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Service sector productivity and economic growth in Asia☆

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ABSTRACT

The paper explores the historical experience of productivity growth in the Asian economies over recent decades, with a focus on the service sector. Based on this historical experience, the paper then evaluates the impact of more rapid growth in labor productivity in the service sector in Asia using an empirical general equilibrium model that allows for goods and capital movements across sectors and economies, and consumption and investment dynamics. We find that faster productivity growth in the service sector in Asia contributes to sustained and balanced growth of Asian economies, but the dynamic adjustment is different across economies. In particular, during the adjustment to higher services productivity growth, there is a significant expansion of the durable manufacturing sector that is required to provide the capital stock that accompanies higher economic growth.

1. Introduction

The purpose of this paper is to explore the potential role of the service sector in future economic growth and rebalancing in Asia. This is undertaken in two parts. The first part uses empirical techniques to analyze the historical role of the service sector in structural change and economic growth in Asia. The second part of the paper, considering this historical data and trends, uses a general equilibrium model of the global economy called the G-Cubed model,[1] to explore future scenarios of more rapid catch-up of service sector productivity growth over coming decades for the Asian economies.

In the era of industrialization since World War II, major Asian economies including Japan, the Republic of Korea and the People's Republic of China (PRC) have undergone spectacular economic transformations − fast economic growth and major employment shifts from the agriculture sector toward the manufacturing sector. The manufacturing sector has been a key engine of growth over this period. This rapid industrialization has been supported by high savings and investment rates and export-oriented policies. In recent decades, however, the pace of output growth in the industrialized East Asian economies has slowed significantly. Japan and Asian newly industrialized economies (NIEs) that had experienced fast growth began to grow less rapidly over time as the gap between their per capita incomes and that of the US narrowed.[2] A number of factors, including slower labor force growth, lower investment rates, declining rates of return to investment, and sluggish technology advancement have been highlighted as the major causes of the "growth deceleration."

Another salient feature in East Asia's growth is the rise of service industries with major employment shifts toward the service sector. The well-established empirical stylized fact shows that there is a positive

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[1] The G-Cubed Model was developed by McKibbin and Wilcoxen (1999).

[2] The trend of declining growth rates over time can be explained by the "conditional convergence" theory (Barro and Sala-i-Martin, 2004), where a country with a low level of initial per capita output relative to its own steady-state potential has a higher growth rate than a country with a higher level of per capita output, owing to a rapid catching-up process through high rates of capital accumulation and technology diffusion from more technologically advanced economies. A fast-growing country eventually grows slower, as it narrows the gap of capital stock and productivity from its steady-state levels. Recent empirical papers including Madsen (2007), Bournakis (2012), Barro (2015), and Lee (2017) apply this theoretical framework to explain growth experiences across economies or an individual economy.

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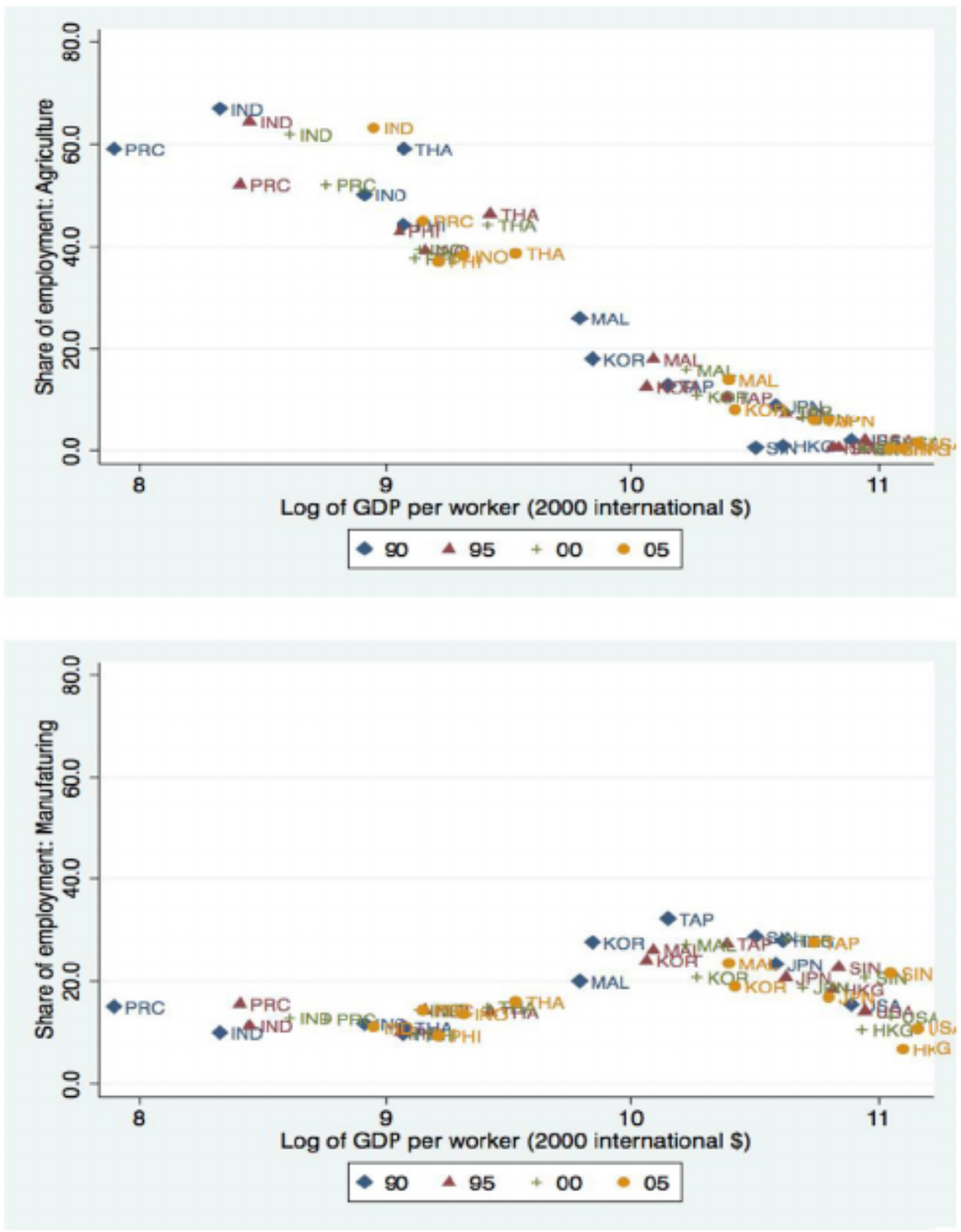


GDP = gross domestic product.

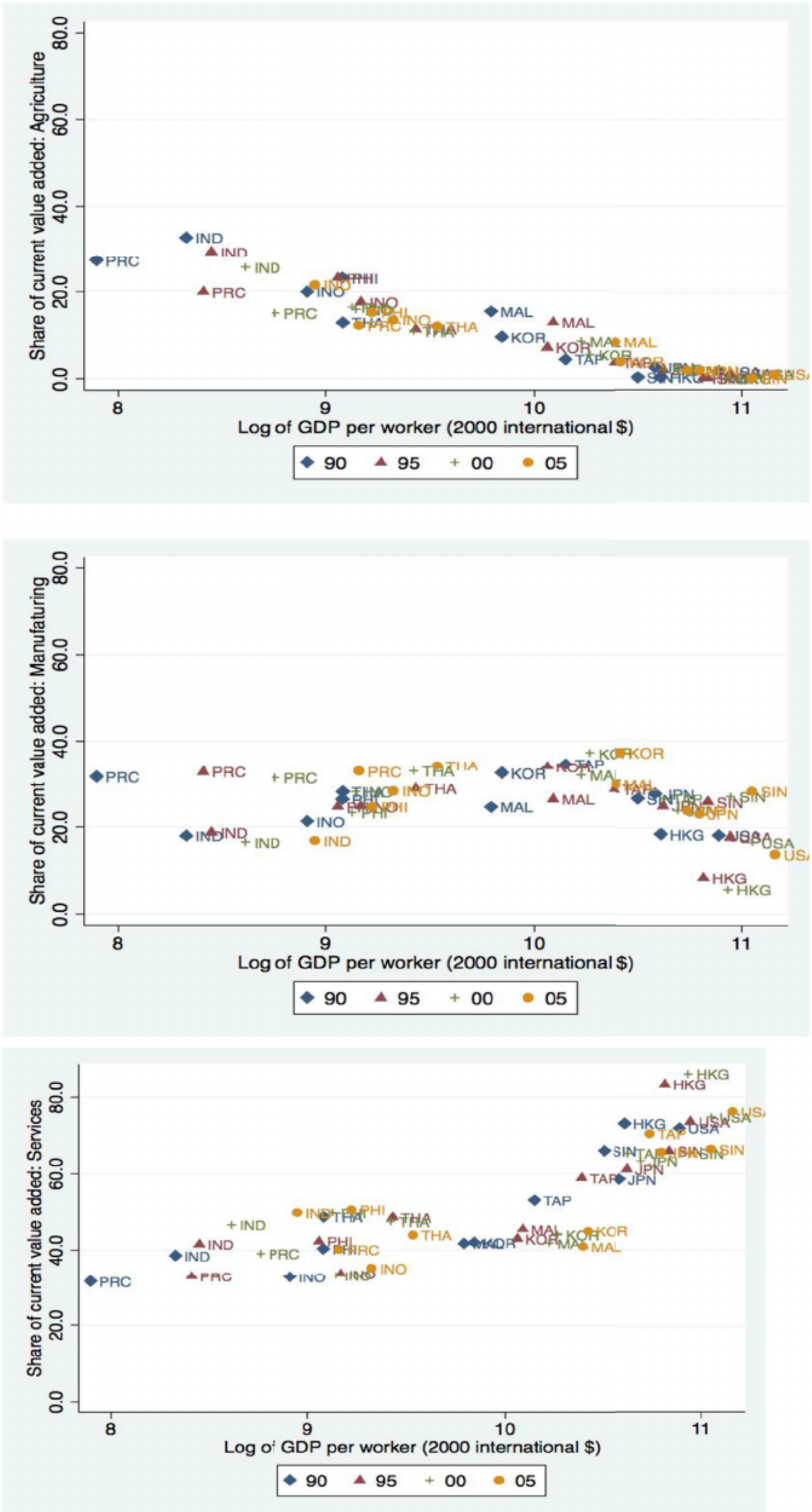
Source: Author's illustration based on Groningen Growth and Development Centre 10-Sector Database].

Fig. 1. Sector shares of employment for 11 Asian economies and the United States, 1990–2005.

relationship between the share of services in GDP (or total employment) and GDP per capita (Clark, 1957; Chenery, 1960). More recently, Eichengreen and Gupta (2013) argue that the relationship is not linear, following two distinct "wave" patterns of service sector growth. In the first wave, the service share in output and employment rises with GDP per capita at a decelerating rate. The service share rises again in the second wave at a higher income level. They argue that the first wave features the rise of traditional services while incomes are still low, while the second wave features modern services including post and communication, financial intermediation, computer, and business services.

How does the rise in the service sector contribute to overall growth in Asian economies? As an economy grows, the service sector becomes larger and hence overall growth depends more on the performance of the service sector. Thus, the service sector's contribution to overall growth tends to become proportionally larger with economic development and expansion of the service sector. However, if labor productivity growth of the service sector is lower than that of the industrial sector, the increase in the size of the service sector with deindustrialization can have a harmful effect on overall output growth.

The literature presents a number of theories that attempt to explain the change in the service sector share and its implication to overall economic growth. Structural change can be driven by both demand and supply-side factors. The seminal paper by Baumol (1967) presents a model of "unbalanced growth," in which higher productivity growth in the "progressive" (manufacturing) sector than in the "stagnant" (service) sector causes shifts of labor from manufacturing to service industries and



GDP = gross domestic product.

Source: Author's illustration based on Groningen Growth and Development Centre 10-Sector Database .

Fig. 2. Sector shares of value added for 11 Asian economies and the United States, 1990–2005.

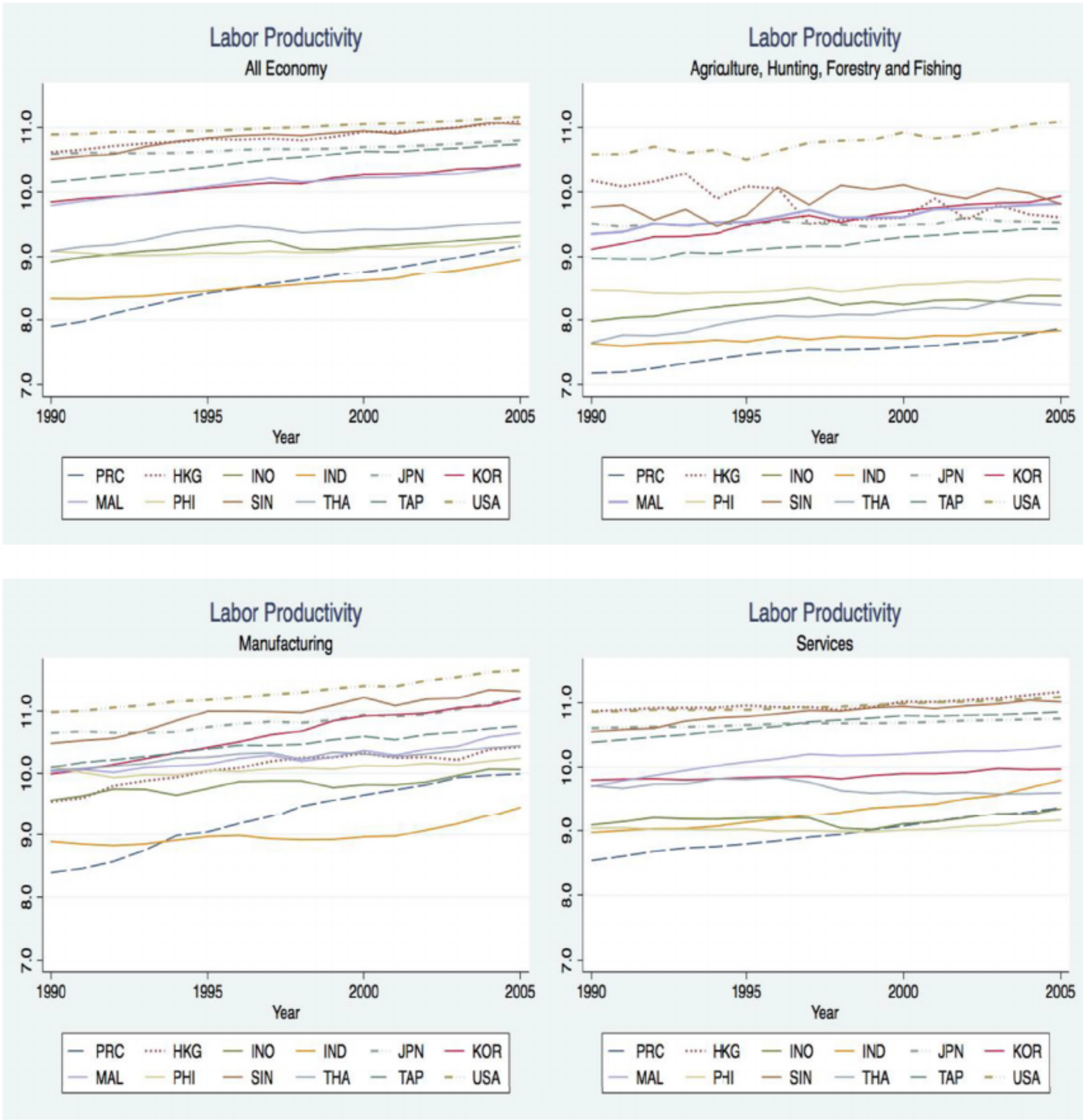


Fig. 3. Sectoral labor productivity for 11 Asian economies and the United States.

shows that aggregate output growth slows down over time as the sector with the lower productivity growth expands.

Recent papers by Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008) develop multisector growth models motivated by Baumol (1967). These models imply that total factor productivity or factor proportion differences generate employment shifts to the "stagnant" (service) sector over the (non)-balanced growth path. Another strand of literature including Kongsamut et al. (2001); and Foellmi and Zweimüller (2008) rely on a demand side explanation for structural change. These papers show that as income grows, the non-homotheticity of the demands for the different consumption goods brings about changes in the sectoral shares.[3] This demand-side explanation suggests that the value added share of services increases and becomes more important for aggregate output growth when its demand is more income-elastic.

This paper contributes to this literature by using an empirically based global intertemporal multi-sector general equilibrium model— a large scale dynamic stochastic general equilibrium (DSGE) model—, to explore the consequences of rising labor productivity in the service sector in Asian economies individually and then across all Asian economies at the same time. The model allows for consideration of inter-industry input–output linkages, factor movements, and consumption and investment dynamics. The model also incorporates spillovers across international borders through trade and financial linkages. This model assesses the impact of supply side factors and picks up the demand side factors through changes in relative prices but not through changing income elasticities.[4]

[3] Herrendorf et al. (2013) present the stylized facts of structural transformation and explain the existing models of structural transformation. .

[4] The parameters of the model are a mix of econometrically estimated and calibrated parameters. The scale of the global model with 8000 equations across 16 countries and inadequate time series data for many countries, rules out a full econometric estimation of the model. Details of how the parameters are estimated or calibrated can be found in McKibbin and Wilcoxen (2013).

Table 1
Ratio of each Sector's labor productivity to manufacturing labor productivity in 2005.

	PRC	HKG	INO	IND	JPN	KOR	MAL	PHI	SIN	THA	TAP	USA
Agriculture, hunting, forestry, and fishing	0.12	0.44	0.18	0.20	0.19	0.28	0.44	0.20	0.22	0.11	0.26	0.57
Manufacturing	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Services	0.54	2.08	0.49	1.41	0.64	0.29	0.73	0.34	0.74	0.43	1.10	0.57
Wholesale and retail trade, and restaurants	0.50	1.79	0.41	1.24	0.54	0.22	0.58	0.31	0.69	0.31	0.86	0.43
Transport, storage, and communications	0.73	2.05	0.44	2.17	0.83	0.87	1.21	0.43	0.84	1.36	1.51	0.88
Finance, real estate, and business services	4.84	4.02	3.43	2.59	0.46	0.13	1.95	0.66	1.21	0.49	1.50	1.05
Community and government services	0.33	1.34	0.36	1.03	0.71	0.28	0.43	0.27	0.40	0.40	1.13	0.38
Others	0.79	1.39	0.92	1.52	0.62	0.68	0.99	0.60	0.46	0.53	0.55	0.54
Mining and quarrying	2.56	1.90	3.66	1.87	0.76	1.61	11.2	1.80	0.38	3.23	3.64	0.91
Electricity, gas, and water	2.77	12.01	1.13	3.74	2.38	4.70	3.69	3.22	2.36	4.72	6.01	3.42
Construction	0.36	0.78	0.42	1.17	0.46	0.51	0.23	0.32	0.34	0.18	0.29	0.34
Aggregate economy	0.44	1.95	0.48	0.60	0.67	0.46	0.78	0.36	0.77	0.40	0.98	0.61

Source: Author's computation based on Groningen Growth and Development Centre 10-Sector Database

The results show that enhancing labor productivity in the service sector can play a major role as a new growth engine leading to Asia's strong and sustainable growth in the long run. With a rise in labor productivity in services, labor moves out of the service sector in the longer run but the adjustment across the other non-service sectors in the short run depends on a range of factors. The allocation of labor depends on the characteristics of each sector (in terms of factor inputs and demand bundles), and the overall impacts on aggregate investment and consumption in each economy. It also depends on the sectoral composition of changes in spending and the effects of productivity growth on the real exchange rate. Rising productivity tends to attract international capital which appreciates the real exchange rate which in the short run hurts the competitiveness of trade exposed sectors. We show that the dynamic story is quite complex in the decades following a new productivity surge, but in the longer term the outcome is broadly similar to the Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008) adjustment story. This presents both a short run and long run challenge for policy makers in the Asian economies.

A number of recent papers have focused on analyzing the patterns of structural change and economic growth experiences of the major East Asian economies such as Japan and the emerging Asian economies (ADB, 2012; Buera and Kaboski, 2012; Uy et al., 2013). However, as far as we are aware, no paper has explicitly focused on investigating the short run adjustment and the long run implications of expanding service sector productivity growth on overall economic growth in Asia.

This paper proceeds as follows. Section 2 describes the data and analyzes the stylized patterns in structural change and convergence of labor productivity in the Asian economies. We also adopt the technique of shift-share analysis to investigate the role of service sector productivity growth in overall economic growth. Section 3 uses the empirical results on historical productivity experience in Asia as exogenous inputs into a large-scale intertemporal general equilibrium model of the global economy. Given this future baseline, we then explore different future scenarios of service sector productivity growth in Asia. We examine how these scenarios on productivity growth affect Asian economies individually and the spillovers within Asia and throughout the world. Section 4 provides some concluding observations.

2. Structural transformation and economic growth in Asia

In this section, we document the patterns of structural transformation, focusing on changes in the share of services in total output and employment in major Asian economies.

2.1. Data and sample

Our data are from the Groningen Growth Developing Centre (GGDC) 10-sector database, which provides annual data on value added (at both current and constant prices) and employment data from 1970 to 2005 (Timmer and de Vries, 2009). The GGDC data provides disaggregated data consisting of 10 sectors, as defined by the ISIC Revision 2. The data covers 10 Asian economies: Japan, four Asian NIEs (Republic of Korea; Taiwan; Singapore; and Hong Kong, China), ASEAN-4 (Indonesia, Malaysia, the Philippines, and Thailand), and India.

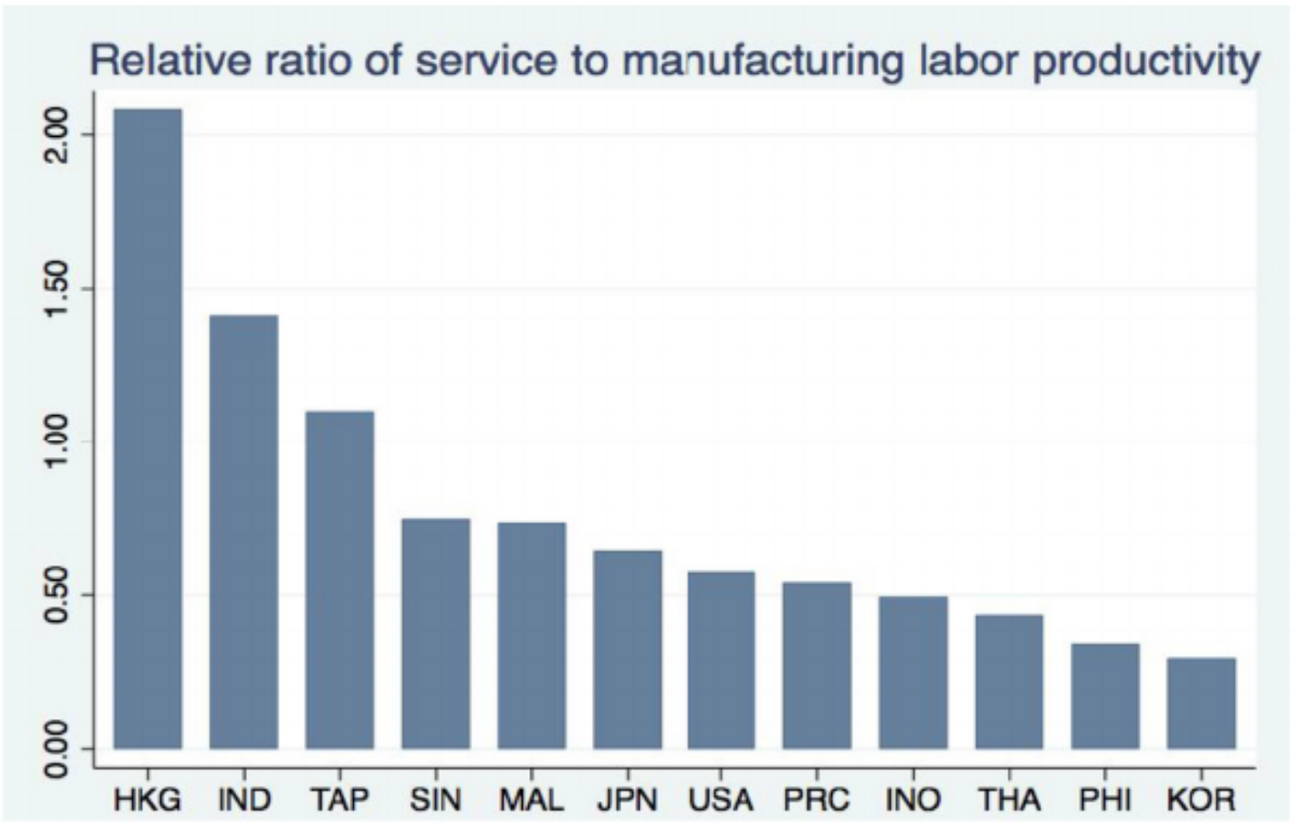


Fig. 4. Ratio of service to manufacturing labor productivity in 2005.

Table 2
Labor productivity growth (%) by sector, 1990–2005.

	PRC	HKG	INO	IND	JPN	KOR	MAL	PHI	SIN	THA	TAP	USA
Agriculture, hunting, forestry, and fishing	4.6	3.8	2.6	1.3	0.1	5.5	3.1	1.0	0.3	3.9	3.1	3.4
Manufacturing	10.7	5.9	3.3	3.8	3.7	8.1	4.1	0.9	5.5	2.6	4.4	4.5
Services	5.6	2.0	1.8	5.5	1.0	1.1	4.2	0.8	3.1	0.7	3.2	1.5
Wholesale and retail trade, and restaurants	4.0	2.3	1.0	4.6	1.1	1.8	4.0	0.4	5.1	2.5	3.9	3.2
Transport, storage, and communications	6.8	3.5	0.7	6.2	1.3	6.0	4.1	0.9	3.1	3.9	6.4	3.2
Finance, real estate, and business services	5.8	0.0	1.3	2.9	2.5	5.2	5.0	0.7	1.1	2.9	0.3	1.3
Community and government services	7.3	1.4	2.0	6.4	0.2	0.8	2.7	0.7	2.5	0.6	2.6	0.2
Others	9.6	0.7	1.3	1.3	1.0	2.3	0.7	0.2	2.0	0.1	1.3	0.2
Mining and quarrying	16.7	0.2	0.6	1.5	0.1	9.1	2.7	4.6	7.9	6.4	3.5	0.5
Electricity, gas, and water	13.8	7.9	6.5	2.8	2.0	8.3	5.3	2.9	5.0	5.9	5.3	3.7
Construction	5.5	2.0	0.3	1.2	2.1	1.0	0.4	2.0	1.7	4.8	0.2	0.7
Aggregate economy	8.4	3.2	2.7	4.1	1.4	3.8	4.0	0.9	3.6	3.0	3.9	1.8

Source: Author's computation based on Groningen Growth and Development Centre 10-Sector Database

The sample has been expanded by adding the PRC, using data compiled by McMillan and Rodrik (2011). The United States (US) is also included as the reference country, for which data is available from the GGDC 10-sector database.

The original data in aggregated into nine sectors by combining community, social, and personal services with government services. The service sector consists of four service branches: wholesale and retail trade; hotels and restaurants; transport, storage, and communications; finance, insurance, real estate, and business services; and community, social, personal, and government services.

We focus on the sample period from 1990 to 2005 because data on PRC industries are available from 1990.

2.2. Pattern of structural change

Fig. 1 summarizes changes in sectoral employment shares for the agriculture, manufacturing, and service sectors. The vertical axis is the share of employment in 1990, 1995, 2000, and 2005 in 11 major Asian economies and the US. The horizontal axis is the log of GDP per worker in 2000 international dollars. Fig. 2 summarizes the change in sectoral value added in current prices. [5]

The figures confirm the stylized patterns of structural change in the previous studies (and the survey by Herrendorf et al. (2013). Increases in GDP per capita are associated with decreases in employment and value added shares for agriculture, and increases in employment and value added shares for services. The manufacturing employment and value added shares show hump-shaped changes. [6]

It is clear, that there have been major employment shifts toward the service sector in 11 major Asian economies over the period 1990–2005. In Japan, the share of employment in the service sector increased from 57.4% in 1990 to 67.1% in 2005, while it increased more dramatically in the Republic of Korea from 46.2% to 64.4% over the same period. The employment share of the service sector in the PRC also increased steadily over the period from 19.9% to 32.6%.

The figures for the employment share and value added share of services suggest that there is an acceleration in the rate of increase of around 9.5 in the log of GDP per worker, consistent with the evidence in Buera and Kaboski (2012) and Eichengreen and Gupta (2013).

2.3. Convergence of sectoral labor productivity

We assess whether convergence in labor productivity at the aggregate economy and sectoral levels has occurred in the sample of 11 Asian economies. Labor productivity is computed by dividing real value added by the number of all employed persons. For the purpose of comparability, we use the real valued added at 2000 purchasing power parity (PPP) prices. Fig. 3 shows the changes in average labor productivity levels for the aggregate economy over the period 1990–2005. The figure shows a broad pattern of convergence in labor productivity levels for the aggregate economy. There is tendency of convergence at the sectoral level for the manufacturing and service sectors. [7] But, there are some outlier economies which have not shown a clear convergence. For example, India and Indonesia have not experienced convergence in aggregate output per worker. Japan and Hong Kong, China are clear outliers in the agriculture sector. In the service sector, the Republic of Korea is an outlier. By contrast, India has made rapidly caught up in service labor productivity, while it has not been converging in labor productivity in manufacturing.

Despite significant convergence of sectoral labor productivity over time, there remain significant differences in sectoral labor productivity. The productivity gap between sectors within an economy is also very diverse. Table 1 shows the ratio of each sector's labor productivity to manufacturing labor productivity in 2005. In Hong Kong, China; India; and Taiwan labor productivity in the service sectors is higher than that for manufacturing, while it is far lower than manufacturing labor productivity in the Republic of Korea, the Philippines, and Thailand (Fig. 4).

Within the service sector, for most economies, the levels of labor productivity across service branches are quite diverse. In general, labor productivity is relatively high in the transport, storage, and communications; and the finance, insurance, real estate, and business services branches (see Table 1).

2.4. Patterns of structural change and economic growth

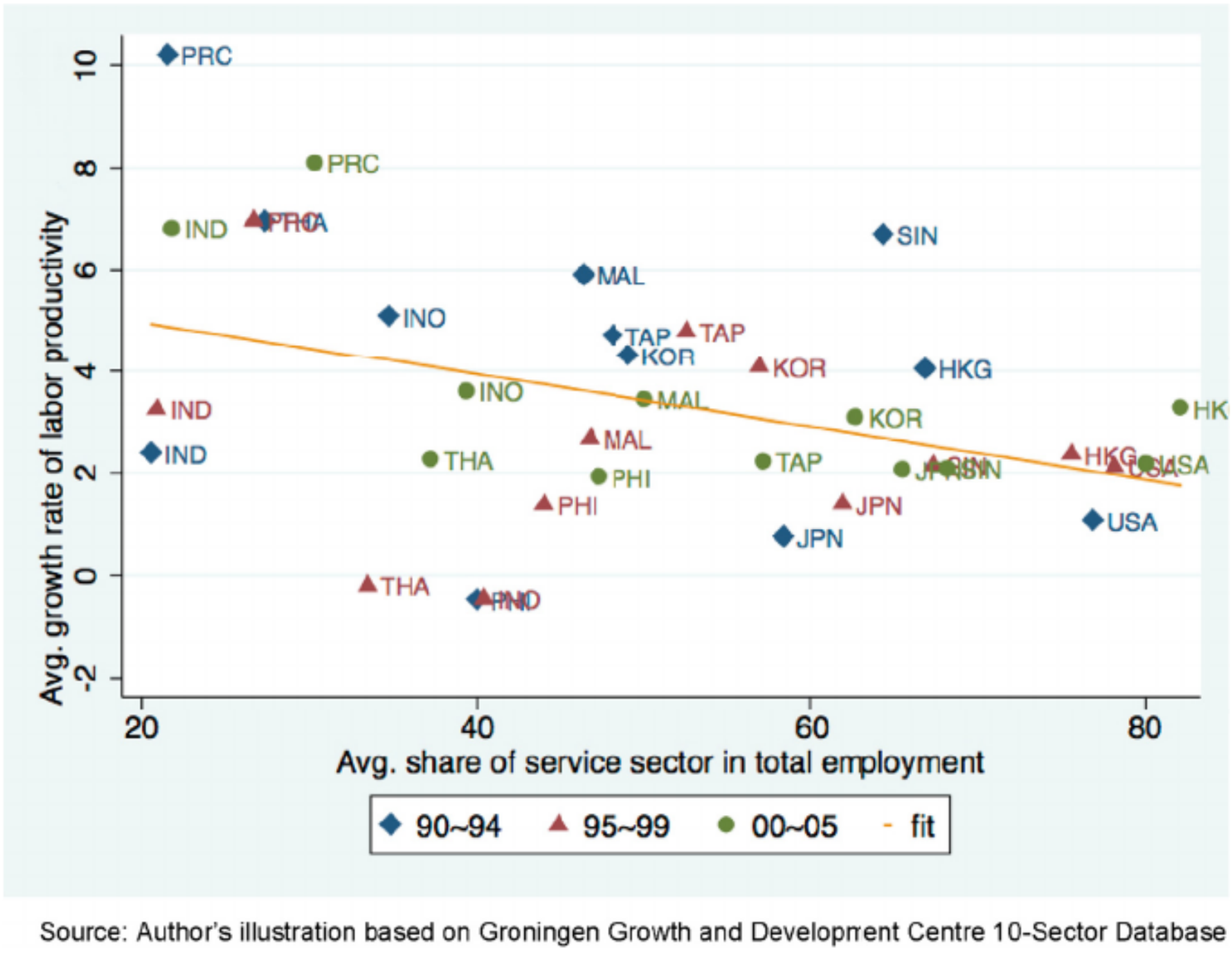
Broadly speaking, the low labor productivity of the service sector relative to the manufacturing sector tends to hamper overall productivity growth. Table 2 shows labor productivity growth by sector for the overall period, 1990–2005. Labor productivity growth of the service sector for the 1990–2005 period was relatively low compared to that of the manufacturing sector for most of the major Asian economies.

Fig. 5 shows the relationship between the share of service sector employment and aggregate labor productivity growth over the three sub-

[5] The patterns are similar for the value added shares with real values.

[6] We test "convergence" in labor productivity at the aggregate economy and sectoral levels using panel data for 11 Asian economies. The estimation results from panel estimation with economy fixed effects support "convergence" across the aggregate economy, and manufacturing and service sectors. No convergence occurs in agricultural labor productivity of Asian economies. The results can be provided upon request.

[7] Some studies also find higher growth rates of total factor productivity (TFP) for the service sector as compared to the manufacturing sector. For example, Rath (2018) shows TFP growth was higher for service-based firms than manufacturing firms for the period 2008 to 2014.



Source: Author's illustration based on Groningen Growth and Development Centre 10-Sector Database

Fig. 5. Service sector employment and aggregate labor productivity growth for 11 Asian economies and the United States.

periods, 1990–1995, 1995–2000, and 2000–2005. Aggregate evidence from 11 Asian economies and the US shows that there is negative relationship between the overall labor productivity growth rate of the economy and the employment share of the service sector in terms of employment. This affirms the relatively low productivity growth in the service sector.

Nevertheless, "tertiarization" is not necessarily an obstacle to overall labor productivity growth in an economy. In India and Malaysia, for example, labor productivity for services grew faster than for manufacturing.[8]

Table 2 shows labor productivity growth by four service branches. The transport, storage, and communications branch has experienced labor productivity growth rates similar to, or even higher, than those of the manufacturing sector in most of the 11 Asian economies (and the US). Here, Indonesia is one notable exception in that labor productivity growth in the transport, storage, and communications branch was even lower than the average growth rate in the service sector. Note that this analysis does not take into account the indirect effects of these services activities on productivity in other sectors.

Other service activities also show dynamic productivity growth in a number of economies. For example, wholesale and retail trade, and the hotel and restaurant service branches in India and Singapore experienced very high labor productivity growth. In Japan and Malaysia, the finance, insurance, real estate, and business services had high labor productivity growth. In contrast, in Indonesia, the Republic of Korea, and Thailand, the finance, insurance, real estate, and business services sectors showed negative labor productivity growth rates. This reflects the impacts of the Asian financial crisis in 1997–1998.

2.5. *Shift-share analysis*

In this section we adopt the technique of "shift-share" analysis to examine empirically the impact of tertiarization on aggregate productivity growth. Shift-share analysis shows how aggregate labor productivity growth is linked to differential growth of labor productivity in individual sectors and the reallocation of labor between sectors.

It uses an accounting technique to decompose aggregate labor productivity growth over a period of time into a "within effect" (labor productivity growth within each industry), and a "shift effect" or "structural change effect" (labor productivity growth due to employment shifts toward more productive industries).

Recent papers such as Maudos et al. (2008), Maroto-S anchez and Cuadrado-Roura (2009), Timmer and de Vries (2009), McMillan and Rodrik (2011), and de Vries et al. (2012) have used shift-share analysis to examine the impact of structural change on economic growth.

We adopt the same technique to analyze the role of tertiarization for aggregate labor productivity growth in the Asian economies.

$$y^T \quad y^0 \qquad \underset{K\,J}{} \qquad y_i^T \quad y_i^0 \; s_i^0 \qquad \underset{K\,J}{} \qquad s_i^T \quad s_i^0 \; y_i^T$$

The equation shows that the overall growth of labor productivity in an economy over period [0, T] is divided into two components. The first is the contribution from labor productivity growth within individual sectors weighted by the share of employment in each sector ("within effect"). The second is the contribution from labor reallocation across different sectors ("structural change effect"). The second term is the change of employment shares multiplied by productivity levels at the end of the time period across sectors.[9]

The contribution of each sector to the structural change effect can be either positive or negative, depending on whether a sector is expanding or shrinking. When the contributions from individual sectors are

[8] The structural change term is again divided into two components: the change of employment shares multiplied by productivity levels at the beginning end of the time period ("static structural change") and the interaction between the change in employment shares and the productivity growth in individual sectors ("dynamic structural change").

[9] These issues include: German unification in the early 1990s; fiscal consolidation in Europe in the mid-1990s; the formation of the North American Free Trade Agreement (NAFTA); the Asian crisis; and the productivity boom in the US.

Table 3
Decomposition of labor productivity growth over 1990–2005.

Economy	Sector	Total	Within	Structural Change
People's Republic of China	All economy	8.42	7.46	0.95
	Manufacturing	3.04	3.21	0.17
	Services	3.46	1.8	1.66
Hong Kong, China	All economy	3.22	1.99	1.23
	Manufacturing	0.2	0.7	0.91
	Services	3.43	1.14	2.28
Indonesia	All economy	2.74	1.7	1.04
	Manufacturing	1.1	0.76	0.33
	Services	1.23	0.46	0.77
India	All economy	4.14	3.17	0.97
	Manufacturing	0.8	0.63	0.17
	Services	2.68	2.05	0.62
Japan	All economy	1.4	1.41	0.01
	Manufacturing	0.38	1.08	0.71
	Services	1.23	0.46	0.77
Republic of Korea	All economy	3.82	5.19	1.37
	Manufacturing	2.07	3.69	1.62
	Services	1.41	0.51	0.9
Malaysia	All economy	4	3.52	0.48
	Manufacturing	1.43	1.05	0.39
	Services	2.31	1.6	0.72
Philippines	All economy	0.94	0.81	0.14
	Manufacturing	0.15	0.24	0.09
	Services	0.79	0.23	0.56
Singapore	All economy	3.64	3.72	0.08
	Manufacturing	1	1.8	0.81
	Services	2.53	1.75	0.78
Thailand	All economy	3.01	1.36	1.64
	Manufacturing	1.74	0.72	1.01
	Services	0.97	0.11	1.07
Taiwan	All economy	3.91	3.38	0.53
	Manufacturing	0.99	1.4	0.42
	Services	2.92	1.7	1.22
United States	All economy	1.78	2.07	0.29
	Manufacturing	0.34	0.93	0.59
	Services	1.42	1.01	0.42

Source: Author's estimates ’

aggregated, the structural change term becomes negative, lowering economy-wide productivity growth, if the labor displaced from high-productivity growth sectors moves to low-productivity growth sectors.

Table 3 presents the results of the shift-share analysis using data from 1990 to 2005, constructed from the data of nine sectors for the major Asian economies and the US. The results show that the within effect dominates the effects of structural changes in most of the Asian economies. Nevertheless, structural change has a made significant contribution to the overall growth of labor productivity in several Asian economies including Hong Kong, China; Indonesia; and Thailand. McMillan and Rodrik (2011) argue that Asia is outstanding not so much in productivity growth within individual sectors, but in the broad pattern of structural change. But, clearly the strong labor productivity growth in individual industries has been a salient feature of Asian economic growth, while structural change has also contributed positively to labor productivity growth in many Asian economies.

Table 3 demonstrates the importance of the service sector in structural change and aggregate productivity growth. In the industrialized Asian economies, including Hong Kong, China; Japan; the Republic of Korea; Singapore; and Taiwan; the structural change effect of the manufacturing sector was negative because they experienced shifts of employment from manufacturing to the service sectors. Nevertheless, because the service sector contributed positively to the overall structural change effect due to the increase in service sector employment, the overall structural change effect became either small or positive.

For the latecomers, including the PRC, India, Indonesia, Malaysia, and Thailand, both the manufacturing and service sectors contributed positively to aggregate growth in terms of the structural change effect because these economies experienced increases in employment in both the manufacturing and service sectors during the period.

For some economies, the service sector dominates the manufacturing sector in terms of contribution to aggregate labor productivity growth due to the strong positive within and structural change effects of the service sector. In Hong Kong, China; India; Malaysia; and Taiwan; the service sector contributed more to the overall within effect aggregate growth than the manufacturing sector. In these economies, the strong positive within and structural change effects of the service sector contributed significantly to aggregate productivity growth.

3. Scenarios for the effects of service sector productivity growth

Based on the initial conditions and the analysis of the historical experience above, this section investigates the effects of future changes in service sector productivity growth on structural change and economic growth in Asian economies. The empirical results in the previous sections show that service sector productivity growth can be a potential engine of economic growth in Asian economies. However, faster productivity growth in the service sector can have significant spillovers to other sectors through inter-industry input–output linkages, factor movements, and consumption and investment dynamics. It can also have spillovers across the border through trade and financial linkages.

The complete analysis requires an empirically based global intertemporal multi-sector general equilibrium model (a large scale DSGE model). We adopt a model, called the G-Cubed model, to explore what happens if labor productivity rises in the service sector in individual Asian economies and then across all Asian economies at the same time.

3.1. The model

The model used in this paper is the G-Cubed model, which is an intertemporal general equilibrium model of the world economy. The theoretical structure is outlined in McKibbin and Wilcoxen (2013) and more details specific to the version used in this paper can be found in the Appendix of Lee and McKibbin (2014) and in online supplementary material to this article. A number of studies, summarized in McKibbin and Vines (2000) and McKibbin and Stoeckel (2018), show that the G-Cubed modeling approach has been useful in assessing a range of issues across a number of economies since the mid-1980s. [10] Some of the principal features of the model are as follows.

The model is based on explicit intertemporal optimization by the agents (consumers and firms) in each economy. In contrast to static CGE models, time and dynamics are of fundamental importance in the G-Cubed model. The G-Cubed model is known as a DSGE (dynamic stochastic general equilibrium) model in the macroeconomics literature and as an intertemporal general equilibrium (IGE) model in the computable general equilibrium literature. The main difference from the small-scale DSGE models now popular at central banks is the large amount of sectoral disaggregation and considerable degree of economy disaggregation.

[10] Once the level of overall consumption has been determined, spending is allocated among goods and services according to a two-tier constant elasticity of substitution (CES) utility function. See the Appendix for details of aggregate consumption as well as the demand equations for sectoral goods by the households.

Table 4
Economies and regions in the G-Cubed model.

United States	
Japan	People's Republic of China
United Kingdom	India
Germany	Indonesia
Rest of eurozone	Rest of Asia
Canada	Latin America
Australia	Other emerging economies
Republic of Korea	Eastern Europe the former Soviet Union
Rest of OECD	Middle East and oil-exporting economies

Source: McKibbin and Wilcoxen (2013).

The behavior of agents is modified to allow for short-run deviations from optimal behavior either due to myopia or to restrictions on the ability of households and firms to borrow at the risk-free bond rate on government debt. This improves the tracking performance of the model. Thus, aggregate consumption is a weighted average of consumption based on wealth (current asset valuation and expected future after-tax labor income) and consumption based on current disposable income. [11] Similarly, aggregate investment is a weighted average of investment based on Tobin's Q (a market valuation of the expected future change in the marginal product of capital relative to the cost) and investment based on a backward looking version of Q. In the model software, it is possible to change the information set of forward-looking agents after a scenario begins to unfold.

The model allows for short-run nominal wage rigidity (by different degrees in different economies) and, therefore, allows for significant periods of unemployment depending on the labor market institutions in each economy. Equilibrium between aggregate demand and aggregate output is maintained by flexible prices, which causes demand to adjust together with short term supply. There is explicit treatment of the holding of financial assets, including money. Money is introduced into the model through a restriction that households require money to purchase goods.

Global accounting identities are imposed on the model so, for example, for every borrower there is a lender, thereby avoiding the fallacy of composition. Likewise, the model gives a careful treatment of stock-flow relations, such as the accumulation of current account deficits into foreign claims on domestic output, which has to be serviced by future trade surpluses. On the fiscal side, which is the focus of this study, the accumulation of fiscal deficits into government debt has to be serviced from future revenues—though it does not have to be completely paid off.

The model distinguishes between the stickiness of physical capital within sectors and within economies, and the flexibility of financial capital, which immediately flows to where expected returns are highest. This important distinction leads to a critical difference between the quantity of physical capital that is available at any time to produce goods and services, and the valuation of that capital as a result of decisions about the allocation of financial capital.

As a result of this structure, the G-Cubed model contains rich dynamic behavior, driven on the one hand by asset accumulation, and by wage adjustment to a neoclassical steady state on the other. It embodies a wide range of assumptions about individual behavior and empirical regularities in a general equilibrium framework. The interdependencies are solved out using a computer algorithm that solves for the rational expectations equilibrium of the global economy.

In the version of the model used here there are 17 economies and regions as set out in Table 4. For Asia, Japan, the Republic of Korea, the PRC, India, and Indonesia are included as individual economies and the other economies are included as the rest of Asia. Each economy has six

[11] This does not require that both sectors purchase the same amount of energy, or even that they purchase energy at all; only that they both feel the same way about the origins of the energy they buy.

Table 5
Sectors of production in each economy.

Energy	Durable manufacturing
Mining	Non-durable manufacturing
Agriculture	Services

Source: McKibbin and Wilcoxen (2013).

sectors (energy, mining, agriculture, manufacturing durables, manufacturing non-durables, and services) as well as a generic capital-producing sector in each economy that draws largely on the durable manufacturing sector for inputs (Table 5).

In this model, each of the six sectors is represented by a price-taking firm, which chooses variable inputs and its level of investment in order to maximize its stock market value. Each firm's production technology is represented by a tier-structured constant elasticity of substitution (CES) function. At the top tier, output is a function of capital, labor, energy, and materials:

$$)^{\frac{1}{}} \quad \frac{}{}^{1}\Big)^{\frac{}{1}}$$

where Q_i is the output of industry I, X_{ij} is industry i's use of input j, and A_i^O, $_{ij}^{O}$, and $_i^O$ are parameters. A_i^O reflects the level of technology, $_i^O$ is the elasticity of substitution, and the $_{ij}^{O}$ parameters reflect the weights of different inputs in production; the superscript o indicates that the parameters apply to the top, or "output", tier. Without loss of generality, we constrain the s to sum to 1.

At the second tier, inputs of energy and materials, X_i^E and X_i^M, are themselves CES aggregates of goods and services. Energy is a single good 1 and materials are an aggregate of goods 2 through 6 (mining through services). The functional form used for these tiers is identical to 0 except that the parameters of the energy tier are A_i^E, $_{ij}^{E}$, and $_i^E$, and those of the

Table 6
Effects of rise in labor productivity in the service sector on GDP and investment (%).

		Real GDP			Investment		
		2014	2020	2040	2014	2020	2040
Japan	Asia wide	1.24	5.32	12.78	18.87	40.45	54.06
	Own	1.05	4.98	12.27	16.57	38.56	52.24
Republic of Korea	Asia wide	0.30	3.23	7.82	5.00	15.16	17.01
	Own	0.11	2.67	6.87	3.57	13.28	15.35
People's Republic of China	Asia wide	0.02	0.91	2.24	0.97	3.01	3.90
	Own	0.00	0.83	1.96	0.87	2.75	3.48
India	Asia wide	0.19	0.89	2.37	0.20	3.44	3.95
	Own	0.07	1.09	2.42	0.73	3.81	4.02
Indonesia	Asia wide	0.07	1.30	3.77	0.92	6.02	7.15
	Own	0.10	1.18	3.50	0.72	5.54	6.81
Other Asia	Asia wide	0.35	1.22	5.17	0.35	8.04	12.16
	Own	0.29	1.19	4.69	0.18	7.53	11.05
United States	Asia wide	0.21	0.12	0.04	1.95	0.80	0.09
Australia	Asia wide	0.01	0.08	0.22	0.19	0.49	0.55
Rest of Eurozone	Asia wide	0.15	0.19	0.01	1.32	1.05	0.28
Germany	Asia wide	0.03	0.04	0.15	0.42	0.70	0.17

GDP gross domestic product.
Source: Author's estimates.

Table 7
Effects of rise in labor productivity in the service sector on consumption and trade balance (%).

		Consumption			Trade Balance		
		2014	2020	2040	2014	2020	2040
Japan	Asia wide	0.53	1.52	5.14	1.61	1.81	1.32
	Own	0.36	1.14	4.52	1.36	1.68	1.25
Republic of Korea	Asia wide	0.41	1.13	3.45	0.42	0.62	0.29
	Own	0.69	1.42	2.63	0.10	0.55	0.38
People's Republic of China	Asia wide	0.44	0.85	1.71	0.18	0.16	0.02
	Own	0.47	0.77	1.37	0.09	0.16	0.07
India	Asia wide	0.77	1.05	1.12	0.20	0.07	0.00
	Own	0.54	0.60	1.26	0.08	0.07	0.09
Indonesia	Asia wide	0.31	0.70	2.09	0.01	0.02	0.20
	Own	0.40	0.61	1.90	0.08	0.06	0.06
Other Asia	Asia wide	0.98	2.29	0.83	0.43	0.24	0.29
	Own	1.06	2.17	0.38	0.50	0.21	0.24
United States	Asia wide	0.22	0.31	0.09	0.19	0.20	0.15
Australia	Asia wide	0.03	0.11	0.02	0.04	0.08	0.14
Rest of Eurozone	Asia wide	0.28	0.43	0.13	0.21	0.23	0.17
Germany	Asia wide	0.11	0.25	0.07	0.11	0.22	0.14

Source: Author's estimates.

materials tier are A_i^M, $_{ij}^{M}$, and $_{i}^{M}$.

The goods and services purchased by firms are, in turn, aggregates of imported and domestic commodities which are taken to be imperfect substitutes. We assume that all agents in the economy have identical preferences over foreign and domestic varieties of each commodity. We represent these preferences by defining 12 composite commodities that are produced from imported and domestic goods. Each of these commodities, Y_i, is a CES function of inputs domestic output, Q_i, and imported goods, M_i. For example, the mining products purchased by agents in the model are a composite of imported and domestic mining. By constraining all agents in the model to have the same preferences over the origin of goods, we require that, for example, the agricultural and service sectors have identical preferences over domestic energy and energy imported from the Middle East.[12] This accords with the input–output data we use and allows a very convenient nesting of production, investment, and consumption decisions.

In each sector the capital stock changes according to the rate of fixed capital formation (J_i) and the rate of geometric depreciation ($_i$):

We assume that the investment process is subject to rising marginal costs of installation. To formalize this we adopt Uzawa's approach by assuming that in order to install J units of capital a firm must buy a larger quantity, I, that depends on its rate of investment (J/K):

$$1 \quad \frac{}{2} \; —$$

where is a non-negative parameter. The difference between J and I may be interpreted various ways; we will view it as installation services provided by the capital-goods vendor.

The goal of each firm is to choose its investment and inputs of labor, materials and energy to maximize intertemporal risk-adjusted net-of-tax profits. Solving the top tier optimization problem gives the firm's factor demands for labor, energy, and materials, and the optimal evolution of the capital stock (see the Appendix).

G-Cubed's parameters are estimated from a consistent time series of input–output tables for the United States. The procedure is described in detail in McKibbin and Wilcoxen (1999). The dataset that was constructed allowed the estimation of the model's parameters for the United States. The elasticity of substitution by sector and by level of nesting is estimated using the US data and this is applied to all economies. The delta share parameters are calibrated using economy-specific input output data from GTAP.[13]

A3 in the supplemental Appendix present the values of the elasticities of substitution $_{i}^{O}$, $_{i}^{E}$, $_{i}^{M}$, and the $_{ij}^{O}$, $_{ij}^{E}$, and $_{ij}^{M}$ parameters that appear on the production side of the model (as well as the substitution between domestic and foreign goods and between economy of origin of foreign goods). The sigmas are common across economies in the same sectors but the deltas are calculated from the economy-specific input/output tables for each economy. The factor shares will be important in the results below.

The model is solved from 2014 to 2100 using the initial conditions on productivity levels and the historical rate of catchup from the first part of this paper, as well as projections of population growth from the United Nations. These changes in the drivers of trend growth are combined with assumptions about monetary and fiscal policies to generate a consistent "baseline" of the global economy. We then use this baseline projection to undertake a range of alternative scenarios about productivity growth implemented as unanticipated deviations from this baseline.

3.2. Simulation results

In generating the baseline, we assume initial conditions on productivity levels and continuation of existing rates of catch-up. The way in which we calculate productivity growth in the manufacturing and service sectors is quite mechanical in the baseline. We use data on the initial levels of productivity for each sector in each country and assume the gap to the frontier (which is assumed to be the US sector) closes based on historical catchup rates. In this section we explore the impact of exogenously changing the rate of productivity growth. The productivity growth of an economy depends critically on favorable economic environmental and policy factors, such as a high investment rate, strong human capital, high trade openness, and good-quality institutions. These fundamental growth factors must be essential to improving the productivity both in manufacturing and services sectors. However, it is typically more difficult to improve productivity in the service sector than in the manufacturing sector. In many emerging economies, service sector firms are too small and spend less for research and development. They are less exposed to international competition than manufacturing counterparts and get smaller benefits from technological diffusion from advanced economies. Hence, specific policies should be designed to target faster productivity growth in the service sector, especially in highly productive

[12] See the GTAP database in Narayanan, G., Badri, Angel Aguiar, and Robert McDougall, eds. 2012.

[13] The reason for the particular time path is to ensure the long-run steady state of the model is preserved and to enable a long period of more rapid growth in service sector productivity until around 2050.

Table 8
Sectoral output change for Asia-wide labor productivity shocks (%).

		Services Productivity Shock				Manufacturing Productivity Shock	
		2014	2020	2030	2040	2014	2040
Japan	Agriculture	1.06	4.19	6.20	7.48	0.43	3.46
	Man – durable	1.04	10.52	14.72	21.86	0.43	13.81
	Man – non-durable	0.54	0.67	2.11	2.96	0.12	5.93
	Service	0.19	5.22	10.70	15.95	0.02	1.51
Republic of Korea	Agriculture	0.43	0.72	3.25	4.38	0.02	3.11
	Man – durable	0.48	6.51	8.40	10.71	0.32	7.82
	Man – non-durable	0.64	0.49	2.80	3.92	0.02	4.86
	Service	0.00	3.78	9.07	12.18	0.05	1.84
People's Republic of China	Agriculture	0.13	0.50	1.33	1.71	0.07	1.50
	Man – durable	0.21	2.16	2.71	3.35	0.21	3.75
	Man – non-durable	0.21	0.53	1.53	2.04	0.03	2.72
	Service	0.01	1.53	3.23	4.34	0.04	1.80
India	Agriculture	0.41	0.42	0.72	0.84	0.13	0.55
	Man – durable	0.19	2.94	3.45	3.80	0.14	2.36
	Man – non-durable	0.32	0.12	1.28	1.63	0.00	2.16
	Service	0.03	1.80	3.74	4.66	0.05	1.03
Indonesia	Agriculture	0.28	0.19	1.41	1.63	0.09	1.20
	Man – durable	0.44	4.59	5.70	6.50	0.30	4.54
	Man – non-durable	0.31	0.29	1.70	2.27	0.00	3.34
	Service	0.03	2.03	4.99	6.96	0.04	1.58

Man manufacturing.
Source: Author's estimates.

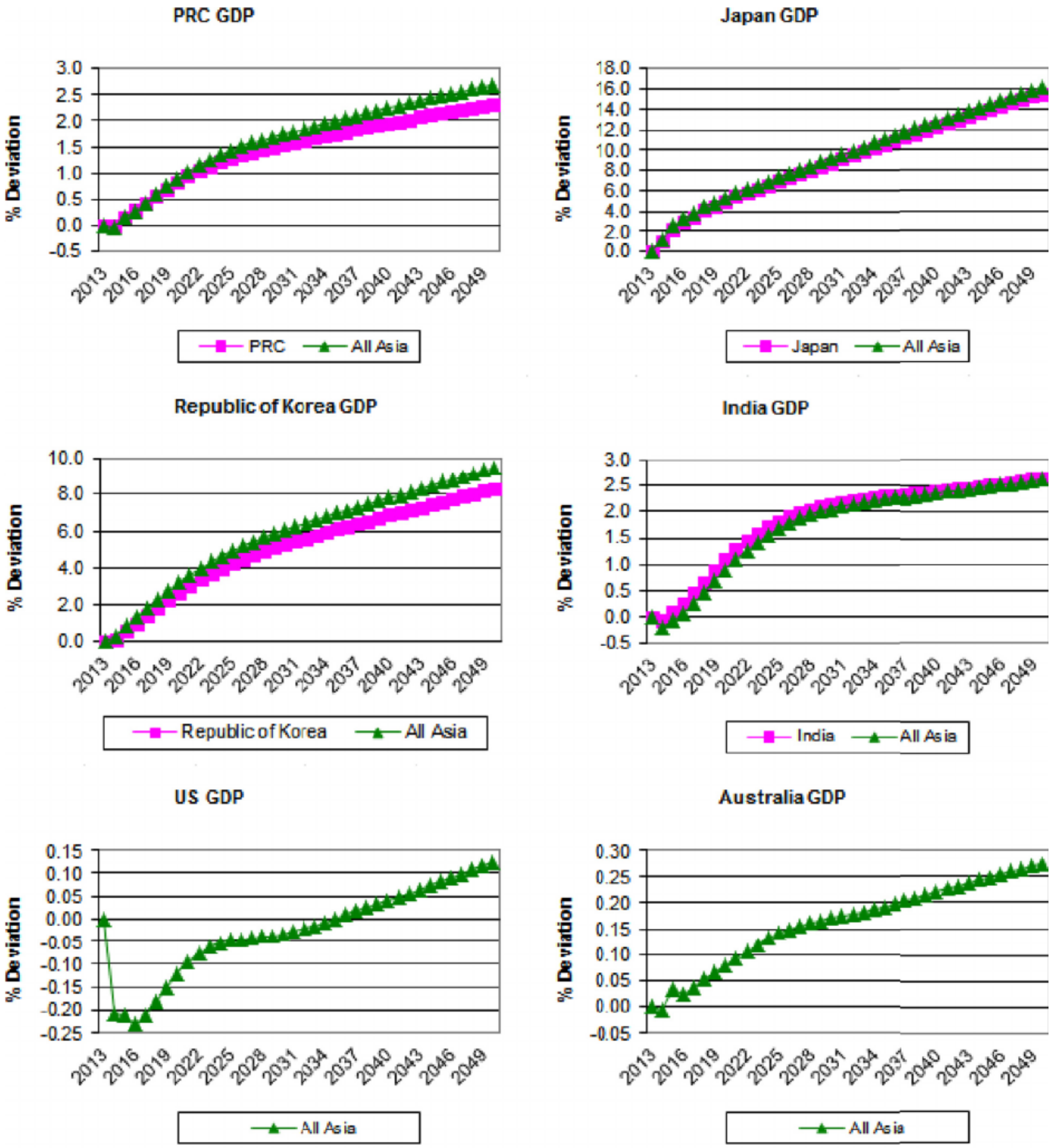
modern service industries. ADB (2012) shows that service sector growth tends to be higher when the level of service trade is higher, the share of urban population is larger and the age-dependence ratio is lower. It also points out that lack of human capital and restrictive regulations are major bottlenecks for developing a modern service sector. Eichengreen and Gupta (2013) find the second wave of service sector growth is most apparent in countries that are open to trade, democratic, and relatively close to the major global financial centers. The increasing practice of global product fragmentation and service off-shoring can also enhance the productivity of actively participating economies by stimulating resource reallocation, specialization and technology transfer, particularly in the services sector (Kang et al., 2010; Bournakis et al., 2018). While there are many interesting questions on the determinants of service sector productivity growth, we are taking the rise in productivity as exogenous and exploring the implications if this could be achieved.

We consider three main scenarios in this section. One is where all Asian economies (PRC, India, Indonesia, Japan, Republic of Korea, and the rest of Asia) experience a rise in labor productivity growth of 1 percentage point per year (relative to the underlying trends in the baseline). This would be a challenge for economies such as India; Malaysia; and Taiwan; which have already had relatively high service sector productivity growth (see Table 2). In contrast, for Japan and the Republic of Korea, which have low service sector productivity growth, there could be more potential to generate such productivity gains by moving toward high-value modern services, such as information and communications technology, finance, and professional business services. We assume the productivity shock occurs in 2014 and then persists until 2053, after which the shock in the growth rate of labor productivity

Table 9
Sectoral output change for Asia wide labor productivity shocks (%).

		Services Productivity Shock				Manufacturing Productivity Shock	
		2014	2020	2030	2040	2014	2040
Japan	Agriculture	0.97	0.28	2.01	3.30	0.20	0.76
	Man – durable	0.29	9.59	13.80	21.49	0.51	2.64
	Man – non-durable	3.23	4.04	6.85	9.70	0.88	2.56
	Service	0.87	0.86	3.52	6.17	0.09	0.51
Republic of Korea	Agriculture	1.76	1.12	2.13	3.76	0.55	2.40
	Man – durable	0.51	7.75	10.12	12.98	0.35	3.22
	Man – non-durable	1.83	1.25	1.34	1.77	0.71	1.74
	Service	1.09	2.54	5.49	9.76	0.16	1.39
People's Republic of China	Agriculture	0.29	0.20	0.48	0.69	0.21	0.02
	Man – durable	0.29	2.71	3.85	5.54	0.13	3.10
	Man – non-durable	0.43	0.17	0.59	1.01	0.28	0.19
	Service	0.44	1.23	2.57	4.11	0.09	2.10
India	Agriculture	0.75	0.37	0.22	0.24	0.26	0.41
	Man – durable	0.38	3.59	4.43	5.53	0.24	3.51
	Man – non-durable	0.42	0.11	0.56	0.87	0.17	0.50
	Service	0.55	1.22	2.13	3.33	0.07	1.28
Indonesia	Agriculture	0.68	0.20	0.48	0.74	0.29	1.19
	Man – durable	0.57	4.98	6.15	7.42	0.01	0.96
	Man – non-durable	0.66	0.18	0.16	0.25	0.33	1.28
	Service	0.56	1.07	2.04	3.26	0.09	1.14

Man manufacturing.
Source: Author's estimates.



GDP = gross domestic product, PRC = People's Republic of China, US = United States.

Source: Illustrations based on Author's estimates.

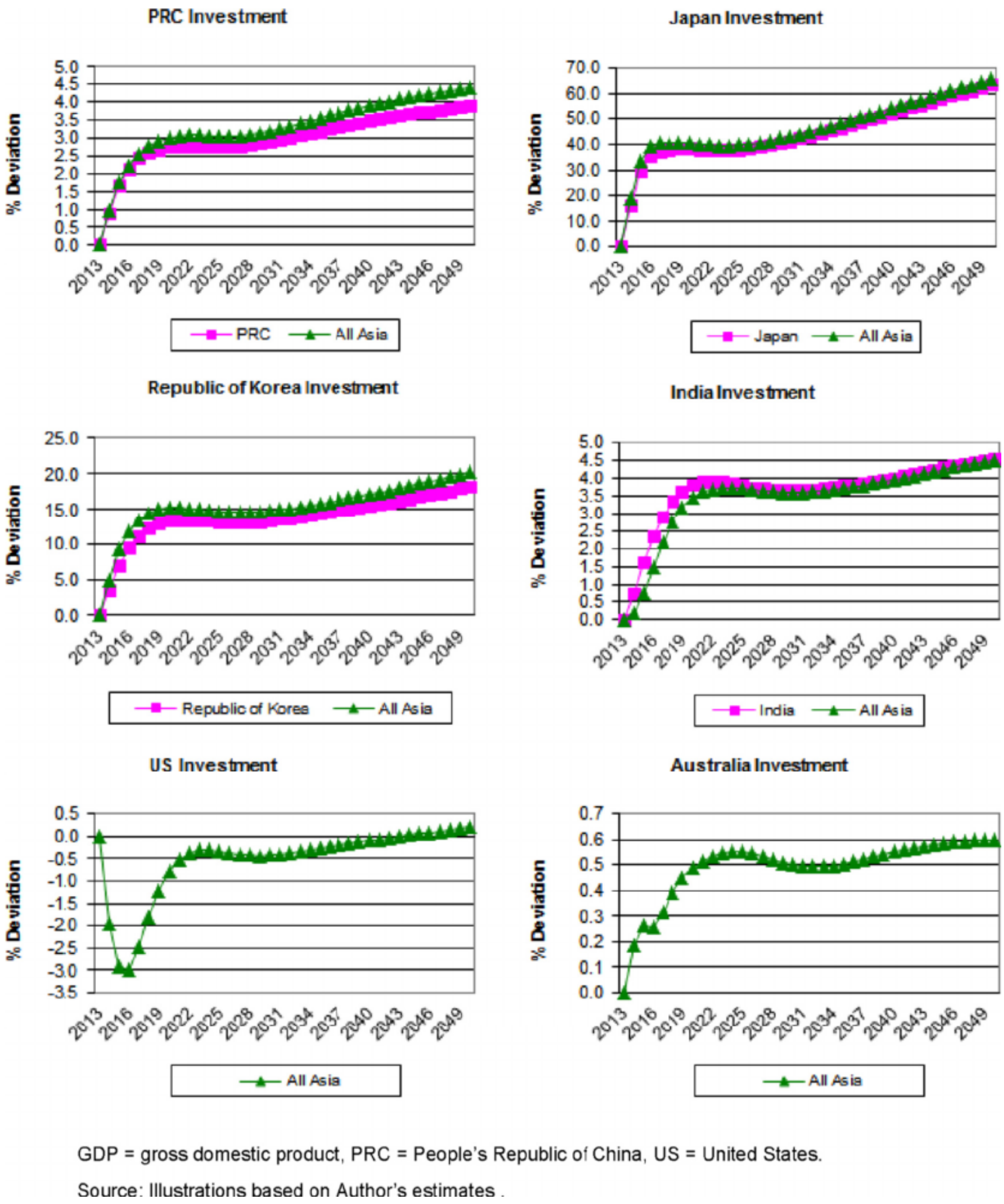
Fig. 6. GDP effects of a services productivity shock.

growth rate decays by 4% per year until returning to baseline in 2100. [14] We then compare the case where all Asian economies successfully raise productivity growth in services to the case where each economy in Asia experiences productivity growth of the same magnitude, but each individually. For the non-Asian results, we only explore the spillovers from the aggregate Asian growth experience.

[14] The elasticity of substitution in this function is the Armington elasticity.

Here, we consider the productivity shock only in the service sector. As a comparison, we also present results at the sectoral level from the third simulation, which assumes the same labor productivity shock across Asian economies, but applied to manufacturing sectors (both durable and non-durable goods) rather than services.

The results are presented in Tables 6–9. Each table shows the deviation from the baseline of a range of variables at different points into the future. In Tables 6 and 7, GDP, consumption, and investment are expressed as percentage deviations from the baseline. The trade balance



GDP = gross domestic product, PRC = People's Republic of China, US = United States.

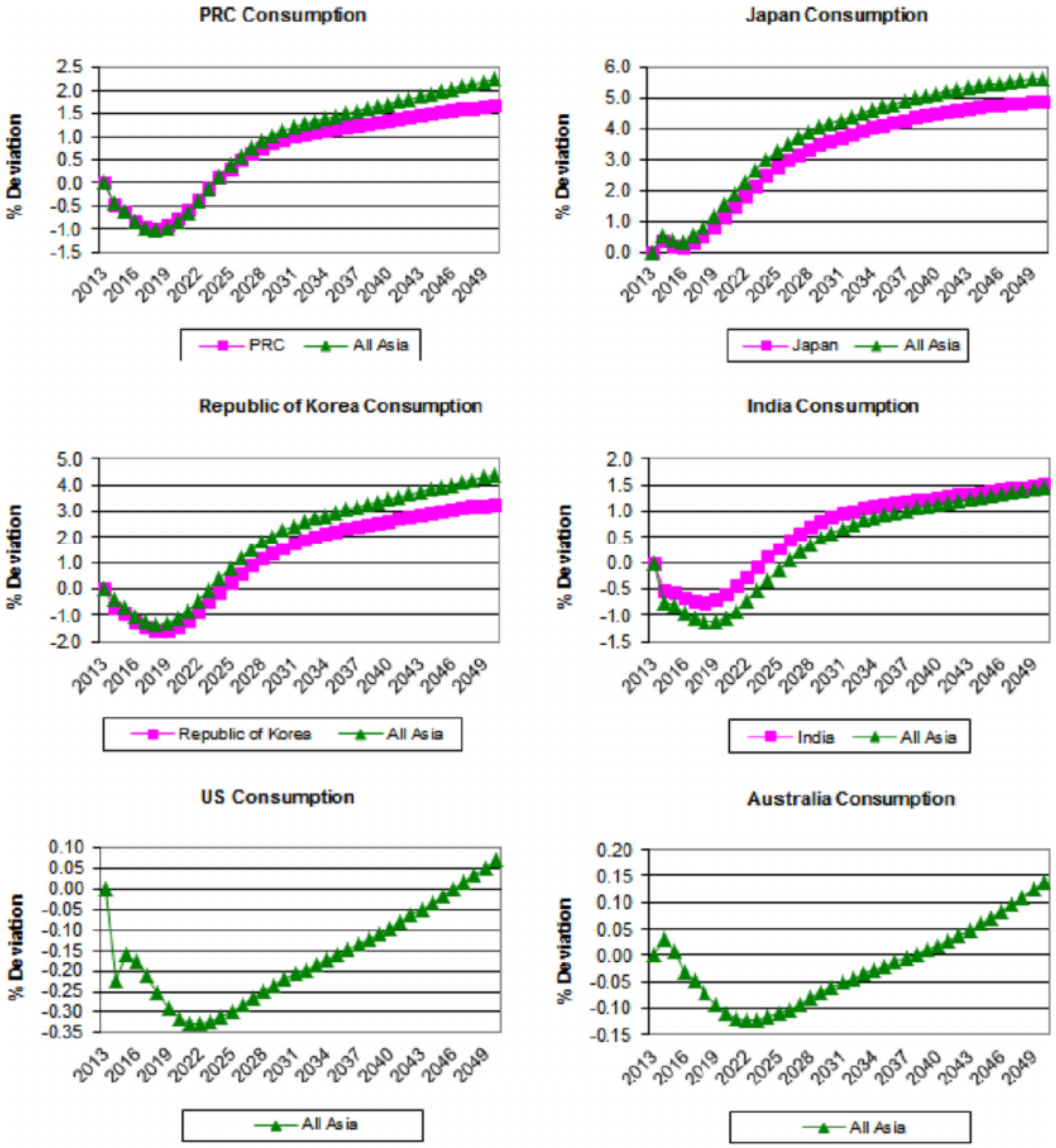
Source: Illustrations based on Author's estimates .

Fig. 7. Investment effects of a services productivity shock.

is percent of baseline GDP deviation from the baseline. Table 8 contains results for the percentage deviation in sectoral output by economy over time. Table 9 shows the results for the sectoral percentage deviation from the baseline in employment by sector over time. These results are also presented in a series of graphs in Figs. 6–9.

At the macro level in Tables 6 and 8 (and Figs. 6–8), the results are clear. Once the surprise rise in labor productivity of the service sector occurs, there is a reallocation of inputs within each economy. Higher productivity in one sector eventually raises GDP across the economy, although the presence of adjustment costs implies that initially GDP can fall as inputs are reallocated. Own productivity growth overwhelmingly benefits the economy experiencing the productivity surge. The magnitude of GDP increase depends on the size of the service sector in the economy and its linkages to other sectors, especially manufacturing sectors. In an individual economy, higher labor productivity raises the return to capital in the service sector. This induces an increase in investment in that sector. It also causes an increase in demand and therefore output in all sectors that feed into that sector (see Table 8 and Fig. 9). In the model, investment goods are produced by a capital-producing sector that draws largely on the output of the durable manufacturing sector so the demand for durable manufacturing goods rises as part of the investment boom. This is true for the domestically produced goods as well as for imports. In all economies that experience the productivity increase, investment rises (Table 8). The strong rise in investment requires physical goods to build the capital stock. These inputs are mostly provided by the durable manufacturing sector. This explains why the positive spillovers from service sector growth is initially stronger into the durable manufacturing sector, because investment is front loaded (although smoothed over time to minimize adjustment costs).

Over time all economies benefit from service sector productivity



GDP = gross domestic product, PRC = People's Republic of China, US = United States.

Source: Illustrations based on Author's estimates.

Fig. 8. Consumption effects of a services productivity shock.

growth in another economy through the increase in national wealth, which is spread globally. The extent of the gain depends on the linkage between economies outside of Asia and the economies experiencing the productivity surge. For example, Australia gains far more than the eurozone because of strong trade linkages, especially for intermediate inputs in Asia. Germany gains more than the rest of the eurozone because of the exports of durable goods for capital investment purposes from Germany to Asia (particularly the PRC).

The increase in investment is initially funded by a rise in aggregate savings (or a fall in consumption) as backward-looking agents do not fully incorporate higher wealth into their consumption decisions in the short term. The higher investment is also partly funded by a capital inflow, with financial capital attracted to the higher return on physical capital in growing economies. This capital inflow appreciates the exchange rate in each Asian economy and worsens the trade balance (which is the counterpart of the capital inflow). The balance between financing domestically and through foreign capital varies across Asian economies depending on the scale of capital inflow required to build the new capital stock. It ranges from very large in Japan, to small in the Republic of Korea and the PRC (where capital controls lessen the available inflow).

GDP rises in all Asian economies after the first year and in the long run (Table 6 and Fig. 6). In non-Asian economies such as the United States and Australia the results vary over time. The initial relocation of capital from the US to growing Asian economies, lowers US GDP below the baseline for 20 years, but eventually the higher demand from Asia through increased wealth increases the demand for US goods. Australia is different because it is more highly integrated into Asian production, particularly through the supply of mining and energy goods, which is very different to the US. Australia is more integrated into Asian production flows and the trade benefits of high growth in Asia dominate the capital outflows from

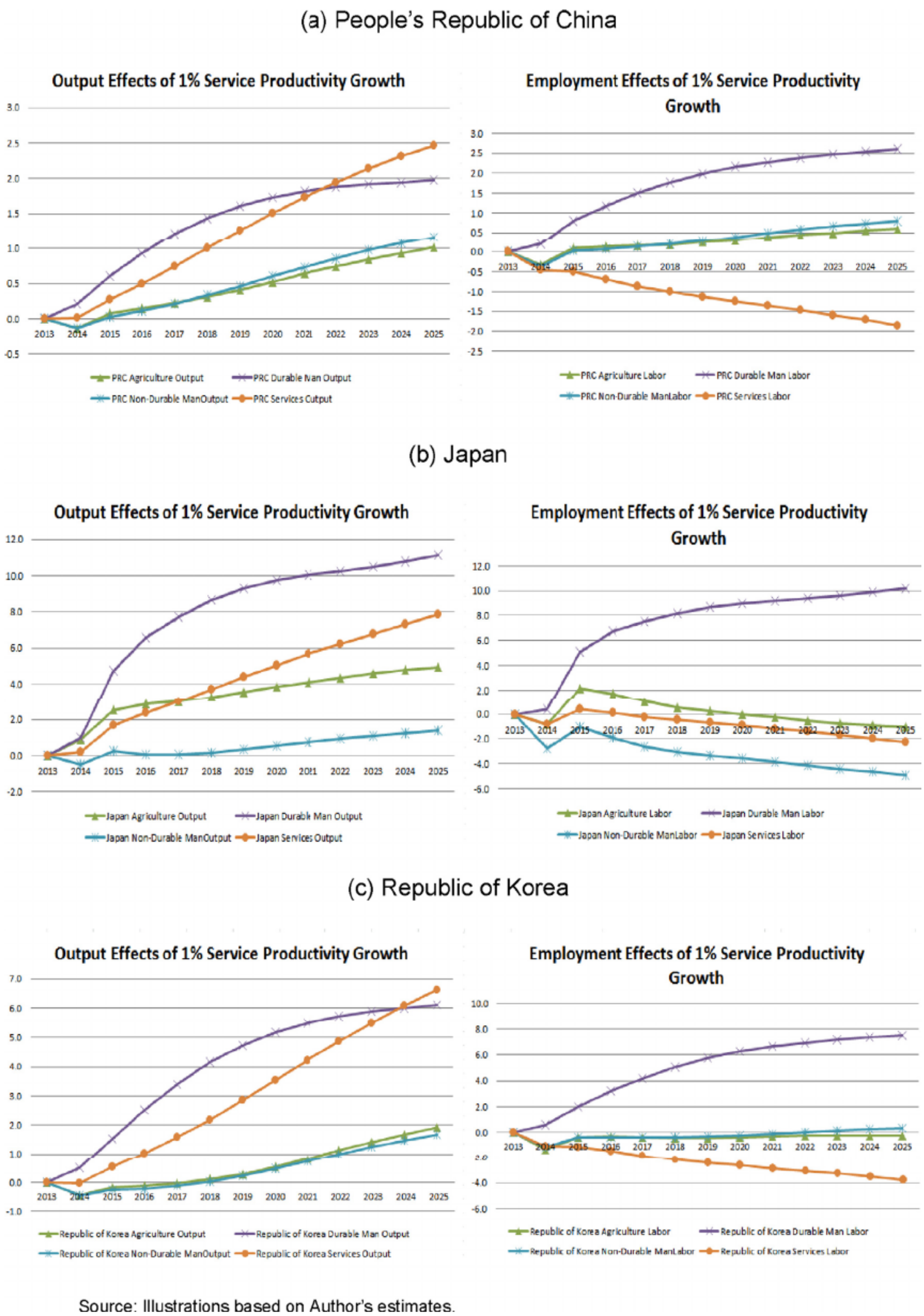


Fig. 9. Sectoral output and employment effects of a services productivity shock (%).

Australia. This illustrates that the spillovers between economies outside Asia and within Asia depend very much on trade patterns and the nature of the goods traded. In particular, Australia experiences a surge in mining and energy exports that feed into the faster growing Asian capital stocks. Thus, Australia's GDP rises continuously from the productivity surge in Asia whereas US GDP is below baseline for more than 20 years because the capital relocation effect outweighs the positive trade effects.

Returning to the sectoral level (Table 8, Table 9, and Fig. 9), the

results differ substantially across the Asian economies. Because the shock is a rise in labor augmenting technical change in the service sector, fewer workers are needed to produce the same level of output. Labor demand tends to fall in all service sectors experiencing the productivity surge, thus freeing up labor to flow into other parts of the economy. This tends to raise the marginal product of capital in these sectors. In particular, the demand for capital goods that are needed to build the capital stock for the expanding service sector raises the demand for durable manufacturing goods well in excess of other sectors. This result is found in each Asian economy, although to a different extent depending on the capital intensity of the service sector relative to other sectors. The fact that the durable goods manufacturing sector is very different to the non-durable goods manufacturing sector (which responds more like agriculture) is an important result and suggests that an aggregate manufacturing sector might mask an important adjustment process especially when the capital accumulation process is endogenous as it is in G-Cubed.

Looking more closely at individual economy results across the major sectors we see that in Table 8 for the PRC there is initially a rise in the output of the durable manufacturing sector as new capital goods are built for the expanding services sectors. The expansion of capital goods is front loaded compared to the persistence rise in labor productivity in the service sector. The employment effects in durable manufacturing are even larger than for other sectors as workers move out of services into the expanding durable manufacturing sector (Fig. 9).

Japan (Table 8 and Fig. 9) shows an even larger flow of workers out of the service sector into other sectors and particularly into the durable goods sector. This is because durable goods is a sector with a large comparative advantage in Japan, with Japan being a major exporter of durable goods throughout Asia and globally. Japan is also much more labor intensive in services than the other Asia economies (see Table 7, parameter delta_k), hence input costs fall by more in Japanese services, and more labor flows into other sectors that are more capital intensive than in other Asian economies. Thus the demand for durable goods for investment purposes increases significantly. The Republic of Korea also experiences a large rise in durables output for similar reasons to Japan, but other economies with less domestic capital production such as the PRC, India, and Indonesia have a much smaller expansion of durable goods production than Japan or the Republic of Korea with some of the expansion spilling over into non-durable goods in the PRC.

In Tables 8 and 9 we also present results for the Asia-wide rise in productivity in the two manufacturing sectors in the model—durable and non-durable goods. Labor productivity growth in durable goods reduces the costs of purchasing capital goods throughout Asia because this sector largely produces the capital goods that each sector purchases for investment. As the cost of capital goods falls, investment rises and GDP rises. Capital-intensive sectors (especially mining) gain most from this reduction in capital goods prices. In addition, there is the relocation effect of labor from the manufacturing sectors into the rest of the economy that parallels the adjustment for the shock to service sector productivity. In the longer run, manufacturing productivity growth increases employment in the service industry but reduces employment growth in agriculture in all economies.

4. Concluding remarks

This paper has empirically explored the historical experience of sectoral growth in major Asian economies with a focus on the performance of the service sector relative to the manufacturing sector and the implication for overall economic growth. It has found evidence of significant catch-up in a number of sectors including the service sector, but there are a wide variety of experiences in each economy. It has also found a substantial gap still remains in labor productivity between the service sectors in Asia and the United States.

Although lower labor productivity in the service sector relative to the manufacturing sector has in general hampered overall economic growth in Asia, the evidence shows that in several Asian economies, the service sector has made a significantly positive contribution to aggregate labor productivity growth, both through own productivity growth and structural change effects, exceeding the net contribution of the manufacturing sector. In addition, some "modern services" industries such as the transportation, storage, communications, financial intermediation, and business services have experienced higher productivity growth.

Overall, empirical evidence from the historical data suggests there is an enormous potential for service sector productivity growth in Asia if policies can be adopted to enhance the catch-up in services to be more like the experience with the manufacturing sector. One critical question is whether enhancing productivity in the service sector can play the role of a second growth engine to lead strong and sustainable growth in Asia in the future. We have addressed this question by exploring simulations of a multi-sectoral general equilibrium model. We find that faster productivity growth in the service sector in Asia can significantly benefit all sectors, contributing to more balanced and sustainable growth of Asian economies. We find that in contrast to the simpler models of economic growth, a key part of the structural adjustment story in the freeing up of labor from the service sector and a rise in the demand for durable manufacturing goods required building the physical capital stock that is induced by the productivity surge. Thus both the service and durable goods sectors experience rapid growth in output, but employment shifts mainly toward the durable goods sector during the adjustment process. This is particularly important in economies such as the Republic of Korea and Japan, which have high productivity in the durable manufacturing sector due to their comparative advantage and openness to international trade in that sector.

To sustain strong growth over long-run, Asian governments should foster climates that can encourage domestic and foreign direct investment in service-sectors, especially modern-service industries. They should continue to implement reforms to remove regulatory distortions and structural impediments that hamper productivity growth in services. Further work, both simulation analysis and empirical work, would improve our understanding of the role of specific policies in improving service sector productivity and, by interacting with other sectors, overall economic growth in individual Asian economies.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.econmod.2018.05.018.

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