Figure 11: Actual and Counterfactual Model Ratio of Agricultural to total GDP per labor age population, Thailand 1960-2000

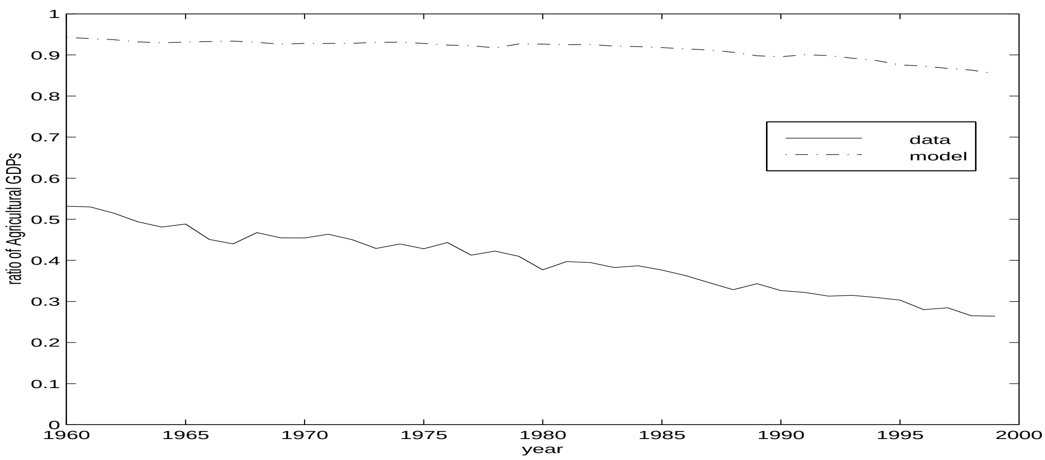

Figure 12: Actual and Counterfactual Model Ratio of Agricultural to total GDP per labor age population, India 1960-2000

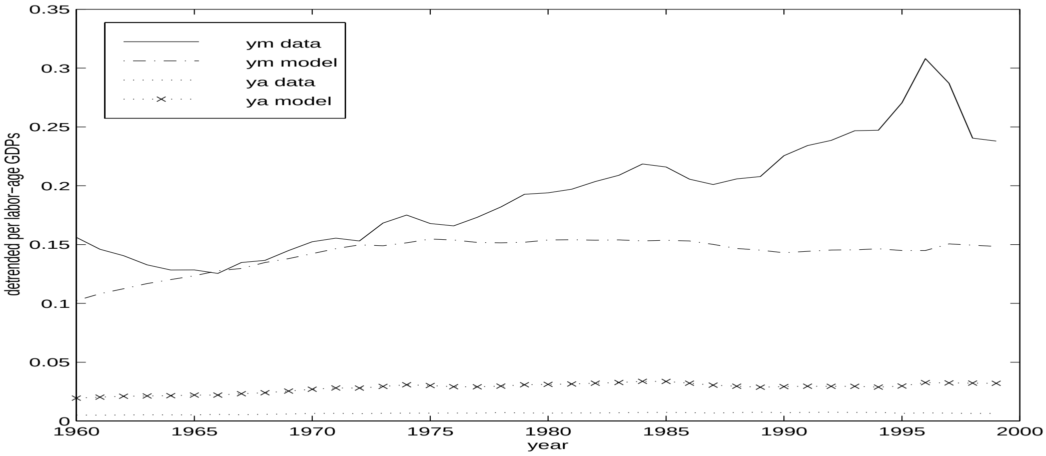

Figure 13: Deterended Actual and Counterfactual Model GDP per labor age population, Thailand 1960-2000

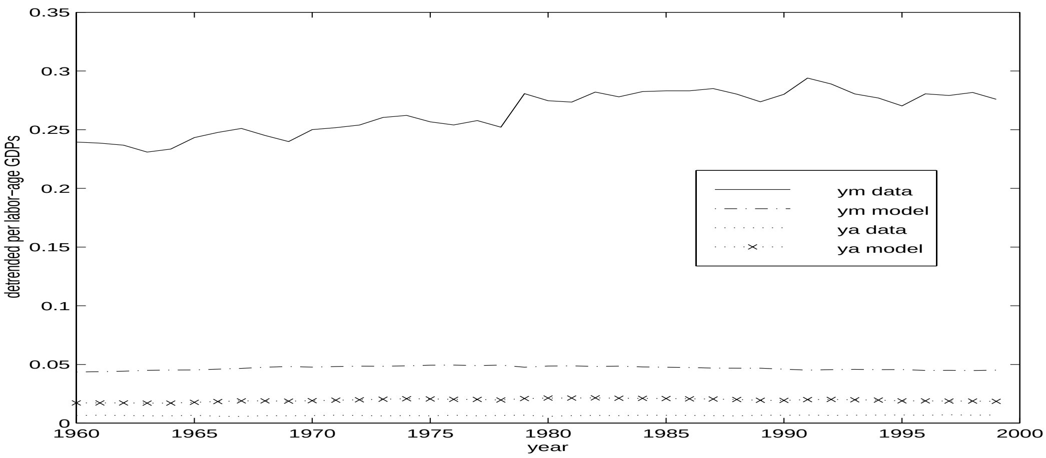

Figure 14: Deterended Actual and Counterfactual Model GDP per labor age population, India 1960-2000