Infrastructure as a Catalyst for Regional Integration, Growth, and Economic Convergence: Empirical Evidence from Asia

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ABSTRACT

As Asia's economic growth process matures, regional integration offers important opportunities to sustain and extend the achievements of the more dynamic economies. Benefits from this process will include geographic diversification, often toward superior growth rates, as well as structural differentiation and more rapid evolution from established North-South patterns of trade and specialization. Propagation of growth linkages across this diverse region will also facilitate more inclusive growth and economic convergence. Infrastructure commitments can be an essential guarantor of the entire process, and this paper examines their potential to contribute to more sustained and broadly based Asian growth.

1. Introduction

Recent ADB research on Asian regional integration (ERD: 2005) has highlighted the importance of structural barriers to trade. Indeed, it now appears that overcoming geographic and institutional obstacles that increase trade and transport margins are much more important to regional trade expansion and sustained growth. In its flagship study of infrastructure requirements for Asia (ADB: 2005), the ADB (in collaboration with JBIC and the World Bank), presents a comprehensive review of the region's infrastructure needs. These needs are very substantial and particularly so in relative terms, i.e. the need is relatively most acute in the poorest countries. In a region that enjoys unprecedented external and domestic savings reserves, at a time when real interest rates are as low as they have been in generations, it is surely a auspicious opportunity to consider how large scale regional investment could help Asia more fully realize its vast economic potential. The goal of the present study is to link the two, using rigorous empirical methods to show how more determined commitments to regional infrastructure can act as a catalyst for Asian integration, facilitating more sustained and comprehensive economic growth.

[†] Opinions expressed here are those of the author and should not be attributed to their affiliated institutions. Thanks to many ADB colleagues for productive discussion.

In a vast literature on trade facilitation, it is doubly unfortunate that investment in infrastructure has received only scant attention. Infrastructure is one of the oldest and most decisive determinants of trade patterns. Secondly, public infrastructure confers some of the most desirable benefits of trade facilitation, including open market access and pro-poor growth and income effects. By lowering costs of market participation in a relatively non-discriminatory manner, improvements in infrastructure broaden the basis for growth and directly contribute to its sustainability. By reducing trade and transport margins, infrastructure promises a neat reconciliation of private interests, increasing producer prices while reducing purchaser prices.

In the Asian context, parallel emergence by China and India portend dramatic change in the economic landscape. Because of geographic realities, however, the full growth potential of these large economies for the region and beyond will depend critically on infrastructure. Although their boundaries are proximate in some areas, the Himalayan plateau is unlikely to sustain more than a small fraction of their bilateral trade in the foreseeable future. A much more attractive bridge between the emerging giants is Southeast Asia, already a robust trading environment and one that could capture many of the indirect benefits of intensified Indian and Chinese trade linkages. For these reasons, the entire Asian region has an important stake in expanded Southeast Asian trade infrastructure. This is particularly true of many of the region's poorest economies, who would be directly in the path of many new transport axes under consideration. Myanmar, Laos, Cambodia, and (to a lesser extent) Viet Nam have long been at the margins of the more dynamic East and South Asian growth experience, yet they could become central pillars of any comprehensive bridging infrastructure between China and India.

The research reported here is based on applications of the Structural ADB General Equilibrium (SAGE) model, a dynamic economic forecasting tool that captures detailed trade and domestic market interactions between and within Asia and in its relationship to the rest of the world. Computable General Equilibrium (CGE) modelling, of which SAGE is an example, has already established itself as the preferred tool for empirical research on trade policy, and is ideally suited in the present context to demonstrate how infrastructure changes neoclassical fundamentals (market access costs) to amplify gains from trade and accelerate growth. There are relatively few examples of economywide simulation modelling being used for infrastructure assessment, an unfortunate missed opportuntiy because this approach is so-well suited to capturing the kinds of neoclassical cost-price effects and extensive indirect linkages that make up infrastructure's main contribution to economic activity.[1]

[1] On exception is Aginor et al (2005) who apply a different but related approach.

Because we are looking at one of the world's most dynamic multilateral trading regions, this is also an ideal application of the GTAP dataset. Preliminary results indicate that determined commitments to infrastructure investment can sharply expand economic participation and leverage the superior growth rates in Asia's largest countries for the benefit of the entire region, with the largest proportionate gains for the poorest countries. In this way, integration will accelerate as regional supply chains are consolidated, and growth externalities can be substantial for all participants. In the absence of such commitments, trade will simply be intensified along established channels and its benefits dissipated over more distant trade routes to traditional markets.

2. Overview and Motivation

Economic theory recognizes the importance of infrastructure from several perspectives, including both macroeconomic and microeconomic elements. A convenient way to understand its role is from three functional economic perspectives:

1. Keynesian – This refers to the expenditure component of infrastructure, as it is reflected in national, regional, and local aggregate demand and employment stimulus.

2. Ricardian – This component refers to infrastructure's effect on the cost of transport and distribution. Reducing trade margins can have a potent effect on prices and competitiveness, intensifying comparative advantage and increasing both domestic and international trade flows.

3. Neoclassical – Modern economic theory recognizes infrastructure's contribution to increasing productivity, as technology embodied in transport, communication and distribution systems increases the efficiency of search, transactions, and shipments. These are geneally terms endogenous growth benefits, and are recognized to be among the most important benefits of modern infrastructure investments.

2.1. Keynesian Stimulus

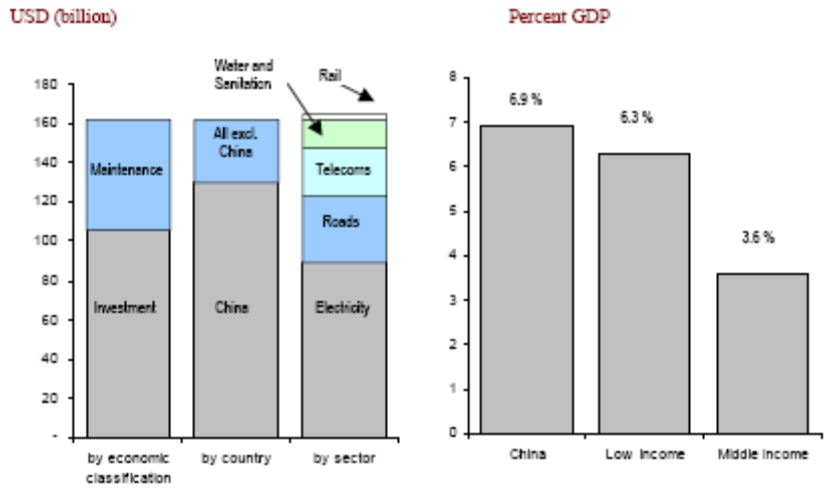
The direct macroeconomic benefits of public investment have long been recognized, and infrastructure spending itself is a popular means of direct long term or transitory employment stimulus. In many economies, programs like WPA (US), Work Relief (PRC), Japan (heavy counter-cyclical and recurrent fiscal commitments to public works) often have employment as their primary goal and downstream benefits as a secondary one.

Because of its generality, this kind of spending can be targeted across a wide spectrum of regions and socio economic groups, conducted at the national, regional, or local level, and timed to

coincide with cyclical economic events. In the case of real public goods infrastructure, multiplier effects from both direct employment and downstream use can be substantial. Obviously, the latter benefits will be greater the more investment can be focused on real public goods and widely used infrastructure capacity. In this study, we examine targeted increases in investment in trade and transport infrastructure for Asian economies that are considered to have the greatest unmet needs.

In its extensive flagship report on Asia's infrastructure needs (ADB: 2005), the ADB identified several countries which needed to maintain higher long term infrastructure investments if they were to "catch up" with faster growing or higher income countries in the region. As the figure below indicates, ADB estimates that Asia will need USD106 billion in new infrastructure between now and 2010

Figure 2.1: ADB Estimates of Asia's Infrastructure Needs



Source: Yeppes, 2004

To accomplish this, it is estimated that low income countries must sustain infrastructure investment levels at 6.3% of GDP over this period and beyond. At the moment, many of these countries have rates below 3% because of low domestic savings, weak fiscal institutions, or both. In the analysis presented below, we examine the detailed growth and structural implications of achieving these investment objectives.

2.2. Ricardian Stimulus

At the more microeconomic level, the role of infrastructure in reducing distribution margins is widely acknowledged in the policy and theoretical literature, but explicit treatments are relatively

few and not easy to reconcile into a general treatment. Policy oriented discussion emphasizes the obvious advantages of increased market participation, as infrastructure commitments reduce distribution margins expand the profitable horizon of market oriented investments, whether private or public. This is particularly the case in emerging economic environments, where distribution costs are an important source of price distortions that significantly limit market access and reduce economic efficiency. Such access barriers are particularly important in countries with rural poor majorities, or between economic zones (e.g. terrestrial South and East Asia) separated by more remote subsistence areas. Not only does infrastructure facilitate integration between active zones, it also confers growth externalities across the networks so established. In this way, for example, parallel emergence of China and India could create substantial growth externalities across Southeast Asia, especially among the latter's poorest countries. Mynamar, Laos, and Cambodia are among the areas ideally suited to become "pillars" of a "growth bridge" between Asia's two emergent giants.

Empirical evidence of the significance of distribution margins is more plentiful and also quite diverse. This can generally be divided into four categories. The first deals with traditional and modern issues related to physical geography. Secondly, a large volume of work relates to direct transport costs, including means as well as distance. Third, institutional economics has examined trade margins arising from administrative, regulatory, and political conditions governing trans-boundary and international commerce. Finally, there is a special component of international finance that deals with exchange rate and PPP distortions and their influence on underlying commerce.

There is a large literature on geophysical (spatial, etc.) determinants of transportation costs, extending from the transport sector itself to general economic geography. This work has a very long history, going back to the founders of trade and microeconomic theory. Heckscher (1916) himself qualified many of his early arguments about the resource basis for trade with caveats about initial physical conditions that might facilitate or hinder trade relations. These were continued down to the present by a variety of authors (most recently Obstfeld and Taylor:2000). Samuelson (1952) made early contributions to economic and trade analysis from a spatial perspective, with many later contributions from regional analysis and location theory (e.g. Bergstrand (1990)). As Neary (2001) points out, contributions such as Fujita, Krugman, and Venables (1999) have initiated a new era of investigations that expand our understanding of the economics of location.

To be more specific, infrastructure reduces trade margins that in turn have three important structural effects on the economy.

Intensification of Comparative Advantage – From classical trade theory we know that price differences create incentives for international and inter-regional exchange of goods and specialization that increases aggregate efficiency. Distribution margins serve to undermine these

prices differences, and with this the basis for trade and more efficient specialization. To see this, consider two prices P_H and P_F for comparable goods from two difference sources. We call them Home and Foreign, although the could simply be from difference regions or even cities in the same country. Given that a trade margin (M) is generally symmetric, the ratio of these two prices, with margins taken into account, is given by the following expression, evaluated as M rises without limit. Evidently, the higher the margin, the less the degree of comparative advantage for either good across these markets.

$$\frac{P_H + M}{P_F + M} \xrightarrow[M \to \infty]{} 1$$

A second advantage of falling margins is to improve international terms of trade. Consider now the domestic producer price of exports P_E = PWE-M, where PWE denotes the international price of an export good and M the margin must be debited against the exporter's net revenue (producer) price. Symmetrically, the domestic purchaser price of imports takes the form P_M=PWM+M where PWM is the corresponding international price of imported goods and the margin M must be added to purchaser prices. Now we observe that falling margins induce an increase in terms-of-trade P_E/P_M since. Once again the double virtue of falling margins, increasing producer prices while reducing purchaser prices, sharpens the incentive for trade.

$$M \downarrow \Rightarrow \frac{PWE - M}{P_D} \uparrow \; and \; \frac{PWM + M}{P_D} \downarrow$$

Finally, margins are inversely related to the rural terms of trade, and thus investments that reduce distribution margins are pro-poor. Consider the rural terms of trade defined as follows:

$$\rho = \frac{P_R^R}{P_U^R} = \frac{P_D - M}{P_D + M}$$

where rural prices of rural goods (P_R^R or rural household producer prices) must be debited for distribution to the domestic market (at prices PD) and rural prices of urban goods (P_U^R or rural household purchaser prices) must include shipping cost from domestic markets. Differentiating this ratio of rural producer prices to rural consumer prices, we get

$$\frac{\partial \rho}{\partial M} = -2\frac{P_D}{(P_D + M)^2}$$

which clearly indicates that falling margins increase the rural terms of trade.

2.3. Neoclassical Stimulus

Modern economic theory recognizes many so-called "endogenous growth factors," i.e. economic conditions that facilitate readiness for growth and can accelerate it when they are present in an economic setting. Many of these are also facilitated by infrastructure, including:

- Productivity enhancement
- Technology diffusion
- Information diffusion
- Supply chain articulation and other network externalities
- Human capital development (migration)

Many of these factors are among the most sought after features of direct investment, whether domestic or foreign in origin. They are often embodied in new investment, particularly technology-oriented investment, and are thought to contribute strongly to economic and institutional modernization, accelerating growth, increasing labor productivity and real wage potential, and ultimately contributing to higher sustainable living standards.

While these characteristics are widely acknowledged and increasingly understood, many of them are notoriously difficult to measure. In the present study, we use a series of counterfactual experiments to assess their general significance.

3. Overview of the SAGE Model

The complexities of today's global economy make it very unlikely that policy makers relying on intuition or rules-of-thumb will achieve anything approaching optimality in either the domestic or international arenas. Market interactions are so pervasive in determining economic outcomes that more sophisticated empirical research tools are needed to improve visibility for both public and private sector decision makers. The preferred tool for detailed empirical analysis of economic policy is now the Calibrated General Equilibrium (CGE) model. It is well suited to trade analysis because it can detail structural adjustments within national economies and elucidate their interactions in international markets. The model is more extensively discussed in an annex below and the underlying methodology is fully documented elsewhere, but a few general comments will facilitate discussion and interpretation of the scenario results that follow.

Technically, a CGE model is a system of simultaneous equations that simulate price directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices, the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is precisely specified, equilibrium always exists and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economywide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes are not only substantial, but may in some cases even outweigh direct effects. Only a model that consistently specifies economywide interactions can fully assess the implications of economic policies or business strategies. In a multi country model like the one used in this study, indirect effects include the trade linkages between countries and regions which themselves can have policy implications.

4. Overview of Initial Conditions

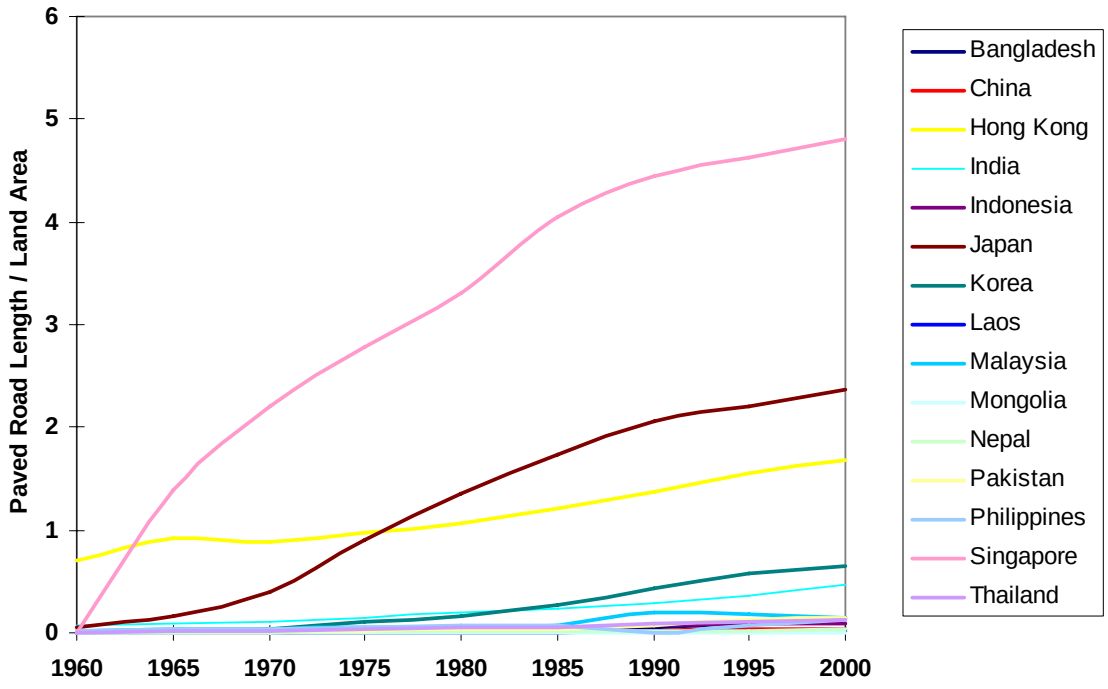
Infrastructure conditions across Asia are highly variegated, even between neighbouring countries. As the following table indicates, Asian infrastructure expansion trends have been dramatic, but only in a few countries. This diversity is addressed in detail in the ADB's flagship infrastructure study (ADB: 2005), and in the next section we examine its growth consequences in some detail.

Before presenting these results, however, it is useful to examine initial infrastructure conditions for the region.[2]

The second part of Figure 2.1 above indicates the variation in overall infrastructure investment flows among Asian economies. Three general groups are distinguishable: high income, high growth, and lower income. The first and second categories evince the highest regional flows to investment (including infrastructure) as a percent of GDP, while the third are understandably constrained by limited domestic resources and less ability to attract external ones (as the second category does).

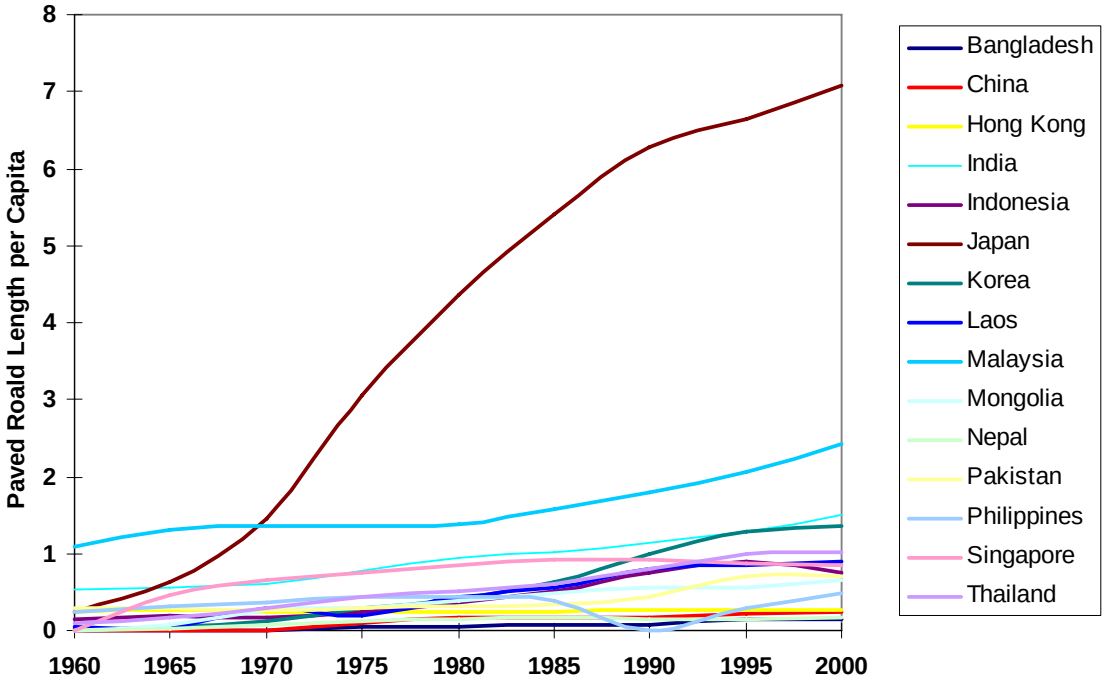
Turning from the investment flow to the stock of infrastructure, we of course see an analogous pattern. The following two figures present trends in installed improved roadway over the last forty five years, expressed in two ways. The first, road length per unit of domestic national land area, give an indication of national road density. This is certainly a trend that should certainly rise for all countries striving for modernization, and indeed those with the fastest rising trends are among the most affluent (Japan and Singapore).

Figure 4.1: Paved Road Systems and Land Area (road length per hectare)



[2] For more extensive discussion of infrastructure assessment and proxies for quality and performance criteria, see e.g. Estache and Goicoechea (2005).

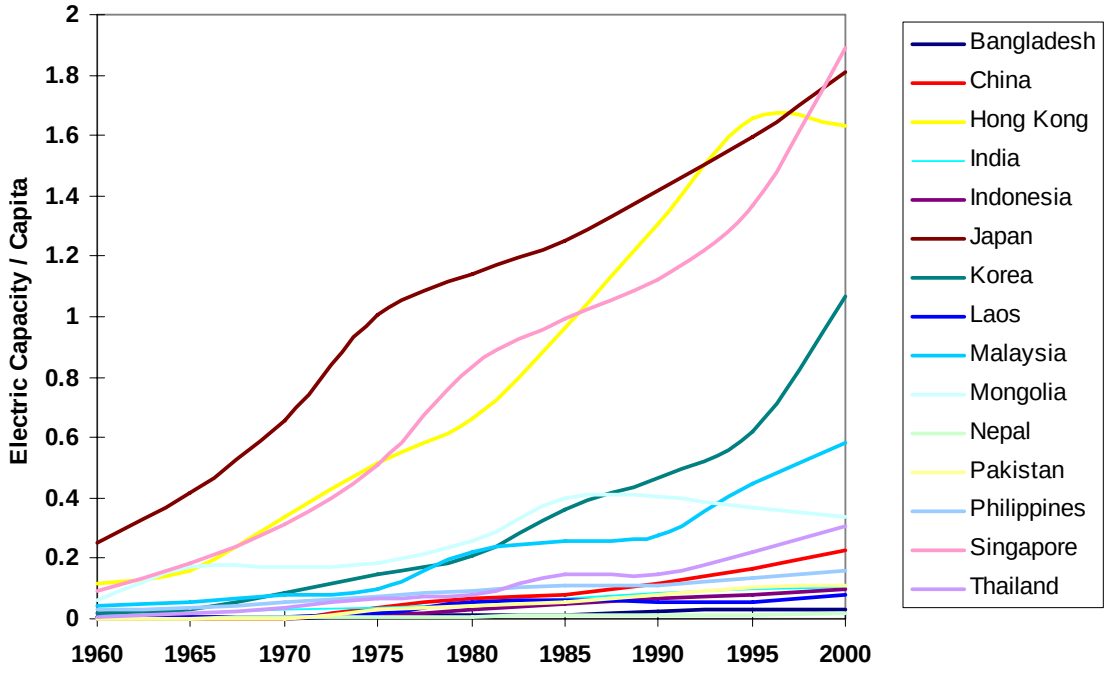
Figure 4.2: Paved Road Systems and Population (road length per capita)



It is another matter, however, to compare this indicator across countries. For example, China has been building roads faster (in road length terms) for the last ten years than the US did during its "Golden Age" of transport infrastructure development in the 1950's. In spite of this, vast tracts of China are and will likely remain desolate of people, markets, and transport services. For this reason, China is very difficult to discern on this chart, even though its annual growth over the last two decades has been nearly double that of Korea, a much smaller country with advanced road networks and much higher per capita income. For the purposes of country comparison, the stage of infrastructure development is probably more accurately reflected in a service measure, such as total road length per capita. Here we see Japan and Malaysia taking the lead in the region, yet we are not taking full account of public transit resources, where Hong Kong and Singapore are well endowed.

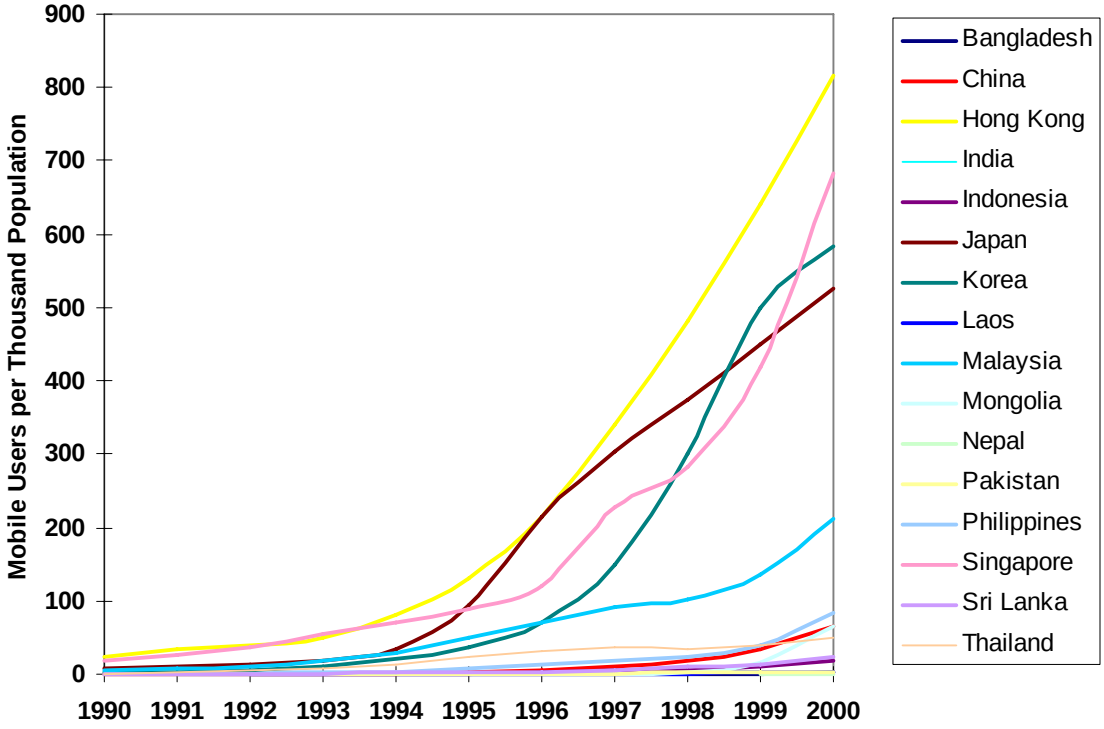
Another popular measure of modernization infrastructure is electricity capacity per capita. This is depicted in Figure 4.3 and the cross-country disparities are very much in line with earlier discussion about regional growth hierarchy. Electrification is an essential component of modernization, sustainable urban development, and higher productivity around the world, and this will clearly be a focal point for Asian infrastructure investment, particularly in countries who are later starters.

Figure 4.3: Electrification (electric capacity per capita)



Another popular index of modernizing infrastructure is the scope of mobile telecom adoption, depicted for the Asian region in figure 4.4 in per capita subscriber terms. Close examination and comparison of these trends reveals this is indeed a good proxy for economic modernization, and indeed, the hierarchy of per capita income in Asia is almost perfectly reflected in this data. Urban density creates a slight bias for the city states, but otherwise mobile saturation is a nearly perfect proxy for per capita income. Having said this, however, it should be observed that different kinds of infrastructure are more appropriate to facilitating growth at different stages of development. In countries with large rural poor populations, for example, improved roads and other transport are much more growth friendly and pro-poor than large investments in modern telecoms.

Figure 4.4: Mobile Telephony (mobile users per thousand population)



The next figure makes clear how domestic income and savings constraint infrastructure development. Lower income Asian countries are caught in a low investment trap, where both domestic private and public resources are insufficient to support rapid emergence from their less developed status. These countries might be considered fortunate in one respect, however. The developing countries are members of the Asian region, which currently enjoys the world's highest average savings rates and unprecedented stocks and inflows of external savings. In its Infrastructure Needs report (2005), ADB emphasizes that external partnership can play an essential role in overcoming these constraints. And Figures 4.6 and 4.7 show clearly why this makes sense. The first figure presents data on incomes, aid levels, and aid sources for a variety of East Asian and Pacific economies, while the second shows trends in private (investment) and public (aid) foreign capital inflows to Asian countries. Both trends support a single conclusion, that we live in a world of complementarity where equitable growth is concerned, domestic and external partnership and public-private partnership. Each is necessary, yet neither is likely to be sufficient, if the comprehensive growth needs for effective Asian economic integration are to be met.

Figure 4.5: Income and Infrastructure

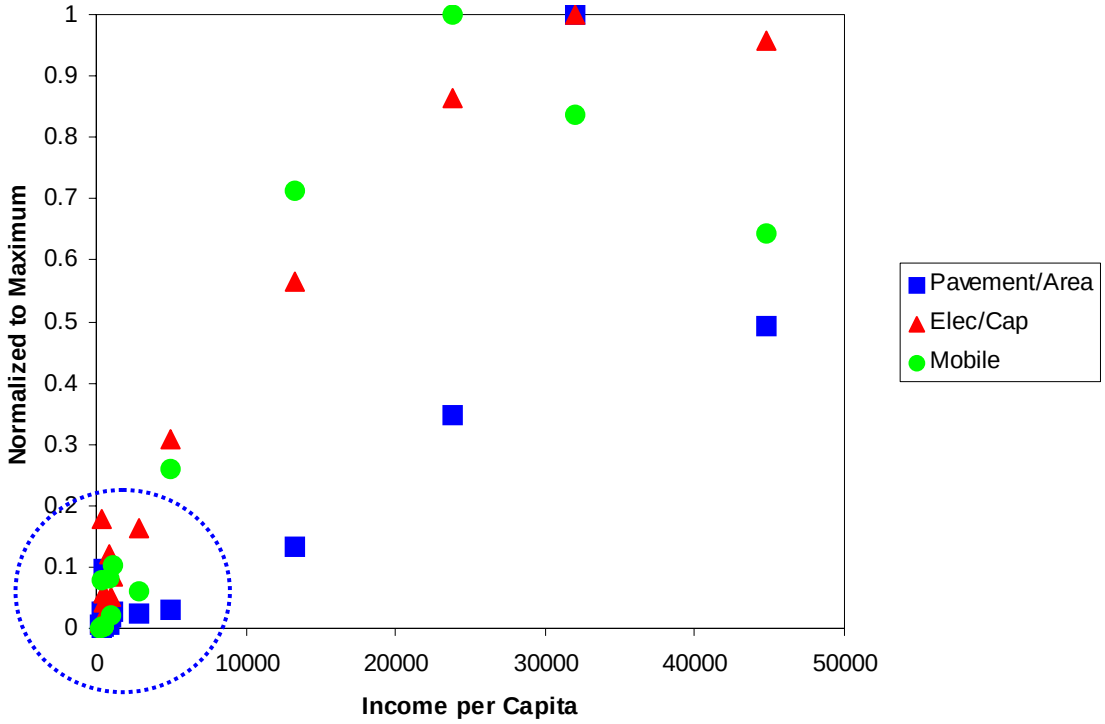


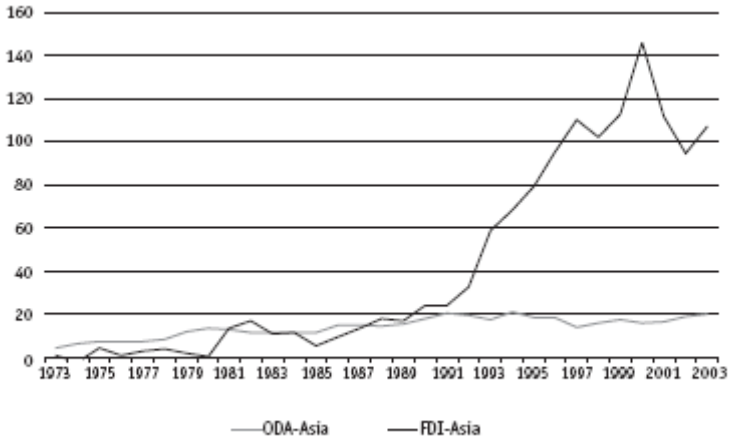
Figure 4.6: Aid Dependency in East Asia and the Pacific, 2002

	Income Per Capita (US$)	Aid Per Capita (US$)	Aid as percentage of: National Income	Gross Investment
Malaysia	3,540	4	0.1	0.4
Thailand	2,000	5	0.2	1.0
Philippines	1,030	7	0.7	3.7
China	960	1	0.1	0.3
Indonesia	710	6	0.8	5.3
PNG	530	38	7.5	
Vietnam	430	16	3.6	11.3
Mongolia	430	85	18.6	60.8
Lao PDR	310	50	17.3	
Cambodia	300	39	12.7	54.7
EAP Average /1	960	4	0.4	1.2

1/ For low and middle income countries.

Source: World Bank, World Development Indicators 2004.

Figure 4.7: Asian Inbound Aid and FDI
(Billions of US Dollars)



Sources: OECD (2005) and UNCTAD (2005).

5. Scenario Analysis

As indicated in the discussion of Section 2 above, our basic approach is to examine the effects of infrastructure investments from three different economic perspectives: macroeconomic (Keynesian), margins/prices (Ricardian), and productivity (Neoclassical). Each approach uses different estimation strategies, and sheds light on different contributions infrastructure can make to the Asian regional economies.

5.1. Macroeconomic experiments (Keynesian)

This category of effects focuses on fiscal commitments and aggregation demand and employment linkages. At the national level, a standard macroeconomic model can capture much of this process, but for the entire region we need a multicountry model and a general equilibrium model more completely captures the myriad of indirect benefits that follow from general investment projects like infrastructure.

To assess the potential contribution from this kind of aggregate demand stimulus, we began from the position set forth in the ADB flagship report: that less developed Asian economies need to attain higher annual rates of infrastructure investment over the long term. In particular, the report suggests that a useful focal point for this investment level over the next decade would be 6.3 percent of GDP. Many economies in the region were below this level and some significantly so, and it can be expected that stepping up their commitments would accelerate growth domestically.

In the counterfactual experiments reported here, we assumed that economies with higher average investment levels (China, Thailand, etc.) or high incomes (e.g. Japan, Korea, and Singapore) maintain their investment at Baseline levels. Other Asian economies, by contrast, increase their investment along a logistic trend to reach the 6.3 percent steady state by 2012. We have assumed that these fiscal commitments are financed with a non-distortionary tax increase, which of course implies institutional discipline that might be difficult to fulfil.

As one would expect in a public finance experiment like this, there are substantial benefits from diverting household gross income to investment, even before considering more complex growth benefits. Two main components drive these results, the first round multiplier effect of government spending (particularly with high average savings rates in Asia), and the macro benefits of capital accumulation (ICOR and average wage effects). For these lower income countries, the effects are striking, increasing real GDP by substantial amounts. In Viet Nam, for example, cumulative GDP over the 20 year period is 60% higher, rising steadily to 84% higher in the terminal year.

Table 5.1: Macroeconomic Results
Percent changes from Baseline
Annual and Cumulative (2005-2025) Real GDP

Country	2010	2015	2020	2025	Cum
Indonesia	10	23	40	59	38
Philippines	13	39	79	134	79
Viet Nam	22	43	65	84	60
Bangladesh	13	27	41	54	38
India	4	12	23	33	21
Sri Lanka	12	29	48	67	44

These macroeconomic results clearly bear out the importance of the Asian infrastructure initiative (ADB: 2005) advanced jointly by ADB, JBIC, and the World Bank. While higher income countries in the region have the means to meet their own infrastructure requirements, the overall regional gains from further integration will depend for all economies on the capacity of less developed Asian economies to facilitate trade and domestic commerce. The dual challenges of more sustainable and inclusive regional growth can be significantly advanced by accelerated infrastructure investment in these economies.

5.2. Margin/Price experiments (Ricardian)

In the so-called Ricardian context, infrastructure is seen as reducing transport, trade, and other distribution margins to facilitate broader market participation. As has already been emphasized, this aspect of public investment is particularly appealing because it facilitates individual private agency and promotes self-directed poverty alleviation. Given the extreme remoteness of marginalized communities in some parts of Asia, such indirect commitments are likely to be much more cost effective than targeted transfer schemes or more direct interventions for poverty reduction.

If one were to assess such policies without a GE framework, however, many indirect effects may be omitted because of the complexity of link between reducing trade costs and growth. Our survey of the economic literature indicates that there are three main ways in which these effects are propagated. Firstly, by reducing commercial margins, infrastructure can narrow the gap between producer and purchaser prices in the domestic economy. The direct effect of this is to benefit domestic agents, particularly those in proximity to the improved infrastructure. Indirect effects of course extend well beyond this however, as narrower margins between producer and purchaser prices increase the scope of profitable commerce and enlarge the domestic market.

A second category of indirect benefits relates to international trade. As border prices come closer to import purchaser prices and to export producer prices, this means net price reductions for the former and increases for the latter. In both cases, trade will be facilitated by expanding the scope for domestic absorption and supply to the export markets. Finally, a third effect of falling margins is on domestic returns to scale. Trade and transport margins are an important component of marginal cost, and reducing these will shift the minimum efficient scale of production to higher output levels, allowing firms that increase supply to realize greater scale economies.

The SAGE experiments conducted in this context capture margin reduction by increasing total factor productivity in the sectors that provide distribution services, i.e. the Trade, Transport, and Communication sectors. Productivity growth in these sectors, directly adducible to infrastructure improvements, will translate directly into reduced costs for the services provided by these sectors, thereby making market access less expensive for all. In this set of experiments, we follow an extensive literature linking infrastructure and productivity of distribution services (surveyed, e.g. in Aschauer: 1989). Using annual US data on public capital, private capital, employment, and output. Ashauer found that an additional dollar invested in public capital yields a much higher economic payoff than another dollar of private capital. Significantly, the main driver of his conclusion was a high temporal correlation between productivity and the stock of public infrastructure.

This experiment is coupled to the last, with the same logistic profile of rising infrastructure investment. In addition to this, we assume that productivity in the distribution sectors increases with unit elasticity with respect to changes in sectoral investment, assuming a five year gestation for the full productivity increase. Thus a 5% increase in infrastructure investment would increase distribution service productivity 1% per year for five years.

Aggregate results in Table 5.2 indicate the importance of trade costs to economic growth and development. To the extent that infrastructure can lower these costs for all market participants, the benefits will be greater the larger the investment relative to the initial stock of infrastructure. For this reason, the poorer countries, with lower levels of initial stocks and concomitantly high internal trade margins, are the greatest beneficiaries. These are precisely the economies identified for accelerated investment by the flagship report, including Indonesia, Philippines, Viet Nam, Bangladesh, and Sri Lanka. Note in this set of experiments, however, that the gains are not restricted to these economies alone. This is because we assume the productivity effects extend to all countries increasing their annual net infrastructure stocks. In this case, even relatively mature economies like Japan can increase cumulative GDP (for 2005-2025) but up to 9 percent.

Table 5.2: Margin/Price Results
Percent changes from Baseline
Annual and Cumulative (2005-2025) Real GDP

Country	2010	2015	2020	2025	Cum
China	1	2	3	3	2
Japan	3	6	11	15	9
Korea	3	6	10	14	9
Taipei,China	1	3	4	6	4
Indonesia	13	30	55	85	53
Malaysia	1	1	2	3	2
Philippines	16	46	97	170	98
Singapore	1	1	1	1	1
Thailand	1	1	1	2	1
Viet Nam	29	64	105	143	98
Bangladesh	24	59	106	158	102
India	9	23	42	63	40
Sri Lanka	19	51	92	138	86

Closer examination of the Ricardian results, at the level of sectoral output and prices, reveals some components of this process. Note first of all that highly variegated sectoral composition of output adjustments. Although the country output totals comport well with real GDP numbers in Table 5.2, reducing distribution margins would clearly have quite variable effects across sectors within a given country. There are two main reasons why some sectors respond more robustly than

others. Firstly, distribution costs are a higher proportion of product value for some goods, including Fuels, heavy manufactures, and of course the distribution sectors themselves. This cost share property extends directly to the observed domestic price effets in the second sub-table, where price declines are concentrated in distribution (from the experiment) and in those goods with high distribution cost components.

Secondly, goods with a high level of tradability and particularly with links to (highly elastic) external markets will respond strongly to underlying price changes. These include fuel and vehicles on the import side and Textile&Apparel and Electrical Equipment on the export side.

Table 5.3: Sectoral Output Adjustments by Country (annual percent change from Baseline in 2025)

Output by Country	1 Agric	2 Fuels	3 ProcFood	4 TexApprl	5 Chemical	6 Vehicles	7 ElecEqp	8 OthMfg	9 Trade	10 TrnsCom	11 PrvServ	12 PubAdm	Total
China	2	1	2	3	3	5	-1	2	6	7	3	1	3
Japan	9	8	17	-1	7	-9	-14	-4	91	33	1	-3	14
Korea	22	-7	50	-6	6	-21	-12	-13	182	49	-8	-1	12
Taipei,China	-3	-19	1	-8	-8	-12	-21	-26	87	31	-5	0	2
Indonesia	6	71	15	43	69	45	107	27	451	278	25	-1	80
Malaysia	7	7	12	5	4	3	-4	-1	16	15	2	1	3
Philippines	6	215	22	100	218	260	133	347	800	367	126	37	187
Singapore	6	0	27	2	16	0	-2	-6	8	7	0	1	3
Thailand	3	-2	4	1	4	6	-4	-2	4	8	2	0	2
Viet Nam	18	216	31	75	209	215	270	126	896	711	61	-26	165
Bangladesh	23	138	36	3	250	447	1058	137	365	321	57	22	140
India	12	14	6	-4	56	4	6	31	245	177	23	0	63
Sri Lanka	-11	NA	67	285	94	-9	161	136	568	86	-15	-16	141

Prices by Country	1 Agric	2 Fuels	3 ProcFood	4 TexApprl	5 Chemical	6 Vehicles	7 ElecEqp	8 OthMfg	9 Trade	10 TrnsCom	11 PrvServ	12 PubAdm	Average
China	2	0	1	1	0	1	0	0	-3	-3	1	1	0
Japan	12	-1	1	2	-2	1	0	-1	-6	-7	-5	11	1
Korea	15	2	7	2	-1	1	-1	0	-8	-10	0	7	2
Taipei,China	5	2	3	3	2	2	1	2	-11	-10	5	10	1
Indonesia	29	-5	9	-3	-4	-6	-10	-4	-27	-22	-4	28	1
Malaysia	3	1	1	0	0	0	-1	0	-8	-7	1	1	0
Philippines	68	-2	27	-8	-11	-16	-11	-21	-38	-28	-23	-9	0
Singapore	6	0	2	1	0	1	-1	1	-2	-1	2	3	1
Thailand	3	1	2	1	0	0	-1	0	-2	-2	1	1	0
Viet Nam	27	-11	15	-7	-11	-11	-14	-14	-30	-25	-39	13	-5
Bangladesh	24	-4	3	1	-23	-37	-37	-17	-19	-24	-37	9	-11
India	33	6	19	11	-6	-3	-9	-8	-22	-15	-6	25	5
Sri Lanka	47	0	-9	-16	-5	0	-12	-16	-9	-8	23	81	6

5.3. Endogenous Growth Effects (Neoclassical)

One of the most important insights to emerge from neoclassical studies of trade and development is the notion of endogenous growth effects. Already alluded to above, this term refers to a wide array of economic conditions that have the potential to accelerate growth, are endemic to the economic environment, and are activated by individual incentives arising from either markets of policy interventions. For example, endogenous growth factors include such things as human capital formation (the individual pursuit of education/training), technology transfer from FDI or direct external assistance, inter-industry or intra-industry spillovers, positive network externalities, etc.

Obviously, the diversity of these factors and the complexity of their economic agency make them notoriously difficult to study empirically. However, they are believed to be among the most potent stimuli for economic growth and modernization, and as such they cannot be ignored. On the contrary, endogenous growth factors like technology transfer and high-skill job creation are intensely sought after in multilateral trade and investment negotiations, both public and private. Finally, infrastructure investment is thought to be one of the most important enabling policies to promote endogenous growth processes. For all these reasons, we need to better understand links between infrastructure and growth through this channel.

As we did in other experiments, we use productivity as a proxy for endogenous growth factors. This is very appropriate in the present context since productivity (individual and in terms of all factors) is one of the most common metrics for assessing the capacity of an economy for accelerating growth by internal (endogenous) means. To get a concrete sense of how these factors can contribute to growth in the context of Asian regional integration, we examine an extension of the previous two scenarios. In particular, we assume that infrastructure trends follow those of the first two experiments, but that productivity dividends from infrastructure are more widely distributed across the economy. In this context then, infrastructure improvements not only lower transactions costs, but also increase individual and total factor productivity. For example, a worker who can drive to work on an improved road saves money and time, increasing both purchasing power and productivity. In the experiment reported next, we assume the same scenario as the previous sections, but apply infrastructure-induced productivity growth to all sectors in each economy.

As is apparent from the macroeconomic results of Table 5.4, the results are predictably higher than in the case where productivity growth is confined to distribution sectors. In the empirical literature on infrastructure and productivity, there is a clear consensus that productivity gains from extensive public goods infrastructure ultimately accrue to most market activities. The extent of this is

an empirical question, but we believe our assumptions of unitary productivity/(aggregate investment) elasticity, with five year gestation, are reasonably conservative. Even in this case, doubling or even tripling of GDP growth is possible for the economies with lowest prior infrastructure stocks. While these are large and important improvements, it must be emphasized that even the highest level (Viet Nam) with 178 percent cumulative income growth, only represents a 3 percentage point growth premium over the 21 year period considered.

Table 5.4: Margin/Price Results
Percent changes from Baseline
Annual and Cumulative (2005-2025) Real GDP

Country	2010	2015	2020	2025	Cum
China	8	15	22	30	21
Japan	7	13	21	30	19
Korea	10	20	30	40	27
Taipei,China	8	15	22	28	19
Indonesia	25	58	108	173	106
Malaysia	5	11	17	23	16
Philippines	24	65	137	249	142
Singapore	3	6	8	11	7
Thailand	3	5	9	12	8
Viet Nam	49	111	187	267	178
Bangladesh	37	86	153	230	149
India	21	50	89	137	88
Sri Lanka	31	76	136	203	127

As the more micro level, we see in Table 5.5 below a more pervasive expansionary process and more comprehensive cost/price savings within individual economies. Note in particular the changing comparative advantages of these economies, where infrastructure affects productivity not just of non-tradeable services of but prominent sectors that are eligible for export (agriculture and processed food).

Table 5.5: Sectoral Output Adjustments by Country (annual percent change from Baseline in 2025)

Output by Country	1 Agric	2 Fuels	3 ProcFood	4 TexApprl	5 Chemical	6 Vehicles	7 ElecEqp	8 OthMfg	9 Trade	10 TrnsCom	11 PrvServ	12 PubAdm	Total
China	38	31	33	35	35	35	20	30	31	27	30	7	29
Japan	25	34	26	5	18	0	-5	7	118	47	17	6	29
Korea	83	49	92	19	30	-3	1	5	247	66	19	23	39
Taipei,China	27	17	20	12	14	4	-13	-7	117	42	22	27	24
Indonesia	145	233	131	80	174	112	79	97	601	384	97	38	165
Malaysia	34	41	25	21	34	29	13	25	32	27	23	5	23
Philippines	147	476	162	218	329	277	131	364	949	423	198	72	265
Singapore	15	-6	12	-8	40	16	5	3	20	11	9	9	13
Thailand	28	23	22	3	26	18	0	6	14	17	15	5	12
Viet Nam	227	414	264	142	419	382	448	294	1453	1034	139	24	319
Bangladesh	160	272	133	134	286	349	478	162	489	358	121	58	221
India	133	163	104	126	144	50	20	67	354	282	77	41	138
Sri Lanka	109	NA	232	346	185	37	199	251	659	96	42	-3	207

Prices by Country	1 Agric	2 Fuels	3 ProcFood	4 TexApprl	5 Chemical	6 Vehicles	7 ElecEqp	8 OthMfg	9 Trade	10 TrnsCom	11 PrvServ	12 PubAdm	Average
China	-7	-2	-4	-2	-1	0	0	0	0	2	1	-1	-2
Japan	-5	-4	-2	-1	-3	-1	-1	-1	1	0	-4	4	-2
Korea	-10	-6	-5	-2	-2	-2	-1	-1	-2	-2	-1	-6	-4
Taipei,China	-12	-4	-4	-1	0	0	1	0	-1	1	4	-8	-3
Indonesia	-23	-13	-15	-7	-9	-5	-6	-8	-8	-7	-7	-4	-11
Malaysia	-8	-3	-3	-4	-3	-2	-2	-2	-2	-2	-2	-4	-3
Philippines	-11	-9	-18	-16	-16	-15	-10	-20	-28	-22	-24	-15	-16
Singapore	-3	1	0	0	-1	1	-1	1	3	3	3	2	1
Thailand	-9	-3	-5	-1	-2	0	-1	-1	3	0	0	-4	-2
Viet Nam	-25	-17	-23	-13	-16	-14	-17	-20	-25	-22	-41	-10	-21
Bangladesh	-25	-15	-26	-13	-18	-24	-23	-11	6	12	-34	-1	-16
India	-27	-8	-17	-12	-9	-5	-6	-7	-8	-6	-7	-5	-12
Sri Lanka	-15	0	-31	-20	-10	-5	-13	-19	10	7	1	28	-10

These results are not a all hypothetical in qualitative terms, as can be made apparent with a important example of Asian regional development, supply networks. One of the more dramatic modern manifestations of reduced trade costs is the regional and global decomposition of supply chains. Foreign Direct Investment and contractual linkages are distributing production tasks, employment, and income around the world for a myriad of reasons. These include factor price differences, local and regional market access, and simple diversification strategies, but in all cases, the result is an ever-growing web of regional trade linkages. This trend has been greatly facilitated in the Asian region by infrastructure investment, which reduces network management and integration costs and sharpens the differentials between costs and prices in different locales. As this process evolves, we see the emergence of mature industries where there once was only a primary product or component producer (see inset). Each time this happens, the individual locality migrates up the value added ladder and local resources command higher premia in the global marketplace. In this way, supply chain decomposition and the infrastructure that makes in possible contributes to ever wider networks of value creation, more stable and equitable regional growth.

A Regional Example – Bamboo Capitalism

- Network externalities in local production and finance allow complete markets to sprout from nodes in a global root system of intermediate supply.
- This culminating aspect of global supply chain decomposition has created a diverse and vibrant population of independent local industries around the East Asian region.
- Many emergent enterprises are still bound to their roots by ownership or component supply contracts
- Increasingly, however, they arise as independent suppliers of finished products with their own brands, technologies, and marketing. This trend is an important driver for the dynamics of global competitiveness and innovation.

In East Asia, this process has advanced very quickly and pervasively, facilitated by both western FDI and a "stepladder effect" where more advanced Asian economies re-allocate production to less advanced ones. In the process of distributing supply chains, foreign investors in the region create new nodes of production in different localities, and another indirect phenomenon emerges. Bamboo Capitalism describes a process where fully autonomous enterprises and markets sprout from these nodes in the "root system" of global intermediate supply. This process is long established in the Tiger economies and can be seen to emerge now in China (even across China) and other

emerging Asian economies. The result is replication of industries and markets are an exponential rate. Infrastructure is a prerequisite for effective participation in this regional production sharing

6. Concluding Remarks

Infrastructure can play a significant role in promoting more rapid and sustained growth and economic integration in Asia. Using a newly developed global CGE model, we find that infrastructure is a potent catalyst for wider economic participation, both within and between Asian economies, and that it can promote private, individual agency as a means of poverty alleviation and more rapid growth among the poorest regional economies. Our basic approach is to examine infrastructure as investment demand and as a means of reducing trade costs. In the former case, significant economywide multiplier effects accelerate growth, particularly in less developed regional economies whose require faster investment rates to upgrade their infrastructure.

A series of simulations focusing on reductions of different forms of trade cost indicate that infrastructure investment can facilitate the regional integration and sharply increase economic growth, but its effects vary significantly between economies. Two types of countries are most likely to gain: those with very high prior domestic margins, and those with high prior levels of external trade dependence. Investment in domestic infrastructure is quite important for less opened low-income countries. In these cases, external partnerships could be an important source of investment leverage to overcome domestic savings constraints, and our results indicate these initiatives would be rewarded with superior regional growth rates and improvements in regional equity via economic convergence. These kinds of multilateral strategies are essential to make regional growth and integration opportunities more inclusive.

Extensions of the present work could shed much new light on the wider implications of infrastructure commitments at every stage, including financial/fiscal sourcing, domestic, bilateral, and multilateral project implementation, and a myriad of downstream assessments including economic facilitation (as studied here), productivity spillovers and other growth externalities, income growth and distributional outcomes. Given the importance of these issues to development generally and the ADB mission in particular, and in recognition of the capacity of CGE models to account for these complex effects, the SAGE model can support a broad agenda of policy research.

As a final observation, it is worth noting that our current experiments have not addressed trade policy directly. To clearly identify the role of infrastructure in domestic economic growth, we have not compounded our experiments with scenarios for regional or global trade liberalization. This

would be a natural extension of the present work, and would in all likelihood demonstrate strong complementarity between the Asian regional integration agendas for trade and investment.

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