American Economic Journal: Macroeconomics 2 (July 2010): 206–234
http://www.aeaweb.org/articles.php?doi=10.1257/mac.2.3.206

Confucianism and the East Asian Miracle†

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We examine two behavioral traits essential to Confucianism, and put forward hypotheses as to whether these behavioral traits impede or are conducive to "leading" or "follower" mode growth. A dynamic leader-follower general equilibrium model with appropriately specified "Confucian" parameters is shown to generate results that correspond to some of the main features of East Asian economies: their miracle growths, subsequent slowdowns, trade surpluses, and persistent accumulations of foreign exchange reserves. We calibrate the model to assess the quantitative importance of these cultural effects and examine their implications for future evolution of these economies. (*JEL* E23, O17, O41, O47, P24, Z12, Z13)

This paper examines the cultural factors that promoted East Asia's economic miracle from a macroeconomic perspective. The Asian miracle has two main characteristics: imitation rather than innovation, and high saving rates. Both characteristics can plausibly be related to some common behavioral traits influenced by Confucian tradition. We utilize a leader-follower model of endogenous growth to show that with appropriately specified "Confucian" parameters, the model can generate results that correspond to some of the main features of East Asian economies: their miracle growths, subsequent slowdowns, trade surpluses with the United States, and persistent accumulations of enormous foreign exchange reserves. We demonstrate that the trade surpluses and the accumulations of foreign exchange reserves could result from rational optimizing behavior by households in both these countries and the United States, once cultural differences are taken into consideration. To the extent that this link between cultural factors and economic outcomes can be captured mathematically, our paper suggests an approach to introducing culturally based explanations into economics that can be tested and may substantially enrich our understanding of economic phenomena.

From the 1960s to the 1990s, Asia's Four Tigers (Taiwan, South Korea, Hong Kong, and Singapore) transformed themselves from technologically backward and poor to relatively industrialized and affluent economies. Each country achieved

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Table 1—Average per Capita Real GDP Growth Rates
(*Percent per Annum*)

Time period	Taiwan	South Korea	Hong Kong	Singapore	Four Tigers (weighted average)	China	United States
Rapid growth:							
1963–1997	7.02	6.54	5.46	6.33	6.58		
1979–2007						8.65	
Slowing growth:							
1998–2007	3.71	3.87	2.65	3.44	3.70		
1963–2007							2.22

Note: We use the sizes of population as weights to compute "Four Tigers (weighted average)."
Source: International Monetary Fund (IMF), *International Financial Statistics*

sustained per capita real gross domestic product (GDP) growth averaging 6 to 7 percent per annum for over 30 years (see Table 1). The growth performance of the economies in these countries vastly exceeded those of virtually all other economies that had comparable productivity and income levels in 1960. The question of how they did it, obviously, is of enormous theoretical and policymaking importance. The literature on this subject can be divided into two distinct schools of thought.

First, it is generally agreed upon that the performance of the Four Tigers was a case of export-driven growth and that subtle government intervention played a key role in attracting foreign capital, promoting exports, and encouraging domestic savings and investments. Discussion in this vein places emphasis on "economic" and "institutional" factors. From the 1970s onward, many other developing countries vied to imitate this aspect of the Four Tigers' experiences, but with the exception of China (Table 1), none were able to match the astounding success of the Four Tigers for a sustained period.

Second, an increasing number of scholars have focused on the "cultural" side in emphasizing the favorable influence of Chinese Confucian tradition on economic growth. The parts of East Asia that have achieved rapid growth, including Japan, the Four Tigers, China, as well as the metropolitan areas of Malaysia, Thailand, Indonesia, and Vietnam, have all been deeply influenced by Chinese culture or are home to a significant number of ethnic Chinese. The aforementioned scholars point to how traditional Confucian ethics such as diligence, frugality, family solidarity, group harmony, and stress on education have been beneficial to economic growth. However, discussion on this aspect is often sweeping and lacking in rigor. In particular, these scholars have not dealt satisfactorily with the thesis put forward by Max Weber in the early twentieth century that Confucian tradition was inimical to modern capitalistic development.[1]

[1] Weber proposed these views starting in 1915 in articles written in German in the *Archiv fur Sozialwissenschaft und Soziapolitik*. This paper quotes from the English translation by Hans H. Gerth in *The Religion of China: Confucianism and Taoism*. After documenting the earlier achievements of Chinese science and technology, Joseph Needham (1981) raised the question of why the Industrial Revolution did not come to China first, but came to Britain instead. This somewhat narrower focus on the event of the Industrial Revolution is referred to in the literature as the Needham Paradox. See Henry Y. Wan, Jr. (1995), Justin Yifu Lin (1995), and David S. Landes (2006).

This paper proposes an approach that is capable of reconciling the differing viewpoints of Weber and more contemporary scholars regarding the influence of Confucian tradition on economic growth. We build on the recent research concerning technological diffusion across countries (e.g., Paul Krugman 1979; David T. Coe, Elhanan Helpman, and Alexander W. Hoffmaister 1997; Daron Acemoglu and Fabrizio Zilibotti 2001; Robert J. Barro and Xavier Sala-i-Martin 1997, and 2004, chapter 8) and distinguish between two modes of growth: the leading mode and the follower mode. Leading mode economic growth is the pattern of growth that has characterized the economic history of most advanced Western countries over the past 100 to 200 years. This kind of growth is nearly always marked by continuous technological innovation. Follower mode economic growth is a different pattern of growth shaped by the countries of East Asia as they made their way forward in the second half of the twentieth century. These countries tap into technologies that already exist in advanced countries, and the "transplantation" of those existing technologies provides the primary driving force of growth. When Weber expounded the view that Confucian tradition retarded modern capitalist development, he was thinking of leading mode growth, which he observed and experienced firsthand during his lifetime (1864–1920). On the other hand, when contemporary scholars from the 1970s onward posited that Confucian tradition was conducive to East Asia's economic development, they were referring to follower mode growth.[2]

In addition to the analysis of technological diffusion, our paper is also related to three strands of recent literature on growth. First, there is a class of endogenous growth models that has gone beyond economic factors to examine "deeper" political and social influences on different countries' growth experiences: factors such as political stability (Alberto Alesina et al. 1996), government corruption (Andrei Shleifer and Robert W. Vishny 1993; Paolo Mauro 1995), and religious participation and beliefs (Barro and Rachel M. McCleary 2003), etc. Our work fits in with this literature in focusing on the cultural influences on growth. The novelty is that we differentiate between the opposite effects of the same cultural forces on the leading and follower modes of growth and use this conceptual framework to look at the growth experiences of East Asian economies.

Second, there have been surprisingly few rigorous attempts to model growth "miracles"—i.e., deviations from average behavior. Robert E. Lucas, Jr. (1993) (*Making a Miracle*) is an inspiring effort. He proposes a theory of "learning spillover technology" as the basic setup for modeling the East Asian miracles. Shortly after, Lucas (1993) appealed for such a need of effort, however, the economic growth in each of the Four Tigers slowed down considerably. Since 1998, the per capita real GDP growth rates of Taiwan (3.71 percent), South Korea (3.87 percent), Hong Kong (2.65 percent), and Singapore (3.44 percent) have fallen far short of their dazzling performances during the golden era of 1963–1997 (Table 1). A successful theory of the East Asian growth miracles should also be able to explain their recent slowdowns. Our work complements Lucas's research and provides an alternative approach for

[2] The idea of this approach originated and took shape during our class meetings at National Taiwan University. We later found that Wan (2004, 59) briefly mentioned the *possibility* of such an approach. But he did not explore further this possibility in his subsequent discussions on the economic consequences of Confucianism.

thinking about the East Asian miracles. Once these East Asian economies catch up with and join the ranks of advanced industrial societies, the Confucian traits that were helpful to their follower mode growth will gradually become an impediment to their leading mode growth.

Finally, several recent growth accounting exercises (Alwyn Young 1995; Chang-Tai Hsieh 2002) have found that the extraordinary rate of output growth of the Four Tigers was due primarily to an equally impressive rate of factor accumulation, with little of it due to total factor productivity (TFP) growth. Many economists were surprised by the low TFP growth estimates and concluded that the growth of the Four Tigers was nothing miraculous because, unlike miracles, which, by definition, cannot be explained, the performance could be explained easily within the simple framework of factor accumulation. As Young concluded, his results should be "heartening" to economists because they showed that the neoclassical growth theory "is admirably well-equipped to explain the East Asian experience" (Young 1995, 675). But if the Four Tigers' startling output growth can be adequately explained by improvements in the quantity and quality of the factors of production, then what were the forces that boosted their ability to make such *miraculous* improvements on the factor of production side? The cultural forces we focus on imply a greater willingness to save and a tremendous emphasis on education, and thus, provide theoretical underpinnings for these empirical estimates.

The rest of the paper is organized as follows. Section I expounds our analysis on Confucianism and modern economic growth. Section II illustrates the analysis in a dynamic general equilibrium growth model of a leader-follower economy. In Section III, we calibrate the model to assess the quantitative importance of the cultural effects and to examine their implications for the future evolution of these East Asian economies. Section IV concludes.

I. Confucianism and Modern Economic Growth

Under the influence of Confucian tradition, East Asian countries share some common behavioral traits. We briefly discuss two such kinds: the importance attached to study and academic qualifications; and the importance attached to family and kinship.

A. *Importance Attached to Study and Academic Qualifications*

Chinese people, and those in East Asia who have been influenced by Chinese culture, attach relatively high importance to study and to academic qualifications. Such dedication can be traced back to the basic teachings of Confucius. Indeed, we can say that Confucius was the first sage in human history to advocate universal education. This tradition of attaching importance to study developed into the imperial civil service examination system during the Sui and Tang dynasties (618–906 AD), thus becoming even more entrenched in the culture. For the next 1,000 years, studying hard and performing well in examinations were the pathway to making a better life for Chinese people of humble origin. Among the traditions of mankind's major civilizations, China was unique in terms of the universal importance attached to education by all of its people and the thousand-year maintenance of an examination system for determining appointments and promotions in the imperial government. This tradition, however, was considered by Weber as an impediment to the development of capitalism. He thought that China's scholar-official class proudly displayed particular cultural depth and moral cultivation, but lacked a rational and scientific temper. The focus of the imperial civil service examinations was on testing a candidate's familiarity with ancient texts and standards of moral behavior, but did not require any critical or logical thinking ability.

We want to stress that an examination system oriented toward testing rigid memorization and focusing on moral rules in the knowledge hierarchy, though perhaps unfavorable to the occurrence of leading mode economic growth in China, was not an impediment to, and perhaps was even conducive to, the promotion of the follower mode economic growth in East Asian countries. In the case of the Four Tigers, once the political situation had stabilized in the aftermath of World War II, the governments made it a priority to implement universal compulsory education. The policy was carried out with relative ease because ordinary people supported it and cooperated. This meant that in the 1960s, when the governments began to launch their policies aimed at encouraging exports and attracting foreign capital, the Four Tigers already possessed a pool of literate and highly disciplined workers. This high-quality work force helps to propel follower mode growth, as some literature has emphasized a robust and strong role for human capital to facilitate the absorption of new technologies from leading countries (e.g., Richard R. Nelson and Edmund S. Phelps 1966; F. Welch 1970; Ann P. Bartel and Frank R. Lichtenberg 1987; Eric A. Hanushek and Dennis D. Kimko 2000). In such models of technology adoption, an increase in the supply of educated workers accelerates the rate of diffusion of new technologies by lowering the cost of adaptation and implementation.

B. *Importance Attached to Family and Kinship*

The teachings of Confucius emphasized family relationships, as exemplified by his injunction to be "a kind father and a filial son; an affectionate elder brother and a respectful younger brother." This mindset of placing high importance on the family is an important characteristic of East Asian countries. Weber considered this same characteristic as a hindrance to the development of capitalism. Because of an over-reliance on family and kinship, China has always lacked "fixed, publicly recognized, formal and reliable legal foundations for a free and cooperatively-regulated organization of industry and commerce, such as is known in the Occident" (Weber 1951, 20). Furthermore, this kind of tradition easily leads to nepotism and is unfavorable to establishing large-scale, independent, and efficient modern enterprises.

The closeness of family ties, however, was helpful to the Four Tigers' economic growth as it encouraged saving, thus facilitating capital accumulation. In East Asian countries, it is taken for granted that parents will support their children financially throughout college, including tuition. After graduating from college, children will often continue to receive financial assistance from their parents. In Taiwan, for example, as people have attained a higher standard of living and have gradually accumulated wealth, the idea of buying a house for their son has become prevalent.

Table 2—Comparison of Gross Savings Rates in Various Countries (*Percent*)

	1971–1980	1981–1990	1991–2000	2001–2007
Taiwan	31.7	32.5	26.6	26.0
South Korea	22.3	32.4	36.2	32.4
Hong Kong	31.3	33.7	31.4	31.6
Singapore	29.9	42.1	48.4	45.4
China	—	34.9	39.8	44.9
United States	20.3	18.4	17.4	14.3
United Kingdom	19.4	18.1	16.4	14.6
Egypt	11.4	18.3	14.6	15.4
Pakistan	10.1	10.1	15.6	15.9
Sri Lanka	13.2	13.3	16.4	16.7
Argentina	24.9	21.9	17.3	25.4
Australia	26.7	24.0	22.2	24.2

Notes: There are various methods for calculating savings rates. For convenience of comparison, we use the simplest formula: Gross savings rate = (GDP − household consumption − government consumption)/GDP.

Source: IMF, *International Financial Statistics*

After providing each of their sons with a house, there are plenty of parents who start saving to buy houses for their daughters as well. This thinking can perhaps be traced back to the customary practice of "the eldest grandson's field" in earlier agricultural society—in accordance with which it was common for a grandfather to give a piece of land to his eldest grandson as a present. In the relatively poor agricultural society, a person would typically endure a lifetime's hardship of scrimping and saving to secure a piece of land to give to his eldest grandson. In the 1970s and 1980s, as savings increased along with the higher standard of living, this customary practice imperceptibly evolved into "buying a house for one's eldest son," then "buying a house for each of one's sons," and "buying a house for each of one's children."

Table 2 presents a comparison of the gross savings rates of East Asian countries and representative countries in other regions that have different cultural traditions. The figures show that from 1971 to 2007, the savings rates of East Asian countries were markedly higher than those in other countries.[3] Such a sustained period of high savings rates greatly contributed to capital accumulation, an area in which Young's (1995) empirical evidence demonstrated the remarkable performance of the Four Tigers.

II. Formal Analytical Modeling

We employ a setup similar to that described in Paul M. Romer (1990), Luis A. Rivera-Batiz and Romer (1991), and Barro and Sala-i-Martin (1997, and 2004, chapter 8). Thus, we can build upon and compare with these earlier analyses. Barro and Sala-i-Martin (2004), in particular, develop a scenario assuming the rates of time preference to be the same in all countries. Our model explores the logical consequences of differing the rates of time preference between the leader and the

[3] Besides the cultural influences emphasized here, there have been many proposed, though not necessarily mutually exclusive, explanations for the high savings rates in East Asian economies, such as the effects of demographics (low dependency ratios), social security systems, tax incentives, land and housing prices, etc. Fumio Hayashi (1986) and Barry P. Bosworth (1993) are some of the representative studies of these explanations.

follower. This simple framework has the advantage of placing our particular focus of cultural forces into sharp relief by suppressing all other factors that have been abundantly addressed in the East Asian economic development literature, such as cheap labor, trade openness, government export-oriented policies, foreign direct investment, etc. The very simplified setup helps us isolate the exact sense in which cultural factors may influence growth.

A. *Assumptions and Notations*

We postulate a world of two countries: an innovating West, and a noninnovating East. Innovation takes the form of the introduction of new intermediate goods used in producing the final output. The level of technology corresponds to the number of varieties of intermediate products that have been discovered by the technological leader. Agents in the West expend effort to invent these products. The inventor of a new variety of product in the West retains a perpetual monopoly right over the production and sale of this good in the West. The flow of monopoly profit provides the incentive for invention. The East does not invent intermediate goods, but instead imitates the products that have been discovered in the West. The use of one of these products requires some effort in adaptation to a different environment. We think of this effort as a cost of imitation. The cost is similar to the research and development (R&D) outlay, except that the cost of imitation is typically less than the cost of invention. The agent who incurs the cost of imitation is assumed to obtain a perpetual monopoly over the use of this intermediate good in the East. We assume that imitators pay no fees to foreign inventors and that these intermediate goods cannot be traded between the two countries.

Final goods produced in the two countries are identical and tradable across borders. We assume initially that there is no global capital market. Hence, trade is balanced between the two countries at any point in time. The two economies are, in effect, closed except for the transfer of technology through imitation. The model is formulated in continuous time. The two countries are denoted by $i = 1, 2$: 1 represents the West, and 2 represents the East. We follow Michael Spence (1976), Avinash K. Dixit and Joseph E. Stiglitz (1977), and Romer (1987, 1990) by writing the production function as

$$Y_i = A_i (L_i)^{1-\alpha} \sum_{j=1}^{N_i} (X_{ij})^{\alpha}, \tag{1}$$

where $0 < \alpha < 1$, Y_i is output, L_i is labor input, X_{ij} is the quantity employed of the j-th type of specialized, nondurable intermediate good, and N_i is the number of types of intermediates available in country i. The total quantities of labor in each country, L_1 and L_2, are constant. The parameter A_i represents the level of productivity. Technological progress takes the form of expansions in N_i, rather than increases in A_i. This identification of the state of technology with the number of varieties of products should be viewed as a metaphor. It selects one aspect of technical advance, and thereby provides a tractable framework to study endogenous growth.

The final goods, Y_i, can be used for consumption (C_i), production of intermediates (X_{ij}), and for the R&D needed to invent or to imitate new varieties of intermediates.

All prices are measured in units of the homogeneous flow of Y_i. Units of C_i or X_{ij} each require one unit of Y_i. The invention of a new variety of intermediate in the West requires a constant outlay of η units of output. The imitation of one of the Western intermediates for use in the East requires ν units of output, and we assume that intermediates known in the West varied in terms of how costly they were to adapt to the environment of the East. The intermediates that were easier to imitate would be copied first, and the ν that applied at the margin would increase with the number already imitated. This property can be captured by specifying that ν is an increasing function of N_2/N_1

(2) $$\nu = \nu\left(\frac{N_2}{N_1}\right), \qquad \text{where } \nu' > 0.$$

It can be shown[4] that the monopoly price for the intermediate X_{ij} is

(3) $$P_j = \frac{1}{\alpha} > 1.$$

Hence, the price P_j is constant over time, and the same for all intermediate goods j. The price is the same for all goods j because the cost of production is the same for all goods, and each good enters symmetrically into the production function in equation (1). If we substitute for P_j from equation (3) into the demand equation for X_{ij}, we can determine[5] the aggregate quantity produced of each intermediate j:

(4) $$X_{ij} = A_i^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2}{(1-\alpha)}} L_i.$$

This quantity is the same for all intermediate j and at all points in time. The total output is

(5) $$Y_i = A_i^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} L_i N_i,$$

and the wage rate equals the marginal product of labor

(6) $$w_i = \frac{\partial Y_i}{\partial L_i} = (1-\alpha) A_i^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} N_i.$$

The flow of monopoly profit to the owner of the rights to intermediate j is

(7) $$\pi_{ij} = \pi_i = \left(\frac{1-\alpha}{\alpha}\right) A_i^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2}{(1-\alpha)}} L_i,$$

which is constant and the same for all j.

[4] See Barro and Sala-i-Martin (2004, 291–92).
[5] See Barro and Sala-i-Martin (2004, 351–57).

If there is free entry into the R&D business, then the present value of the monopoly profit flow must equal η (or ν) at each point in time. This condition implies that the rate of return to investing in R&D in the West is constant over time and given by

$$r_1 = \frac{\pi_1}{\eta}. \tag{8}$$

In the East, since ν varies over time according to equation (2), the rate of return to investing includes a capital-gain term, $\dot{\nu}/\nu$:

$$r_2 = \frac{\pi_2}{\nu} + \frac{\dot{\nu}}{\nu}. \tag{9}$$

η is also the market value of a firm that possesses the blueprint to produce one of the intermediate goods. Therefore, the aggregate market value of innovating firms in the West is ηN_1. On the other hand, ν is the market value of an imitating firm in the East. The market value of all imitating firms in the East is νN_2.

We assume that there is one single infinitely lived household in each country. The household receives the wage rate w_i on the fixed quantity L_i of labor, earns the rate of return r_i on assets ηN_1 (or νN_2), purchases goods for consumption (C_i), and saves by accumulating assets. At time 0, the household seeks to maximize the discounted sum of future instantaneous utilities

$$U_i = \int_0^\infty \left[\frac{(C_i^{1-\theta} - 1)}{(1-\theta)}\right] e^{-\rho_i t}\, dt, \tag{10}$$

where $\rho_i > 0$ is the rate of time preference, and $\theta > 0$ is the reciprocal of the elasticity of intertemporal substitution of consumption. A positive value of ρ_i means that utilities are valued less the later they are received. If parents prefer a unit of their own consumption to a unit of their children's consumption, the parental "selfishness" corresponds to $\rho_i > 0$. Maximization of utility subject to the budget constraint leads to the familiar Euler equation for the growth rate of consumption:

$$\frac{\dot{C}_1}{C_1} = \left(\frac{1}{\theta}\right)(r_1 - \rho_1) = \left(\frac{1}{\theta}\right)\left(\frac{\pi_1}{\eta} - \rho_1\right), \tag{11}$$

$$\frac{\dot{C}_2}{C_2} = \left(\frac{1}{\theta}\right)(r_2 - \rho_2) = \left(\frac{1}{\theta}\right)\left(\frac{\pi_2}{\nu} + \frac{\dot{\nu}}{\nu} - \rho_2\right). \tag{12}$$

B. *Steady-State Growths with Uniform Rates of Time Preference*

We have provided a quick summary of the model setup above. We shall make use of the following known properties of the model:

- The West has no transitional dynamics and is always in a steady state with N_1 and Y_1 growing at the same constant rate as C_1. Let us denote this steady-state growth rate as γ_1.

- The dynamic behavior of the East is not as simple as that of the West. Since ν depends on the ratio N_2/N_1, if the growth rate of N_2 differs from that of N_1, the ratio N_2/N_1 will display transitional dynamics, and so will r_2 and the growth rate of C_2. During the transition, N_2 grows faster than N_1 as being predicated on the initial condition for N_2 being below its steady-state value. Furthermore, it has been shown[6] that during the transition, the growth rate of N_2 falls steadily toward that of N_1, and both r_2 and the growth rate of C_2 decline monotonically toward their steady-state values.
- In the steady state of the world economy, N_2 grows at the same rate, γ_1, as N_1. The ratio N_2/N_1 remains constant, denoted by $(N_2/N_1)^*$. Assume that the parameters are such that the East never completely catches up with the West so that $0 < (N_2/N_1)^* < 1$. The growth rates of Y_2 and C_2 equal the growth rate of N_2, which equals γ_1. Therefore, the steady-state growth rates of all the quantities in the East, denoted by γ_2^*, equal γ_1. In such an equilibrium, the West is the perpetual leader and the East is the perpetual follower.

Barro and Sala-i-Martin (1997, 2004) assume ρ's to be identical in all countries. Their scenario implies that the world long-run growth rate will be driven by discoveries in the leading economies, while the comparison of growth rates across countries reflects the conditional convergence behavior related to the costs of copying inventions. They believe that such a form of conditional convergence is a fair approximation of a real world situation, "a property found in the cross-country data on economic growth" (Barro and Sala-i-Martin 1997, 23; see also Barro and Sala-i-Martin 2004, 372–73). We will now see how this model, by adopting exceptional magnitude for some of the parameters, can shed light on the exceptional performance of East Asian economies.

C. *The Scenario of Miracle Growths: The Convergence Phase*

The cultural factors discussed in Section I can be represented by the magnitude of three parameters in the model:

- The cost of inventing a new intermediate is prohibitively high for the East, reflecting Weber's view that the behavioral traits essential to Confucianism were unfavorable for generating innovation.
- The function $\nu(N_2/N_1)$ is situated at a low position because an educated workforce facilitates the absorption of new technologies from the leading economy by lowering the cost of adaptation.
- ρ_2 is low because close family relationships decrease the degree of parental "selfishness," resulting in a greater willingness to save. From equation (12), we see that low values of ν and ρ_2 generate high growth rates of C_2, and hence of N_2 and Y_2 during the transition phase. The two behavioral traits provide the possible underlying forces for exceptional performance of miracle growths.

[6] See Barro and Sala-i-Martin (2004, 362–63).

It is true that in our simple leader-follower setup, a low initial value of N_2 *alone* would be able to generate high growth rates of C_2, N_2, and Y_2 for the East during the transition phase, a feature common in most technological diffusion models. In the analysis of this paper, however, we want to focus on the low imitation cost function and a low value of ρ_2, in addition to the low initial value of N_2, as the major factors behind the high growth rates in the East. Essentially, we want to use the model setup to highlight the two cultural traits as the driving forces that enable the East Asian countries to outperform other developing economies with similar initial economic conditions, but different cultural traditions.

Thus, with appropriately specified "Confucian" values of ν and ρ_2, our model can have Y_2, C_2, and N_2 of an East Asian economy growing at miraculous rates (at 6–8.6 percent annually), while Y_1, C_1, and N_1 of a leading country (such as the United States) grow at more moderate rates of around 2 percent annually during the same period. We are not asserting that these cultural factors are the only forces behind the East Asian miracle. Rather, we are emphasizing that these factors should be taken into proper account in *any* study of East Asian economies. In trying to explain the East Asian miracle, scholars tend to be puzzled by the diversity in these economies if they limit themselves to the traditional confines of economic analysis. For example, Hong Kong is a classical case of *laissez-faire* economy with hardly any government intervention, while Taiwan, South Korea, and Singapore have all been under government management to a great extent; and China is essentially a planned economy under an authoritarian government. Another frequently cited example of difference is that South Korea is dominated by a few large conglomerates, while Taiwan is famous for small and medium-sized enterprises. We want to stress that the influence of Confucian traditions is uniformly present and quite dominant in all these economies.

D. *The Scenario of Growths with Differing Rates of Time Preference: The Maturity Phase*

We have looked at the transition path with the assumption $\rho_2 < \rho_1$. We now explore the logical consequences of $\rho_2 < \rho_1$ in the mature stage. If we continue to maintain the assumption of no trade between the two countries, then from equations (11) and (12), $\gamma_2^* = \gamma_1$ and $\rho_2 < \rho_1$ imply that the steady-state $r_2^* < r_1$. In other words, ν will have to rise to the extent that r_2 in the East actually becomes lower than r_1 in order to reach a steady-state equilibrium with the West.

Let us assume that at $t = T_0$, before reaching the steady state, r_2 reaches the level of r_1. Instead of letting r_2 decline further, consider a more realistic scenario that allows the East to ship its savings (in the form of final output) across national borders to the West to earn the constant rate of return r_1. Innovators in the West could expend these imported resources of output to invent new varieties of intermediates. We could assume that the Western household owns the innovating firms thus established, but obtains the financing by issuing bonds to the Eastern household. The results would be the same if we allowed the Eastern household to own these innovating firms rather than bonds.

Let us use N_{12} to denote the number of intermediates invented by these innovating firms located in the West, but owned directly or indirectly by the Eastern household. Once invented, the new varieties of intermediates would be available for adaptation in the East as well. Let us use N_{11} to denote the number of intermediates owned by the Western household. We now have $N_1 = N_{11} + N_{12}$ and final output in the West is

$$
\text{(13)} \qquad \begin{aligned} Y_1 &= A_1^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} L_1 N_1 \\ &= A_1^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} L_1 (N_{11} + N_{12}). \end{aligned}
$$

The budget constraint of the Western household can be written as

$$
\text{(14)} \qquad \begin{aligned} \eta \dot{N}_{11} &= w_1 L_1 + r_1 \eta N_{11} - C_1 \\ &= w_1 L_1 + r_1 \eta N_1 - C_1 - r_1 \eta N_{12}, \end{aligned}
$$

where $r_1 \eta N_{12}$ are the returns to the innovating firms owned by the Eastern household. Maximization of utility by the Western household implies that the growth rate of C_1 is related to r_1 in the usual way, as in equation (10): $\dot{C}_1/C_1 = (1/\theta)(r_1 - \rho_1)$.

For tractability, we assume a constant-elasticity form of the cost function from equation (2):

$$
\text{(15)} \qquad \nu = \overline{\nu} \left(\frac{N_2}{N_1} \right)^{\sigma},
$$

for $N_2/N_1 < 1$, where $\sigma > 0$ and is a constant. Note that ν approaches $\overline{\nu}$ as (N_2/N_1) approaches 1. We assume that as ν rises to the level

$$
\nu^{**} = \overline{\nu} \left[\left(\frac{N_2}{N_1} \right)^{**} \right]^{\sigma},
$$

such that

$$
\text{(16)} \qquad \frac{\pi_2}{\nu^{**}} = \frac{\pi_1}{\eta} = r_1,
$$

for some $(N_2/N_1)^{**} < 1$, the East begins to ship saved output to the West. Equation (16) can be rewritten as

$$
\text{(17)} \qquad \left(\frac{N_2}{N_1} \right)^{**} = \left[\left(\frac{\pi_2}{\pi_1} \right) \left(\frac{\eta}{\overline{\nu}} \right) \right]^{\frac{1}{\sigma}} \equiv \lambda,
$$

where $0 < \lambda < 1$ and is a constant.

At each instant for $t > T_0$, λN_1 intermediates will be imitated in the East. Final output in the East is

$$(18)\qquad Y_2 = A_2^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} L_2 N_2$$

$$= A_2^{\frac{1}{(1-\alpha)}} \alpha^{\frac{2\alpha}{(1-\alpha)}} L_2 \lambda N_1.$$

The budget constraint of the Eastern household is now different. The market value of all imitating firms in the East is $\nu \; \lambda \; N_1$. The total of the Eastern household's assets equals the market value of domestic imitating firms $(\nu \; \lambda \; N_1)$ and that of foreign innovating firms located in the West (ηN_{12}). Total savings in the East will be allocated simultaneously among investment in: creating new innovating firms in the West $(\eta \dot{N}_{12})$; imitating these newly invented intermediates for use in the East $(\nu \, \lambda \, \dot{N}_{12})$; and imitating the new intermediates invented from the Western household's savings $(\nu \, \lambda \, \dot{N}_{11})$. These three channels of investment earn the same constant rates of return $r_2 = r_1$. It follows that the Eastern household's budget constraint becomes

$$(19)\qquad \nu \, \lambda \, \dot{N}_{11} + (\nu \, \lambda + \eta)\dot{N}_{12} = w_2 \, L_2 + r_2 \, \nu \, \lambda \, N_1 + r_1 \, \eta \, N_{12} - C_2.$$

Since the growth of N_{11} is exogenously determined in the West, the choice constraint for the Eastern household becomes

$$(20)\qquad (\nu\lambda + \eta)\dot{N}_{12} = w_2 L_2 + r_2 \nu \, \lambda N_1 + r_1 \eta \, N_{12} - C_2 - \nu \, \lambda \dot{N}_{11}.$$

Maximization of utility subject to this budget constraint implies that the growth rate of consumption in the East is

$$(21)\qquad \frac{\dot{C}_2}{C_2} = \left(\frac{1}{\theta}\right)(r_2 - \rho_2)$$

$$= \left(\frac{1}{\theta}\right)(r_1 - \rho_2).$$

The West is no longer in a steady state because of the influx of resources to expand the technologies:

$$\frac{\dot{Y}_1}{Y_1} = \frac{\dot{N}_1}{N_1} \neq \frac{\dot{C}_1}{C_1}.$$

The dynamic behavior of the West can be studied by considering differential equations (11) and (14) for the variables C_1 and N_{11}. We also have differential equations

(21) and (20) for the variables C_2 and N_{12}. The solutions can be stated as follows (see the Appendix[7] for the derivation):

$$C_1(t) = C_1(T_0)\, e^{\gamma_{C1} t}, \tag{22}$$

$$C_2(t) = C_2(T_0)\, e^{\gamma_{C2} t}, \tag{23}$$

$$N_{12}(t) = -\left[\frac{a}{(r_1 - \gamma_{C1})}\right] C_1(t) + \left[\frac{b}{(r_1 - \gamma_{C2})}\right] C_2(t), \tag{24}$$

$$N_{11}(t) = \left\{ f \Big/ \left[r_1\left(\frac{1+\alpha}{\alpha}\right) - \gamma_{C1}\right]\right\} C_1(t) - \left\{ g \Big/ \left[r_1\left(\frac{1+\alpha}{\alpha}\right) - \gamma_{C2}\right]\right\} C_2(t), \tag{25}$$

$$N_1(t) = m\, C_1(t) + n\, C_2(t), \tag{26}$$

where γ_{C1} and γ_{C2} denote the two constant growth rates of C_1 and C_2 as specified in equations (11) and (21), and $a,\ b,\ f,\ g,\ m,\ n > 0$,

$$a = \frac{\nu\lambda}{[(\nu\lambda + \eta)\eta]},$$

$$b = \frac{1}{(\nu\lambda + \eta)},$$

$$f = a\frac{r_1}{[\alpha(r_1 - \gamma_{C1})]} + 1/\eta,$$

$$g = b\frac{r_1}{[\alpha(r_1 - \gamma_{C2})]},$$

$$m = b \Big/ \left[r_1\left(\frac{1+\alpha}{\alpha}\right) - \gamma_{C1}\right],$$

$$n = b \Big/ \left[r_1\left(\frac{1+\alpha}{\alpha}\right) - \gamma_{C2}\right].$$

Since both Y_1 and Y_2 are proportional to N_1 from equations (13) and (18), the dynamics of Y_1 and Y_2 are the same as those of N_1.

Note that the growth rates of consumption in the two countries, γ_{C1} and γ_{C2}, are both constant with $\gamma_{C2} > \gamma_{C1}$ because $\rho_2 < \rho_1$. The dynamic properties of the Ns can be summarized by the following propositions (see Appendix for the proof):

[7] The Mathematical Appendix is available upon request (e-mail: tedc3@ms12.hinet.net). It is also posted at the following Web page: http://www.tedc.org.tw/AEJ/app.doc.

PROPOSITION 1: *The growth rate of* N_{11}: $0 < \dot{N}_{11}/N_{11} < \gamma_{C1}$ *initially, and then declines monotonically. At* $t = T_1 > T_0, \dot{N}_{11}/N_{11} = 0,$ *and then* $\dot{N}_{11}/N_{11} < 0$ *for* $t > T_1$. *At* $t = T_2 > T_1, N_{11} = 0,$ *and then for* $t > T_2, N_{11}$ *becomes negative.* $\dot{N}_{11}/N_{11} > \gamma_{C2}$ *immediately after* $t > T_2$, *and then declines monotonically toward* γ_{C2} *as* $t \to \infty$.

PROPOSITION 2: *The growth rate of* N_{12}: $\dot{N}_{12}/N_{12} > \gamma_{C2}$ *initially, and then declines monotonically toward* γ_{C2} *as* $t \to \infty$.

PROPOSITION 3: *The growth rate of* N_1: $\gamma_{C1} < \dot{N}_1/N_1 < \gamma_{C2}$ *initially, and then rises monotonically toward* γ_{C2} *as* $t \to \infty$.

In deriving the solutions for the Ns, we do not place any constraint on the value of N_{11}. N_{11} *can* decrease because we assume that the Western household can sell the monopoly rights of existing designs to the Eastern household at the price of η per design. The solution reveals that at $t = T_1, N_{11}$ starts to decrease, and the saving of the Western household becomes negative for $t > T_1$. N_{11} can also become negative because our model admits intertemporal trades of future labor for current consumption in a loan market extending into the indefinite future. In our solution, N_{11} starts to become negative at $t = T_2$, indicating that the Western household begins to borrow against future wage income in order to increase its current consumption. For $t > T_2$, the number of types of intermediates existing in the West is still represented by N_1, and these innovating firms are entirely owned by the Eastern household, while N_{11} $(= N_1 - N_{12})$ serves to delineate the size of debt incurred by the Western household.

A number of interesting implications follow from the above propositions. First, output growth in the East $(\dot{Y}_2/Y_2)$ slows down from that of the miracle scenario, reflecting the typical tendency that catching-up economies tend to grow more slowly as they close the gap between themselves and the world's technological frontier. The more interesting result is that output growth in the West $(\dot{Y}_1/Y_1)$ speeds up because of the influx of resources to expand the technologies. Immediately after $t > T_0, \dot{Y}_1/Y_1 = \dot{Y}_2/Y_2 = \dot{N}_1/N_1 > \gamma_{C1}$, and this growth rate rises monotonically toward γ_{C2}. Our analysis thus implies that the real GDP growth in the United States may well be affected by the influence of Confucian tradition in East Asia! While Barro and Sala-i-Martin (1997, 2004) develop a long-run scenario in which all economies grow at the rate of invention in the leading countries, our model implies that the world's growth rate would be determined by the rate of invention in the leading economies *and* the rate of time preference in the follower countries.

Second, there is a continuous growth of N_{12} as $\dot{N}_{12}/N_{12} > 0$ for $t > T_0$. The increasing holding of assets in the West by the Eastern household persists because of the behavioral trait $\rho_2 < \rho_1$. Thus, our model offers a fresh perspective on another remarkable feature of East Asian economies, namely, their persistent accumulations of enormous amounts of foreign exchange reserves. According to IMF IFS statistics, as of December 2007, the top five countries in the world that hold the largest amounts of per capita foreign exchange reserves are: Singapore (US \$36,603), Hong Kong (US \$21,171), Taiwan (US \$11,821), Japan (US \$7,409), and South Korea

(US $5,428), far exceeding those of the rest of the world. Because of its huge population size, China has per capita foreign exchange reserves of only US $1,150. In terms of an absolute figure, however, China has accumulated an extraordinary amount of total foreign exchange reserves (US $1,528 billion), while Japan takes second place with US $948 billion. While other factors might have possibly contributed to this phenomenon, we have demonstrated that this peculiar feature of East Asian economies could result from rational optimizing behavior by households in both these countries and the United States once cultural differences are taken into account.

Third, our model also sheds light on the issue of time preference and wealth holdings in a general equilibrium with heterogeneous households. In our model, the increasing growth of N_{12} eventually crowds out all N_{11}, so that at $t = T_2, N_{11} = 0$, and then becomes negative for $t > T_2$. In a one-good model of dynamic equilibrium with heterogeneous households, Frank P. Ramsey (1928) made a famous conjecture that the more patient households would eventually hold all the capital in the long run, whereas the less patient households tend to spend their income and even their capital. This property of Ramsey's model of optimal capital accumulation had been formally proved by Robert A. Becker (1980) for the case in which households face borrowing constraints. Becker's formulation requires total assets to be nonnegative at each moment of time. For the less patient households with zero capital stocks, this implies that the wage income is consumed at each point in time in the steady state. Trout Rader (1981) and Truman Bewley (1982), on the other hand, investigated the issue for the case without borrowing constraints. In such a context, the less patient households mortgage their future income beyond a certain date in order to consume more, earlier. The results reveal that the less patient households have zero consumption asymptotically.

In modeling aggregate national economies with representative households, we consider Bewley's (1982) case of no borrowing constraints to be a more realistic representation of the real world situation. In fact, the net international investment position of the United States shows a shift from surplus before 1986 to a persistent and growing deficit in the period since then. The size of this deficit grew to be about 20 percent of GDP between 2001–2006, equaling $2,139.9 billion at the end of 2007.[8] Therefore, we adopt the assumption of no borrowing constraints in the specification of our model, allowing N_{11} to become negative. Our analysis, however, differs from Becker's and Bewley's in one important respect. While both Becker and Bewley cover the standard neoclassical models in which the economy approaches a stationary equilibrium, our endogenous growth setup allows for perpetual growth of per capita output. In our solution, the Western household continues to enjoy positive consumption growth at the rate of γ_{C1} forever despite its declining and eventually negative saving. This is made possible because the accumulation of foreign-owned assets (N_{12}) continue to improve the technology (N_1) and to drive the wage rate (w_1) to grow asymptotically toward the rate γ_{C2}.

Finally, notice that for the West, the trade deficit and the accumulation of foreigners' assets are not a sign of its economic weakness, but rather of its desirability as a place

[8] Source: Bureau of Economic Analysis *NIPA* tables (http://www.bea.gov/international/index.htm#iip).

in which to invest. On the surface, we may have observed that *consumer products* are being exported from East Asian countries to the United States, but the importation of these consumer products has enabled the United States to devote more of its resources to innovative activities than otherwise possible. We may also have observed that a considerable portion of the foreign exchange reserves held by these East Asian countries are in the form of Treasury bills and government bonds; but the purchase of these Treasury bills and government bonds has contributed in maintaining a lower level of interest rates and has helped to generate more funds available for innovative activities than otherwise possible. Our simplified model tries to capture part of the underlying forces behind these observed phenomena.

III. Quantitative Experiments

This section performs quantitative experiments to assess whether the model can plausibly capture the relevance of the aforementioned cultural traits to economic growth. We first calibrate the model with exceptional, but realistic values of ν and ρ_2 to simulate miracle growth of the follower country. Using standard calibration procedures, we find that the model approximates, quite well, some of the key features of the Four Tigers' rapid growth for the period of 1963–1997. The results enable us to quantitatively evaluate how large these cultural effects are and which effect is most important.

Next, we use the calibrated economy of the fast growing Four Tigers as a starting point to explore two issues. First, how would the Four Tigers' economy behave when it enters the maturity phase and begins to invest in the leading country? Second, can the calibrated model shed light on the implications of our theory for China, assuming that Chinese people share the same influence of Confucian traditions as those of the Four Tigers? In particular, can we use the model to guess what China's growth rate may be in the future? While the first issue involves interactions of resource constraints of two economies, the second deals with an economy whose population size is unprecedented in studies of quantitative growth theory. In either case, there is less guidance from prior aggregative studies for specifying parameters in such experiments. Nevertheless, our numerical analyses yield vital insights into these issues beyond the qualitative statements of the previous section and point to some possible directions for future research.

A. *Calibration of the Leading Country*

We take the United States as defining the growth of the "technical frontier" and, hence, choose the parameters for country 1 such that its balanced growth path resembles empirical features of the US economy. These parameters are chosen as follows. First, α is the share for the gross income accruing to capital and is set to 1/3, which accords with empirical estimates (e.g., Edward F. Denison 1962; Dale W. Jorgenson, Frank M. Gollop, and Barbara M. Fraumeni 1987) and is widely used in literature. Second, the productivity level A_1 is a scale parameter and is normalized to $A_1 = 1$. The total quantity of labor L_1 is also a scale parameter assumed to be constant in the model and is set to $L_1 = 100$. Third, we require that the steady-state

TABLE 3—AVERAGE PER CAPITA REAL CONSUMPTION GROWTH RATES
(*Percent per Annum*)

Time period	Taiwan	South Korea	Hong Kong	Singapore	Four Tigers (weighted average)	China	United States
Rapid growth:							
1963–1997	6.50	5.26	5.01	4.26	5.54		
1979–2007						8.01	
Slowing growth:							
1998–2007	3.33	4.75	2.41	3.68	4.10		
1963–2007							2.43

Note: We use the sizes of population as weights to compute "Four Tigers (weighted average)."
Source: International Monetary Fund (IMF), *International Financial Statistics*

rate of return to investing r_1 be 5.5 percent per annum, which corresponds to the average of the annual return on equity (6.5 percent) and the annual real yields on long-term corporate bonds (4.5 percent).[9] Fourth, we set the growth rate of per capita consumption to 2.43 percent per year—its actual value for the United States during the period of 1963–2007 (Table 3). Finally, we set the intertemporal substitution elasticity $1/\theta$ to 1, which is frequently used as the benchmark assumption for macro investigations (e.g., King and Rebelo 1990, 1993). Given the specified parameters above, we can compute an implied value of the time preference rate $\rho_1 = 0.0307$, and, from equations (7) and (8), the lump-sum cost of inventing a new intermediate $\eta = 134.68$ units of output.

N_1 is essentially a scale variable. For the initial condition, we choose $N_1 = 100$ for $t = 0$ which corresponds to the year 1962 in our first experiment. From equation (5) and the economy's resource constraint,[10] we can compute $Y_1 = 3333.3$ and $C_1 = 2635.7$ for $t = 0$. The implied ratio of consumption to output is 79.1 percent, which is very close to the actual value of the US data (78.6 percent in 1962). Country 1 in our model exhibits no transitional dynamics: the variables N_1, Y_1, and C_1 begin with the values specified above, and all three variables grow at the same constant 2.43 percent per year.

B. *Calibrating the Follower Country: The Convergence Phase*

We now calibrate country 2 to simulate the fast-growing economy of the Four Tigers during the period of 1963–1997 (35 years). The parameters are chosen as follows:

$$\alpha = 1/3 \qquad 1/\theta = 1 \qquad A_2 = 0.8 \qquad L_2 = 27 \qquad \rho_2 = 0.014$$

$$\text{Average } \frac{\dot{C}_2}{C_2} = 5.54 \text{ percent} \qquad \text{Average } r_2 = 6.94 \text{ percent.}$$

[9] Please refer to Robert G. King and Sergio T. Rebelo (1993, 916). For real yields on corporate bonds, we take actual data on Moody's composite corporate bonds (20 years or more), being 4.53 percent per annum for the period of 1963–2007.

[10] The economy's resource constraint can be written as:

$$C_1 = Y_1 - \eta\,\gamma_{C1} N_1 - \alpha^2 Y_1.$$

See Barro and Sala-i-Martin (2004, 296).

For easier comparison, α and θ are set to be the same as those of country 1. We choose $A_2 = 0.8$ as the benchmark case for our calibrating exercises. This figure reflects the degree of the relative development stage of country 2 in comparison to country 1 ($A_1 = 1$). It can easily be checked that changing A_2 to 0.75, 0.7, or 0.6 does not affect the results of our analyses. We choose $L_2 = 27$ to accord with the actual population size of the Four Tigers relative to that of the United States. The average total population of the Four Tigers for the period of 1963–2007 is 66.4 million, about 27 percent of that of the United States during the same period (246.1 million). The average growth rate of per capita consumption, 5.54 percent, is the actual figure of the Four Tigers during the period (Table 3).

To derive the time preference rate, we make the assumption that during the slowdown period of 1998–2007, the Four Tigers enter the maturity phase and earn the same real rate of return to investing as in country 1 ($r_1 = 5.5$ percent). Given that the actual per capital consumption growth is 4.1 percent per year for this period (Table 3), we can use equation (21) to compute the implied time preference rate ρ_2=0.014. Since our model postulates a constant time preference rate, the same equation (21) can be used to calculate an average real rate of return to investing (r_2) to be 6.94 percent for the fast-growing period. This number is within the range of actual estimates for these economies and will be used as the average real rate of return in the following computations.[11]

For the initial condition, we set $N_2 = 25$ for period $t = 0$. Changing the initial N_2 to 20, 15, or 10 does not affect any of our calculations except for the terminal ratio of N_2/N_1 at $t = 35$ when country 2 enters the maturity phase. We also make the simplifying assumption that the cost of imitation (ν) rises and the rate of return to investing (r_2) declines steadily throughout the 35 year period such that, at the end of the period, the rate of return becomes exactly 5.5 percent per annum. This assumption, together with the twin requirements that the average r_2 be 6.94 percent and the average $\dot{C}_2/C_2$ be 5.54 percent, enables us to compute $\sigma = 0.261$ and $\overline{\nu} = 28.66$ for equation (15). For $t = 0$, $N_2 = 25$ implies that $Y_1 = 161.00$. We can also identify $C_2 = 110.04$ as the initial value of consumption that will place country 2 on the stable convergence path. The ratio of consumption to output is 68.3 percent, a reasonable figure for the Four Tigers during this period.

Figure 1 summarizes the simulated results over a horizon of 35 years by our model using the parameters as specified above. Notable implications of these trajectories are as follows. First, for realistic parameterization, our simple model is surprisingly successful at reproducing the extraordinary long-run growth of the Four Tigers' economy by taking exceptional values of ν and ρ_2. While our finding does not rule out that other factors could also have played a role, the simulation can be interpreted as a useful example demonstrating how cultural factors might plausibly help to explain the key features of this miracle growth. Second, actual data show

[11] During the 1960s and 1970s, financial markets in the Four Tigers were still quite undeveloped. Among the currently available figures, we found the average real interest rate on corporate bonds in South Korea for 1981–1997 to be 6.51 percent per annum. Taiwan's statistics for the average real interest rate on 5-year corporate bonds for 1985–1997 was 4.7 percent per annum; but we know that this market had been fragmentary and inactive. Taiwan also published interest statistics for unorganized markets on unsecured loans—around 19.4 percent per annum during this period.

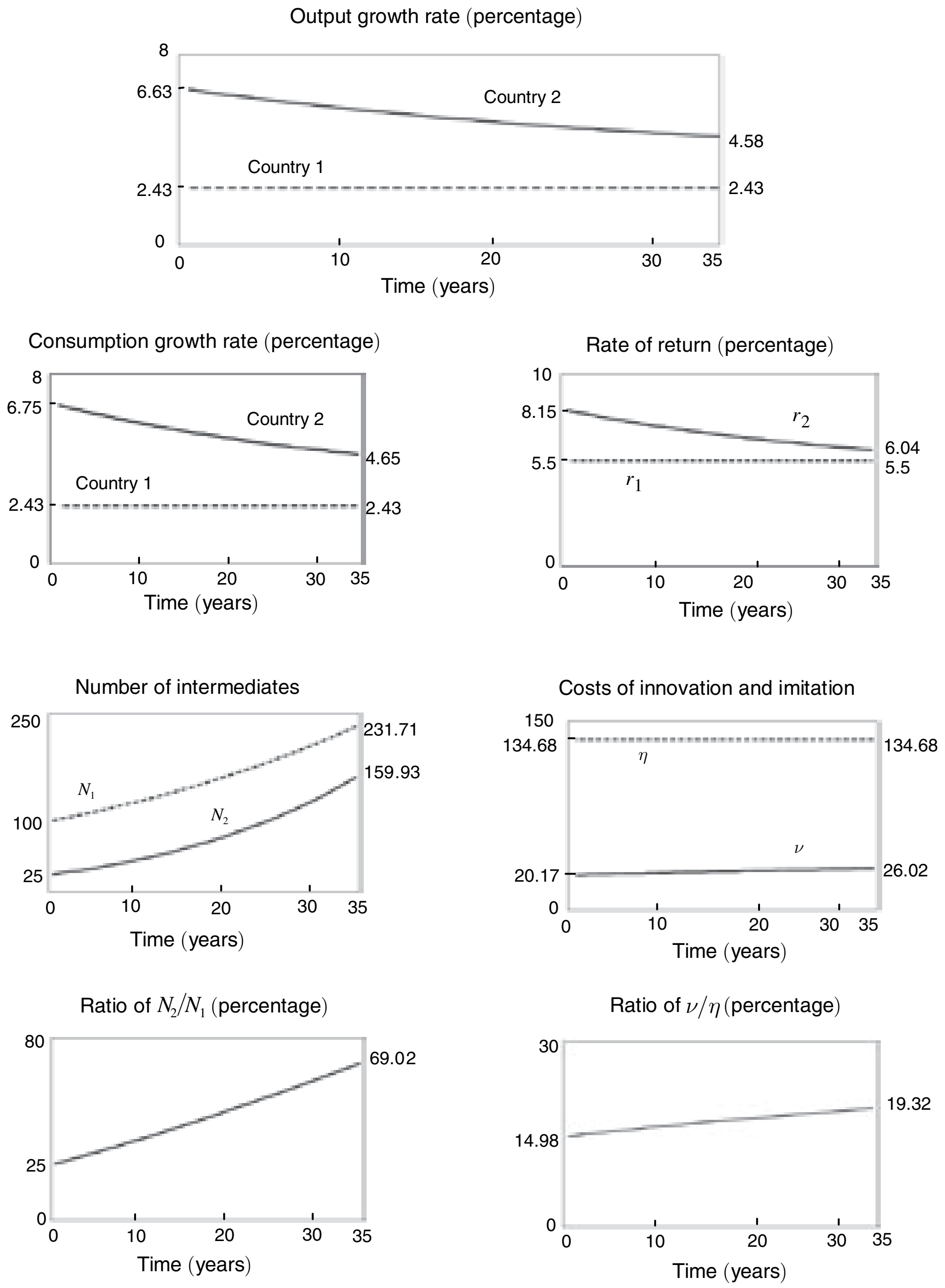

FIGURE 1. CALIBRATION FOR THE CONVERGENCE PHASE

that, over the period of 1963–1997, the increase in the Four Tigers' per capita real consumption outstripped that of the United States by an average of 3.11 percent per year. Our calibrated model reveals that slightly more than half of that extra growth

(1.67 percent per year) could be attributed to the effect of lower time preference rate ($\rho_2 < \rho_1$), while the remaining portion (1.44 percent per year) was due to the higher value of real rate of return ($r_2 > r_1$), reflecting the effect of low imitation cost.

Finally, in our calibrated country 2, the imitation cost ν rises slowly over the course of 35 years, from 20.17 to 26.02. Its average value, 23.28, is only 17 percent of the cost of innovation in country 1 ($\eta = 134.68$). Edwin Mansfield, Mark Schwartz, and Samuel Wagner (1981) studied the cost of imitation in the United States for 48 product innovations that were made in the chemical, drug, electronics, and machinery industries. They found that the cost of imitation averaged 65 percent of the cost of innovation. The cost ratio varied substantially across the products. "In about half of the cases, the ratio of imitation cost to innovation was either less than 0.40 or more than 0.90" (Mansfield, Schwartz, and Wagner 1981, 909). Their study, however, was limited to imitations *within* the United States. David J. Teece (1977), on the other hand, examined the cost of technological transfer across countries for multinational firms. For 26 cases in chemical, petroleum refining, and machinery, he found that the cost averaged 19 percent of total project expenditures. Our simulated imitation cost is thus within the range estimates suggested by these empirical studies.

C. *Predicting Future Growth of the Four Tigers: The Maturity Phase*

Assuming that near the end of the last century the Four Tigers had passed the miracle growth stage and gradually settled into the slowed-down maturity phase, we now use our model to guess what their growth rates may be in the future. We calibrate the model for the maturity phase with the following set of parameters:

Country 1:
$\alpha = 1/3$ $\quad 1/\theta = 1$ $\quad A_1 = 1$ $\quad L_1 = 100$ $\quad r_1 = 5.5\%$ $\quad \gamma_{C1} = 2.43\%$ $\quad \eta = 134.68$ $\quad \rho_1 = 0.0307.$

Country 2:
$\alpha = 1/3$ $\quad 1/\theta = 1$ $\quad A_2 = 0.8$ $\quad L_2 = 27$ $\quad r_2 = r_1 = 5.5\%$ $\quad \nu = 26.02$ $\quad \lambda = (N_2/N_1)^{**} = 0.70.$

All parameters of country 1 are the same as those used in previous computations. As for country 2, we now choose different values for some of the key parameters. The rate of return to investing is set to be a constant 5.5 percent per annum, the same as that of country 1. Both the imitation cost ($\nu = 26.02$) and the $(N_2/N_1)^{**}$ ratio ($\lambda = 0.70$) are also set to be constant values representing the state of the situation when country 2 reaches the end of the convergence phase.

To simplify computations, we, again, set the initial values $N_1 = 100$ and, with $\lambda = 0.70$, $N_2 = 70$ for $t = 0$. These two values of N_1 and N_2 imply that $Y_1 = 3{,}333.33$ and $Y_2 = 450.79$. We also need to set the initial values of C_1 and C_2, and the initial distribution of N_1 into N_{11} and N_{12}, in order to arrive at the implied growth rate for the calibrated country 2. We choose $C_1 = 2{,}685.12$ and $C_2 = 297.29$. These two values correspond to actual data for consumption to output ratio of the United States ($C_1/Y_1 = 81$ percent) and of the Four Tigers ($C_2/Y_2 = 66$ percent) around 1997–1998. As for N_{11} and N_{12}, we have no actual statistics for these magnitudes.

There are, however, two pieces of relevant evidence to consider. First, according to the Bureau of Economic Analysis *NIPA* tables, the US net international investment position (defined as the difference between all foreign assets owned by US citizens and all domestic assets owned by foreign citizens) equaled to about −20 percent of GDP around the year 2000. In our calibrated model, such a value of net international investment amounts to 666.67 units of output, which is equivalent to the ownership of five innovating firms in country 1. Second, the Four Tigers' trade surpluses with the United States could account for only part of the deficit in the US net international investment position. Thus, we also look at the data of accumulated trade surpluses of the Four Tigers. During the final two decades of the last century, the Four Tigers' net exports to GDP ratio averaged 3.12 percent for 20 years. The accumulated total of trade surpluses over 20 years amounted to 62.4 percent of GDP, about 281.26 units of output in our calibrated economy—just enough to invest and establish two innovating firms in country 1. We therefore set $N_{12} = 2$ and $N_{11} = 98$ as the starting condition for our simulation. From these choices of initial C_1, C_2, N_{11}, and N_{12}, we can identify the implied *perpetual* consumption growth rate of country 2 (γ_{C2}) to be 3.05 percent, about 1 percentage point less than the actual figure of the Four Tigers for the period 1998–2007 (Table 3).

Figure 2 presents the main results of our simulations for the two interacting economies thus calibrated. Note that we endowed this artificial economy with a country 2 that imitates and maintains a lower and constant time preference rate *perpetually*. Hence, our model is quite simplistic, and its calibration is somewhat metaphorical. Nevertheless, several interesting features emerge from these projected paths. First, ηN_{12} represents net claims by the country 2 household on country 1's economy. In the simulated growth path, N_{12} begins with only 2 percent of N_1, but grows fast and persistently. At $t = 35$, N_{12}/N_1 exceeds 20 percent; and at $t = 83$, N_{12} surpasses N_{11} so that N_{12}/N_1 reaches 50.25 percent. This tendency is consistent with the observed phenomena of persistent accumulation of foreign exchange reserves by the Four Tigers.

Second, proposition 1 of Section II states that $\dot{N}_{11}/N_{11}$ declines monotonically until at $t = T_1$, $\dot{N}_{11}/N_{11}$ becomes negative, and at $t = T_2 > T_1$, N_{11} becomes negative. Our calibration shows that $\dot{N}_{11}/N_{11}$ starts out at 1.99 percent per year, but declines only very slowly. Even a century later at $t = 100$, the growth rate of N_{11} is still a positive 0.55 percent per year. Therefore, the computational experiments demonstrate that with the invading investment of the size of the Four Tigers, Ramsey's dire prediction that the less-patient household would eventually own nothing will not begin to take place until very, very far into the future.

Third, country 2's desired capital accumulation in country 1 ($\eta \dot{N}_{12}$) exceeded the returns from its existing capital investment ($r_1 \eta N_{12}$) for the period $t = 1 - 33$. Thus, optimizing behavior by the country 2 household dictates that country 2 would continue to ship final output to country 1 for another 33 years before it begins to ship back net returns. Finally, country 1's per capita consumption remains higher than that of country 2 during the entire 100 year period of our computation. Unlike Becker and Bewley who cover the standard neoclassical cases of stationary equilibrium, we use an endogenous growth setup that allows country 1's household to enjoy positive consumption growth *forever*. This is made possible because the accumulation of foreign-owned capital (N_{12}) continues to improve country 1's technology (N_1) and

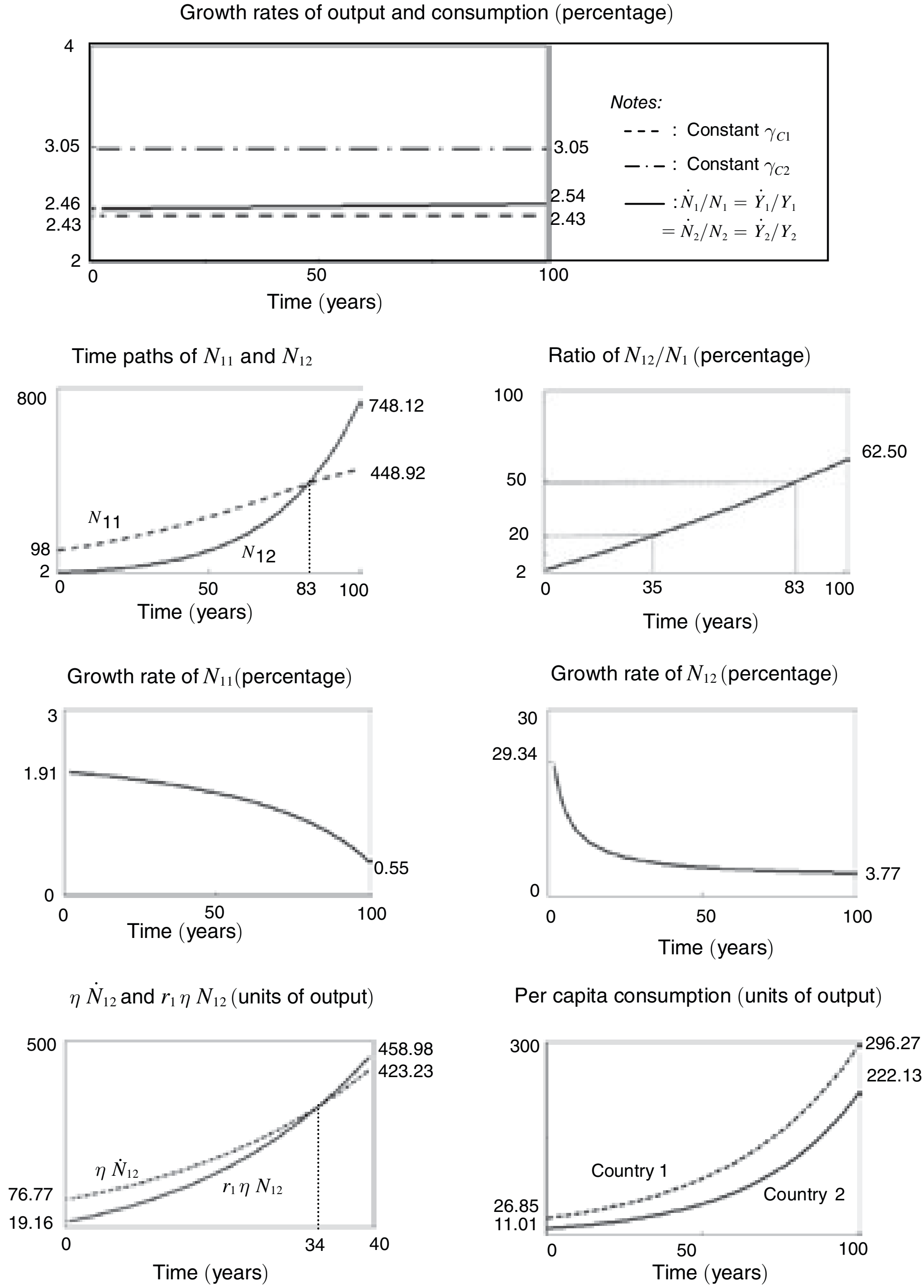

Figure 2. Predicting Future Growth of the Four Tigers

helps to drive up the wage rate (w_1). For the country 1 household, the increase of wage income supports the growth of consumption despite its declining and eventually negative saving.

D. *China's Rapid Growth: The Case of Low and Constant Costs of Imitation*

Since 1979, China has consistently been the most rapidly growing economy, sustaining an average annual growth rate of around 10 percent for 28 years, according to official statistics. To calibrate country 2 of our model to simulate China's rapid growth, we must consider two key differences between the actual performance of the Chinese economy during the 1979–2007 period and that of the Four Tigers during the 1963–1997 period. First, China's average per capita GDP growth rate (8.65 percent) exceeds that of the Four Tigers (6.58 percent) by more than 2 percentage points (Table 1). Second, looking at the growth rates separately by decades, we can see that while the Four Tigers' growth has shown a distinctly gradual slowing down from the 1980s on, the Chinese economy has maintained the same growth momentum through 2007.[12] To generate these two features of China's economy, we must modify our previous parameterization for the Four Tigers and assume the case of "low and constant" costs of imitation. We will see how such a modification might provide insight into understanding China's past experiences as well as predicting its future growth.

All parameters for country 1 are the same as those used in previous calibrations. To simplify computations, we, again, set the initial $N_1 = 100$ for $t = 0$, which now corresponds to the year 1978. As for country 2, the parameters are chosen as follows:

$$\alpha = \frac{1}{3} \qquad \frac{1}{\theta} = 1 \qquad \frac{\dot{C}_2}{C_2} = \text{constant 8.01 percent} \qquad \rho_2 = 0.014$$

$$r_2 = \text{constant 9.41 percent} \qquad \nu = \text{constant 20.17.}$$

We, again, set α and θ to be the same as those of country 1 for easier comparison. The growth rate of consumption $\dot{C}_2/C_2$ is the actual figure of average per capita consumption growth in China during this period (Table 3). The time preference rate ρ_2 is set to be the same as that of the Four Tigers, assuming that the Chinese share the same influence of Confucian traditions with these countries. Equation (21) can then be used to calculate a real rate of return to investing (r_2) to be 9.41 percent per annum. We set the imitation cost ν to be 20.17 units of output, the figure that initiated the Four Tigers' rapid growth in our previous calibration. We assume that this imitation cost, instead of rising, remains constant throughout the entire convergence phase.

China's average population over the period of 1979–2007 (1,175.16 million) is 4.43 times as much as the United States. If we set $L_2 = 443$, the model has the counterfactual implication that the value of A_2 is implausibly small, about 15 percent of the value for the United States. What happens here is that our model features a scale benefit because a new product, which costs ν to imitate, can be used across the entire country. The larger the economy represented by L_2, the lower the cost of an imitation per unit of L_2. As with a decrease in ν, an increase in L_2 raises π_2 and r_2 (equations

[12] During 1981–1990, 1991–2000, and 2001–2007, the average annual per capita real GDP growth rates of the Four Tigers combined were 6.95 percent, 5.09 percent, and 3.95 percent, respectively, while the same rates for China were 7.82 percent, 9.36 percent, and 9.51 percent, respectively.

(7) and (9)) and, hence, the growth rate (see equation (12)). With such a high figure of L_2, the model would be forced to adopt a low value of A_2 in order to be consistent with the actual observed growth rate of $\dot{C}_2/C_2$.

However, China *as a whole* may not be the proper unit for measuring scale in our investigation. Since the beginning of China's reform in 1979, economic growth has been concentrated largely in coastal regions. This geographic pattern of economic growth has been the subject of a number of recent papers (see, e.g., Martin Ravallion and Jyotsna Jalan 1999). The literature points to signs of dualistic divergence between the coastal provinces and much of inland China. This is seen to have been the result of government policies, including the greater emphasis on industrial reform than on agricultural reform since the mid-1980s, and a structure of inter-provincial transfers (through differential tax treatment and public investment) that has favored coastal areas (Haishun Sun and Dilip Dutta 1997; Martin Raiser 1998). Thus, to have a more reasonable value of A_2 for our calibration, we must recognize the coastal-inland gap as a fundamental feature of China's fast-growing economy and must not treat the entire population as L_2 in the simulation. Available data show that, over the period of 1987–2007, the population of China's 10 coastal provinces and municipalities[13] averages 419.5 million, about 1.517 times the size of the United States' population during the same period (276.4 million). As a first experimental computation, we set the level of $L_2 = 151.7$. Equation (7) then implies that $A_2 = 0.306$, a reasonable figure that is within the range estimates suggested by empirical evidence (Acemoglu and Zilibotti 2001).[14] Our calibrated model thus depicts a fast-growing economy of the size about 1.5 times as large as that of the United States and about 34 percent of China's total population.

For the initial condition, we set $N_2 = 15$. This figure is lower than that for the Four Tigers ($N_2 = 25$ at $t = 0$) and reflects the fact that by the time China began its market transition in 1979, it had many more innovations to imitate than the Four Tigers had in the early 1960s. For $t = 0$, $N_2 = 15$ implies that $Y_2 = 128.11$. We can also identify $C_2 = 89.64$ as the initial consumption that will place country 2 on the stable convergence path. The implied ratio of consumption to output is 69.97 percent, which is slightly higher than the actual value of China's national average during this period (being 66.78 percent for 1981–1982), but a reasonable figure for our simulation.

Figure 3 presents the simulated results of country 2 over a span of 35 years. In comparing Figures 3 and 1, we notice the following. First, for realistic parameterization, especially regarding the size of the economy, our simple model is also capable of reproducing the extraordinary long-run growth of China's economy by taking exceptional values of ν and ρ_2. In particular, by assuming a low and constant ν, the

[13] The ten coastal provinces and municipalities include Guangdong, Hainan, Fujian, Zhejiang, Jiangsu, Shandong, Hebei, Beijing, Tianjin, and Shanghai.

[14] Acemoglu and Zilibotti (2001) studied cross-country differences in total factor productivity (TFP). They found that "TFP in the LDCs is 22 percent of the United States in the low-skill industries, 26–27 percent of the United States in the medium skill industries, and 30 percent of the United States in the high skill industries" (Acemoglu and Zilibotti 2001, 585). The LDCs in their sample were: Colombia, Ecuador, India, Indonesia, Malaysia, the Philippines, Turkey, and Venezuela.

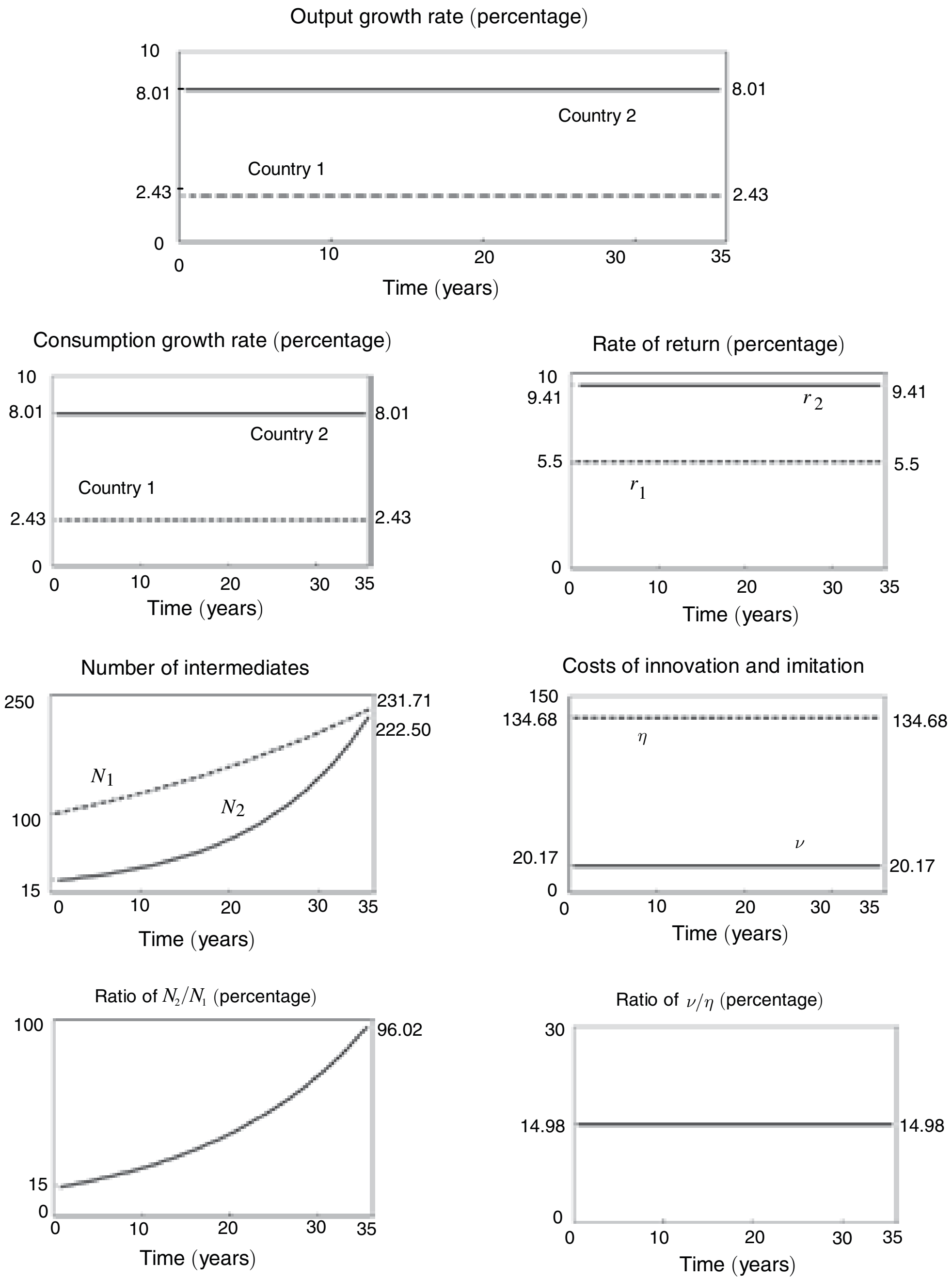

FIGURE 3. CALIBRATION OF COUNTRY 2 WITH LOW AND CONSTANT IMITATION COSTS

model can generate an economy that annually grows 2.47 percentage points more than that of the fast-growing Four Tigers for a sustained period.

Second, actual data show that, over the period of 1979–2007, the increase in China's per capita consumption surpassed that of the United States by an average of 5.58 percent per year. The calibrated results indicate that only about 30 percent of that extra growth (1.67 percent per year) could be attributed to the effect of a lower time preference rate while the remaining 70 percent (3.91 percent per year) was due to the effect of low imitation cost. In comparison to the Four Tigers, the emphasis on education and study plays a much larger role in contributing to China's rapid growth than the importance attached to family and kinship.

Finally, in our calibration of the Four Tigers with rising imitation cost, country 2 reaches the end of the convergence phase at $t = 35$, when the rate of return to investing declines to the level prevailing in country 1. In the present calibration of China with low and constant imitation cost, the rate of return to investing remains high and constant throughout the entire convergence phase. The imitation process will be carried on at a sufficient pace to eventually exhaust all the available products discovered in country 1.[15] Our calibrations show that the end of the convergence phase occurs, coincidentally, also at $t = 35$, which corresponds to the year 2013. However, such a scenario of evolution depends on the assumption that L_2, and hence the size of the economy, is constant. While the coast-inland gap has been widely recognized as a fundamental feature of the Chinese economy, the Chinese government officially launched the Western Development Program in 1999 to give preference to western and inland provinces in investment projects and other economic development policies. It remains to be seen how effective the program turns out to be, and there is potential for China to sustain its rapid growth phase much longer if the effects of dynamic growth along the coast can diffuse to the inland areas. This aspect of the Chinese economy should be an important subject of any future investigation into the next phase of China's economic growth.

IV. Conclusion

Until recently, economists have been reluctant to rely on culture as a possible determinant of economic phenomena in a rigorous, formal framework. Much of this reluctance stems from the very notion of culture. It is broad and the channels through which it can enter economic discourse are so ubiquitous (and vague) that it is difficult to design testable hypotheses. In recent years, however, better techniques and more data have made it possible to identify systematic differences in people's preferences and beliefs and to relate them to various measures of cultural legacy. This paper is an attempt to examine the cultural aspect of factors that promoted East Asia's economic miracle. We highlight two behavioral traits of Confucian tradition and put forward hypotheses as to whether these traits impede or are conducive to leading or follower mode economic growth. From the academic perspective, our approach can reconcile the differing viewpoints of Weber and more contemporary scholars regarding the influence of Confucian tradition on economic growth. For policymakers, our analysis has an important bearing on three fronts:

- For policymakers in other developing countries, our analysis serves as a reminder that if they want to apply the lessons of East Asia's experiences, it

[15] Barro and Sala-i-Martin (2004, 363–368) briefly discussed mathematical properties of such a case.

is not enough to merely imitate the economic and institutional aspects of said experiences, they must also factor in the cultural aspects that played a part in East Asia's achievements. That is not to say that they need to adopt Confucian tradition. Rather, it is to remind them that they need to realize the effects brought into play by Confucian tradition.

- Our analysis implies that as soon as these East Asian economies catch up with those of Western countries and embark on leading mode growth, the traits of Confucian tradition that originally were helpful in promoting follower mode growth will start to exert an impeding effect on the leading mode growth. This is something that these East Asian countries need to be on their guard against and deserves to be deeply pondered.
- To the extent that the model captures some aspects of the real world situation, the implication is that the accumulation of foreign exchange reserves in the United States by these East Asian countries will be a persistent event.

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