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# Industrial Convergence in East Asia

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Akira Kohsaka

Professor Emeritus, Osaka School of International Public Policy
Osaka University

Jun-ichi Shinkai

Lecturer, Faculty of Business Administration
Kinki University

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[Abstract] Despite generally solid growth in East Asia since the 1980s, there remain large differences in productivity across the economies. Focusing on convergence in industrial productivities, this paper examines their convergence processes. We decompose industrial productivity growth into intra-industry productivity growth and inter-industry reallocation of resources. We find that, as contrasting to ANIEs (Hong Kong, Korea, Singapore and Taiwan), ASEAN4 (Indonesia, Malaysia, Philippines and Thailand) have not shown persistent industrial productivity convergence nor persistent structural transformation toward industrialization, while China's productivity growth shows some magnified version of those of Korea and Taiwan. In other words, we argue that ANIEs and ASEAN4 make two distinct groups in terms of aggregate and sectoral productivity convergence.

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## 1. Introduction

It has been well known that economic development accompanies unbalanced growth or structural transformation. The Lewis model with two sectors depicts development resulting from labor movement from traditional to modern sectors as well as capital accumulation in the modern sector. Recently, the relationship between structural transformation and economic development has begun to attract research interest again (Herrendorf *et al*. (2014), Matsuyama (2008), Ray (2010), for example). The literature, however, remains theoretical models with traditional three sectors, i.e. agriculture, manufacturing and services. We have seen few empirical studies that discuss how sectoral productivity growth and reallocation of resources shape economic development of an economy[1].

Among the few, McMillan and Rodrik (2011) and Rodrik (2013), focusing on sectoral differences between productivity levels and convergence, clarify how differential aggregate productivity growth depends on directions of resource reallocation and its speed. Successful developing economies are those who succeeded in growth-enhancing structural transformation, i.e. successfully reallocating resources to manufacturing where unconditional productivity convergence prevails.

With these considerations in mind, by focusing on differential patterns in sectoral productivity convergence, we try to empirically analyze how structural transformation of multi-sector economies and sectoral resource reallocation there contribute to aggregate productivity growth. There have been relatively few studies on the role of sectoral productivity growth and resource reallocation on economic development process of an economy. Thus, examining patterns of sectoral productivity growth and resource reallocation, we assess structural transformation in the context of sectoral productivity convergence for policy implications for future development strategies. Our main target is East Asia.

Despite generally solid growth in East Asia since the 1980s, there remain large differences in productivity across the economies. Focusing on convergence in sectoral productivities, this paper examines their convergence processes. We decompose aggregate labor productivity growth into intra-industry productivity growth and inter-industry reallocation of resources (labor). We find that, as contrasting to the region's high-income economies as Hong Kong, Korea, Singapore and Taiwan, the higher-middle income economies as Indonesia, Malaysia, Philippines and Thailand have not shown persistent industrial productivity convergence nor persistent structural transformation toward industrialization, while China's productivity growth shows some magnified

[1] GGDC appears to start this line of research recently. See, for example, Timmer et al. (2014).

version of those of Korea and Taiwan.

While intra-industry (sectoral) productivity growth is the most dominant factor of aggregate productivity growth, the overall reallocation effect on aggregate productivity growth will be found out to be occasionally non-negligible. The most important growth factor is sectoral productivity. We will show, however, that manufacturing industry is not always the top contributor, and that, depending on economies and decades, agriculture, trade, transportation and even service industries significantly contributed to aggregate productivity growth in East Asia.

We will find significant aggregate productivity convergence even among emerging economies, while their convergence speed is smaller than that among advanced economies. ANIEs are found to go along with the advanced economies' convergence path, while ASEAN4 with the lower, emerging economies' path. We will also confirm that manufacturing shows significant productivity convergence in both advanced and emerging economies, but its speed is different. Again, ANIEs appear to belong to the advanced economies' convergence club, while ASEAN4 remain in the emerging economies'. We will argue that ANIEs and ASEAN4 make two distinct groups of economies in terms of aggregate and sectoral productivity convergence.

## 2. Labor Productivity Growth and Structural Transformation

Industrialization accompanies productivity growth as well as structural transformation. In its early stage, labor and other resources shift from agriculture and other low-productivity traditional sectors into manufacturing and other high-productivity modern activities, resulting in overall productivity and per capita income growth. With this structural transformation, increasing allocative efficiency could help the economy grow even without productivity growth within sectors. "High-growth countries are typically those that have experienced substantial growth-enhancing structural change." (McMillan and Rodrik, 2011, p. 1) In fact, this was probably the case in Japan in the postwar rapid growth period of 1955-72.

As early as in the 1960s, however, Baumol (1967) points out that labor shifts from manufacturing to service along with productivity increase in manufacturing, resulting in a decline in the aggregate productivity growth. Recently, Dennis and Ican (2008) shows that, in addition to this Baumol effect of sectoral productivity growth differentials, differentials of income elasticity of sectoral demand have also caused labor shift from agriculture to non-agriculture (the Engel effect) in the United States in the past two centuries. In the stage of post-industrialization, therefore, there is no a priori reason

why structural transformation is growth-enhancing any more. There, resources shift toward non-manufacturing or services sectors, whose productivities may or may not higher than those of manufacturing.

High and higher-middle income economies in East Asia, i.e. Asian NIEs (Hong Kong, Korea, Singapore and Taiwan), ASEAN4 (Indonesia, Malaysia, Philippines and Thailand), and China have shown significant aggregate labor productivity convergence to advanced economies such as the United States in the past four decades, as shown in Figure 1. GDP per worker in East Asia, indexed as 2000 = 100, cut through that of US from below over time. Exceptions are the brief period during and after the Asian economic crisis in 1997 and the Philippines. In contrast, those of selected emerging economies in Latin America cut through that of US from above. This time, exception is Chile, which shows sustained convergence as against the others in the region.

>>Figure 1: Aggregate labor productivity growth

During the decades' growth processes, however, the patterns and speeds of industrial structural transformation are diverse among the economies as shown in Figure 2. In the two city-size economies, Hong Kong and Singapore, which have negligible primary sector, the transformation is de-industrialization with decreasing manufacturing share (in employment, hereafter, unless otherwise noted), particularly in Hong Kong, and of services-orientation with increasing finance industry share in both economies. Korea and Taiwan showed typical industrialization pattern as in advanced economies in the past, with sharply declining agriculture share and increasing manufacturing share until the 1980s and then showed a symptom of de-industrialization afterwards. In ASEAN4, although only Malaysia appears to follow the pattern of Korea and Taiwan with some time lags, the other three economies show slower processes of industrialization, where agriculture's share remains the largest and manufacturing's share less than 20 percent. Somewhat surprisingly, in China, agriculture's share in employment remains the largest and manufacturing's share less than 20 percent until the early 2000s.

>>Figure 2: Industrial structural transformation

On top of this above, remember that aggregate productivity growth is simply a weighted average of productivity growth in the industry level. Productivity growth of industries, as will be shown, significantly differs from each other as well as over time along with their changing weights. Which industry contributes to aggregate productivity

growth most and when? How resources are reallocated among industries under structural transformation? These whole pictures end up with aggregate productivity growth. Now, let us start our scrutiny by introducing our methodology and dataset.

## 3. Methodology and Dataset

### Methodology

We decompose labor productivity growth into intra-industry labor productivity growth and inter-industry reallocation of labor. An increase (decrease) in labor share in higher (lower) productivity sectors increases (decreases) the aggregate labor productivity of the economy as a whole. Industry *i*'s intra-industry labor productivity in period *t*, $y_{i,t}$, is defined as:

$$y_{i,t} = \frac{Y_{i,t}}{L_{i,t}}$$

where *Y* and *L* are value added and employment of the industry, respectively. Industry *i*'s labor share at *t*, $\theta_{i,t}$, is defined as

$$\theta_{i,t} = \frac{L_{i,t}}{L_t}$$

Then, the aggregate labor productivity in period *t*,$y_t$, is expressed as a total sum of intra-industry productivity multiplied by labor shares, i.e.

$$y_t = \sum_{i=1}^{n} \theta_{i,t} y_{i,t}$$

Now, we can decompose the aggregate labor productivity change into an intra-industry productivity growth and an inter-industry reallocation of labor as:

$$\Delta y_t = \sum_{i=1}^{n} \theta_{i,t-k} \Delta y_{i,t} + \sum_{i=1}^{n} \Delta\theta_{i,t} y_{i,t}$$

By dividing both sides by the labor productivity in period *t-k*, we obtain the following expression in growth terms:

$$\frac{\Delta y_t}{y_{t-k}} = \sum_{i=1}^{n} \theta_{i,t-k} \frac{\Delta y_{i,t}}{y_{i,t-k}} \frac{y_{i,t-k}}{y_{t-k}} + \sum_{i=1}^{n} \Delta\theta_{i,t} \frac{y_{i,t}}{y_t} \frac{y_t}{y_{t-k}} \qquad (1)$$

where the first term on the right-hand side represents the effect of intra-industry productivity growth and the second term represents the effect of inter-industry reallocation of labor on the aggregate productivity growth, between periods *t-k* and *t*.

### Data

Our data on East Asia consists of aggregate as well as sectoral real value added at constant 2005 prices and employment (persons employed) for the period of 1970-2010, obtained from Groningen Growth and Development Centre (GGDC) 10-Sector Database[2]. The data covers 10 sectors, i.e. agriculture, mining, manufacturing, utilities, construction, trade, transportation, finance, government and service[3]. We decompose aggregate and sectoral productivity growth for the periods of 1970-1979, 1980-1989, 1990-1999, and 2000-2010, except for Hong Kong (from 1974), Indonesia and Philippines (from 1975).

## 4. Structural Transformation

Table 1 and Figure 3 show the result of the above decomposition of labor productivity growth into intra-industry (sectoral) labor productivity growth and inter-industry reallocation of labor decade by decade in 9 emerging economies in East Asia. Defining labor productivity as value added per worker, aggregate labor productivity growth in the last three decades of the 20$^{th}$ century is as high as more than 8% a year in China, 5% in Korea and Taiwan, about 4% in Hong Kong, Singapore, Thailand, and Malaysia, and less than 3% in Indonesia and Philippines. Note that the US labor productivity growth was only 1% a year on average during the same period. In the 2000s, aggregate labor productivity growth slowed down to mostly less than 2% in East Asia, except for China whose growth reached at 14% a year. During the period, as Table 1 and Figure 3 show, sectoral productivity growth is a major determinant of the aggregate productivity growth, while reallocation of labor across sectors also played a non-negligible role.

**>Table 1: Decomposition of aggregate labor productivity growth: East Asia**
**>Figure 3: Decomposition of aggregate labor productivity growth: East Asia**

In order to look into the dynamic process of sectoral transformation in more detail, Figure 4 illustrates which industry contributes how much to aggregate productivity growth through structural transformation decade by decade. Note that, according to the second term on the right hand side of Equation (1), the larger the increase (decrease) in

[2] http://www.rug.nl/research/ggdc/data/ggdc-10-sector-databaseGGDC.
[3] 1. Agriculture (agriculture, mining, forestry and fishing), 2. Mining (mining and quarrying), 3. Manufacturing, 4. Utilities (electricity, gas and water supply), 5. Construction, 6. Trade (wholesale and retail trade, hotels and restaurants), 7. Transportation (transport, storage, and communication), 8. Finance (finance, insurance, real estates and business services), 9. Government (government services), and 10. Service (community, social and personal services).

employment share of higher (lower) productivity industry, the higher the aggregate labor productivity growth.

In Figure 4, the vertical axis measures each industry's relative labor productivity levels to aggregate productivity (= 1.0) and the horizontal axis measures changes in each industry's labor share during each decade. If an industry is plotted in the first (north-east) quadrant, it contributes positively to the reallocation by attracting labor to higher productivity industry, while, if in the third (south-west) quadrant, it contributes positively by freeing labor from lower productivity industry.

**>Figure 4: Structural transformation dynamics**

In the two city economies, the reallocation played some role -- raising the aggregate labor productivity growth by 1.5% a year on average in Hong Kong, but almost none in Singapore (Table 1). In Hong Kong (Figure 4, Panel A), the reallocation effects came from the growing higher productivity sector (finance, trade, service) as well as from the shrinking lower productivity sector (manufacturing).[4] In Singapore (Panel B), while the highest productivity sector, finance, has led reallocation just like in Hong Kong, shrinking low-productivity service industry contributed to the reallocation effect rather than manufacturing, because manufacturing is an average productivity industry, not lower one as in Hong Kong.

In Korea and Taiwan (Panels C and D), reallocation from lowest productivity industry, agriculture, had most dominant effects of as large as 15% decline in share a decade on aggregate productivity growth until the 1980s. Interestingly, reallocation to manufacturing, as large as 10% increase in share a decade was not growth factor through reallocation until the 1980s in Korea and until the 1970s in Taiwan, after which de-industrialization kicked in. This is because the productivity level of manufacturing is almost equal to (or slightly less than) the average productivity level. We also note that non-negligible reallocation to sectors as lower-productivity trade and higher-productivity finance industries has been witnessed in Korea and Taiwan. Moreover, the reallocation effects on productivity growth turn out to be negative in Korea as manufacturing being plotted in the second (north-west) quadrant in the 1990s and 2000s, and the same holds true to a lesser degree in Taiwan, probably due to de-industrialization in recent decades.

Among ASEAN4, reallocation from lowest productivity sector, agriculture, was the most dominant productivity-growth factor until the 1990s also in Malaysia, Thailand

[4] De-industrialization then partly reflected a Dutch disease due to strong domestic currency under the dollar-peg.

and Indonesia (Panels E, F, and G, respectively). But the size of reallocation is relatively modest as compared to those of Korea and Taiwan (almost 15% a year over decades) in their early industrialization period. Also, reallocation to higher productivity manufacturing industry is also modest, i.e. as small as 2% a decade in Malaysia, Thailand and Indonesia[5], as compared to Korea and Taiwan (10%). In other words, manufacturing industrialization in ASEAN4 so far was far more modest than that of Korea and Taiwan. Instead, in ASEAN4, we find some reallocation to other productivity-growth sectors in finance industry in Malaysia and in trade industry in Thailand, Indonesia and Philippines (Panel H).

In China (not reported here), reallocation from lowest productivity sector, agriculture, had most dominant effects of as large as more than 10% decline in labor share a decade on aggregate productivity growth throughout the past four decades. Interestingly, the size of reallocation to higher-productivity manufacturing industry appears modest, i.e. annual average 2% a decade in labor share over the past three decades. We find also that the reallocation size to another higher productivity sector, i.e. trade (and construction) industry turns out to be almost equivalent to that to manufacturing. Labor has been also significantly reallocated to service industry, whose productivity level is lower than agriculture. Structural transformation in China looks as if not simply industrialization as in Korea and Taiwan, but simultaneous explosion of production and consumption of an entire society.

## 5. Sectoral productivity growth

In this section we turn to the role of sectoral productivity growth for aggregate productivity growth. Figure 5 (and Appendix Table 1) show contributions of intra-industry (sectoral) productivity growth to aggregate productivity growth, calculated as a product of three metrics, i.e. intra-industry productivity growth, employment share and relative productivity to aggregate productivity, as indicated by the first term on the right-hand side of Equation (1). We note that, the larger the employment share and the higher the productivity level, the larger contribution to aggregate productivity growth the higher sectoral productivity growth could attain.

**>Figure 5: sectoral productivity growth**

As to sectoral productivity growth in ANIEs, the most dominant driving industry

[5] We see that manufacturing is shrinking in Philippines throughout the past 4 decades.

throughout the economies is manufacturing as shown in Figure 5. Productivity growth in manufacturing has been the largest contributor to aggregate productivity growth (by more or less than 2% a year) in Hong Kong, Singapore, Korea and Taiwan for the 1980s and 1990s, although its relative productivity level is less than the average in Hong Kong and Korea. Productivity growth in retail and wholesale trade industry (simply, trade industry, hereafter) also contributes much (by 1-2% a year) to aggregate productivity growth due to its higher productivity level and fairly large employment share in Hong Kong and Singapore, and due to large employment share despite less than average productivity level in Korea and Taiwan. While productivity growth of transportation and telecommunication industry (transportation industry, hereafter) also contributes to aggregate growth in Hong Kong and Singapore, productivity growth of agriculture contributes to aggregate growth in Korea and Taiwan despite its lower productivity level and declining employment share.

In ASEAN4, manufacturing contributes the most to aggregate productivity growth, due to its relatively higher productivity level and not small employment share, but in a smaller scale than in ANIEs. Productivity growth in agriculture also contributes to aggregate growth -- despite its lower productivity level -- due to its large employment share. Sectoral productivity growth pattern in Malaysia appears becoming more similar to Korea and Taiwan in the recent decades, while that of Philippines looks least remarkable in various respects among the four.

China's sectoral productivity growth looks as a magnified version of those of Korea and Taiwan. The most dominant driver of sectoral productivity growth is manufacturing with higher productivity level and significant employment share, and the second dominant driver is agriculture with largest employment share despite lower productivity level. Manufacturing contributes by 3.5% a year and agriculture by 1.7% a year to aggregate growth for the 1980s through the 2000s. In addition, trade, transportation and construction industries contribute by 0.5% to more than 1% a year due to higher productivity level and significant labor share during the same period. Even mining and finance industries contribute by more than 0.5% a year with higher sectoral productivity growth despite their small labor shares.

## 6. Productivity convergence

In this section, we examine productivity growth paths of these emerging economies in East Asia in an international perspective. Particularly, we are concerned with how they can be mapped in productivity convergence to the international frontier as we observe remaining or persistent big gaps in both aggregate and sectoral productivity

levels between developed and developing economies.

Table 2 shows the regression result of aggregate and sectoral productivity growths on initial productivity levels for 24 OECD economies and 19 emerging economies over the four decades from the 1970s through the 2000s[6]. The estimated convergence coefficients of aggregate productivity growth are -.019 and -.006 for OECD and emerging economies, respectively, and statistically significant. The Table also shows significantly negative convergence coefficients of sectoral productivity growth for 9 out of 10 industries among OECD economies, and for 6 out of 10 industries among emerging economies. Furthermore, we find that convergence coefficients, representing the speed of convergence, are larger in OECD economies than in emerging economies in aggregate as well as sectoral productivities except for manufacturing. In other words, the result suggests that aggregate and most sectoral productivity convergence is faster among OECD than among emerging economies, and that only exception is manufacturing, where its productivity converges faster among emerging economies.

**>>Table 2: Estimation results: Productivity convergences**

Now, let us look at the patterns of productivity convergence. Figure 6 plots the combination of a country's initial aggregate as well as sectoral labor productivity levels and its labor productivity growth over a decade. The first panel shows changes in aggregate labor productivity. We find that, while ANIEs' and China's productivity is higher in both levels and growth rates than Latin America, ASEAN4's is lower in levels, but higher in growth rates than Latin America's. We also note that ANIEs and China are along or above the convergence line of OECD economies. The observation suggests: ANIEs and China appear to follow productivity convergence profiles of OECD, but ASEAN4 show very slower convergence to OECD, that is, these two groups have generated distinct convergence patterns in aggregate productivity from each other.

**>>Figure 6: Productivity convergences**

When we look at convergence patterns of sectoral productivities, we also find

[6] OECD: Austria, Australia, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxemburg, Netherland, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, United States. Emerging economies: Asia: China, Hong Kong (China), India, Indonesia, Korea (Republic of), Malaysia, Philippines, Singapore, Taiwan, Thailand. Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Venezuela.

distinct patterns in agriculture, manufacturing, trade and transportation between the two groups in relation to OECD and/or emerging markets in Latin America[7]. In agriculture (Panel A), there appears some convergence among developed economies, but no productivity convergence among emerging economies. Even so, Korea, Taiwan and China follow mostly convergence paths of OECD, but ASEAN4 do not show productivity convergence. In manufacturing, in contrast, we see strong convergence among emerging economies, too (Panel B). Particularly, emerging economies in East Asia appear to go along with this path, while those in Latin America go below it. Note, further, that ANIEs and China are on the productivity convergence path of OECD economies. In other two industries, trade and transportation, productivity convergence appears to exist, but is weaker among emerging economies, with ASEAN4 more or less along the convergence line of emerging economies, but below OECD convergence path (Panels C and D). Again, ANIEs and China go along (or beyond) higher convergence line of OECD economies. The observation suggests: major obstacles against aggregate productivity convergence in ASEAN4 in contrast to ANIEs should be most seriously existing in or best represented by agriculture and trade.

## 7. Productivity growth and structural transformation in East Asia

In this section, we summarize what we have found so far on productivity growth and structural transformation in East Asia in the past 4 decades.

**Structural transformation**

While intra-industry (sectoral) productivity growth is the most dominant factor of aggregate productivity growth, the overall reallocation effect on aggregate productivity growth is occasionally non-negligible (as large as more than 1% a year in a decade) as compared to aggregate productivity growth (2 to 5% a year over the whole period).

Reallocation to manufacturing industry contributed by more than 1 % a year to aggregate productivity growth for the 1970s in Korea, Taiwan, Malaysia and Thailand, for the 1980s in Korea, for the 1990s in Malaysia and Thailand, but not any more. In fact, reallocation from manufacturing industry negatively contributed to growth since the 1970s in Hong Kong, since the 1980s in Singapore, and since the 1990s in Korea and Taiwan.

Also, manufacturing is not the only major source of reallocation effect on productivity growth. Reallocation to finance industry enhanced productivity growth by

[7] These industries play a dominant role in structural transformation of these economies as discussed in Sections 4 and 5.

0.5 to 1.5% for the 1970s through 1990s in Hong Kong, Singapore, Korea and Taiwan. Moreover, that most important growth effect comes from reallocation from low-productivity agriculture for the 1970s in Korea, Taiwan, and Malaysia, for the 1980s in Korea and Malaysia, for the 1990s in Thailand (by more than 10% reduction in labor share).

In China, reallocation to manufacturing industry became significant in the 2000s and contributed to growth by more than 2% a year, while reallocation from agriculture is significant since the 1980s. Reallocation from agriculture is relatively small and reallocation to manufacturing as well as trade industries is smaller throughout the 4 decades in Indonesia, so that their growth effects are small. In the Philippines, we see some, not large reallocation from agriculture and to trade (instead of manufacturing) industries, and rather weak reallocation effects.

**Sectoral productivity growth**

The most important growth factor is sectoral productivity. Manufacturing industry is not always the top contributor, though. The ranking of growth contribution by industry depends on economies and decades.

Trade and then manufacturing contributed to growth by 1 to 2% a year each to attain 2.5% aggregate productivity growth in Hong Kong. Manufacturing and trade contributed by 1 to more than 2% a year each to attain intra-industry productivity growth of 4% a year for the period of 1970-2000 in Singapore. Manufacturing, agriculture, trade and transportation are main drivers to intra-industry productivity of 4% a year in Korea.

Likewise, manufacturing, trade, transportation and service in Taiwan, manufacturing, agriculture, trade, finance and transportation in China, mining (the 1970s and 80s), manufacturing, agriculture, trade and transportation in Malaysia, manufacturing and agriculture in Thailand, and, manufacturing and agriculture in Indonesia. No remarkable contribution of sectoral productivity growth can be found in Philippines.

**Productivity convergence**

We found significant aggregate productivity convergence not only among advanced economies, but also among emerging economies, but their slope coefficients suggest stronger convergence among advanced economies than among emerging economies. And then, ANIEs not only started from higher productivity levels than ASEAN4, but also appear to go along with the advanced economies' convergence path, while ASEAN4 with the lower, emerging economies' path. These two groups' convergence paths are fairly distinct from each other. Also note that China in the 1990s and 2000s is a distinct outlier above the advanced economies' convergence path.

We found significant sectoral productivity convergence in almost all industries

among advanced economies, but in only half of industries among emerging economies. We confirmed that manufacturing shows significant productivity convergence in both groups, although convergence speed in other industries appears significantly larger in advanced economies. Again, ANIEs appear to be a member of the advanced economies' convergence club, while ASEAN4 remain in the emerging economies' convergence club.

In agriculture, no productivity convergence is detected among emerging economies, while ANIEs appear around the advanced economies club again. Exactly similar pictures can be found in both trade and transportation industries where productivity convergence is present, but weaker in emerging economies. We confirm that ANIEs and ASEAN4 are two distinct groups of economies in terms of aggregate and sectoral productivity convergence, too.

## 8. Concluding remarks

We have examined how structural transformation of multi-sector economies contributes to aggregate productivity growth in East Asia. Despite generally solid growth in East Asia since the 1980s, there remain large differences in productivity among the economies. Focusing on convergence in aggregate as well as sectoral productivity, we decompose aggregate productivity growth into intra-industry (sectoral) productivity growth and inter-industry reallocation of resources.

While intra-industry (sectoral) productivity growth is the most dominant factor of aggregate productivity growth, the overall reallocation effect on aggregate productivity growth is found out to be occasionally non-negligible. Reallocation to manufacturing industry used to contribute significantly to aggregate productivity growth in Korea, Taiwan, Malaysia and Thailand, but not any more. Also, manufacturing is not the only major source of reallocation effect on productivity growth. Moreover, another important growth effect came from reallocation from low-productivity agriculture in Korea, Taiwan, Malaysia, and Thailand.

The most important growth factor is sectoral productivity. Manufacturing industry is not always the top contributor, though. Depending on economies and decades, agriculture, trade, transportation and even service industries showed significant contribution to aggregate productivity growth in East Asia.

We found significant aggregate productivity convergence even among emerging economies. ANIEs not only started from higher productivity levels than ASEAN4, but also appear to go along with the advanced economies' convergence path, while ASEAN4 with the lower, emerging economies' path. We also found that manufacturing shows

significant productivity convergence in both advanced and emerging economies, but convergence speed appears larger in the former. Again, ANIEs appear to belong to the advanced economies' convergence club, while ASEAN4 remain in the emerging economies'. In agriculture, no productivity convergence is detected among emerging economies, while ANIEs appear to be in the advanced economies club again. Thus, we confirmed that ANIEs and ASEAN4 are two distinct groups of economies in terms of aggregate and sectoral productivity convergence, too.

Finally, we know that 10 sector disaggregation rather than three (i.e. agriculture, manufacturing and services) is far from enough to take account of the diversity of industries. Manufacturing consists of a full range of various factor intensive subsectors, for example. Even with this level of disaggregation, however, we come up with significant convergences to technological frontiers in industries on one hand, and with differences in sectoral productivity levels and speeds of factor reallocation and productivity convergence on the other, in East Asia. It is not simple manufacturing industrialization, but both reallocation among sectors and sectoral productivity growth what matters to aggregate productivity growth. Although this fact is not limited only to East Asia, because of its diversities and dynamics, East Asia continues to be an important and stimulating source of our interests in economic growth.

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## Table 1: Decomposition of aggregate labor productivity growth

| | Aggregate labor productivity | Intra-industry productivity | Inter-industry reallocation |
|---|---|---|---|
| **Hong Kong** | | | |
| 1970s | -0.63 | -2.03 | 1.40 |
| 1980s | 9.06 | 7.15 | 1.91 |
| 1990s | 2.92 | 1.66 | 1.26 |
| 2000s | 3.47 | 3.09 | 0.38 |
| **Singapore** | | | |
| 1970s | 3.79 | 2.93 | 0.87 |
| 1980s | 4.10 | 3.93 | 0.16 |
| 1990s | 4.88 | 5.82 | -0.94 |
| 2000s | -0.28 | -0.37 | 0.10 |
| **Korea** | | | |
| 1970s | 3.26 | 2.33 | 0.94 |
| 1980s | 5.69 | 3.73 | 1.97 |
| 1990s | 4.24 | 4.68 | -0.44 |
| 2000s | 2.46 | 2.46 | 0.00 |
| **Taiwan** | | | |
| 1970s | 6.50 | 5.27 | 1.23 |
| 1980s | 5.09 | 4.68 | 0.41 |
| 1990s | 6.17 | 6.02 | 0.15 |
| 2000s | 1.62 | 1.45 | 0.17 |
| **Malaysia** | | | |
| 1970s | 4.65 | 5.74 | -1.09 |
| 1980s | 2.47 | 5.20 | -2.73 |
| 1990s | 4.36 | 3.88 | 0.49 |
| 2000s | 2.11 | 2.04 | 0.07 |
| **Thailand** | | | |
| 1970s | 4.64 | 1.59 | 3.06 |
| 1980s | 3.82 | 3.24 | 0.58 |
| 1990s | 3.56 | 0.98 | 2.58 |
| 2000s | 2.71 | 2.03 | 0.69 |
| **Indonesia** | | | |
| 1970s | 5.62 | 1.22 | 4.39 |
| 1980s | 0.20 | -0.75 | 0.95 |
| 1990s | 2.58 | 1.97 | 0.61 |
| 2000s | 2.95 | 2.40 | 0.55 |
| **Philippines** | | | |
| 1970s | 3.00 | 4.31 | -0.74 |
| 1980s | -1.38 | -1.60 | 0.22 |
| 1990s | 0.26 | -0.25 | 0.51 |
| 2000s | 2.33 | 1.98 | 0.35 |
| **China** | | | |
| 1970s | 3.20 | 1.38 | 1.82 |
| 1980s | 7.46 | 5.89 | 1.56 |
| 1990s | 12.92 | 12.07 | 0.85 |
| 2000s | 14.49 | 11.05 | 3.44 |

Source: Authors' calculation.

**Table 2. Estimation results: labor productivity convergence**

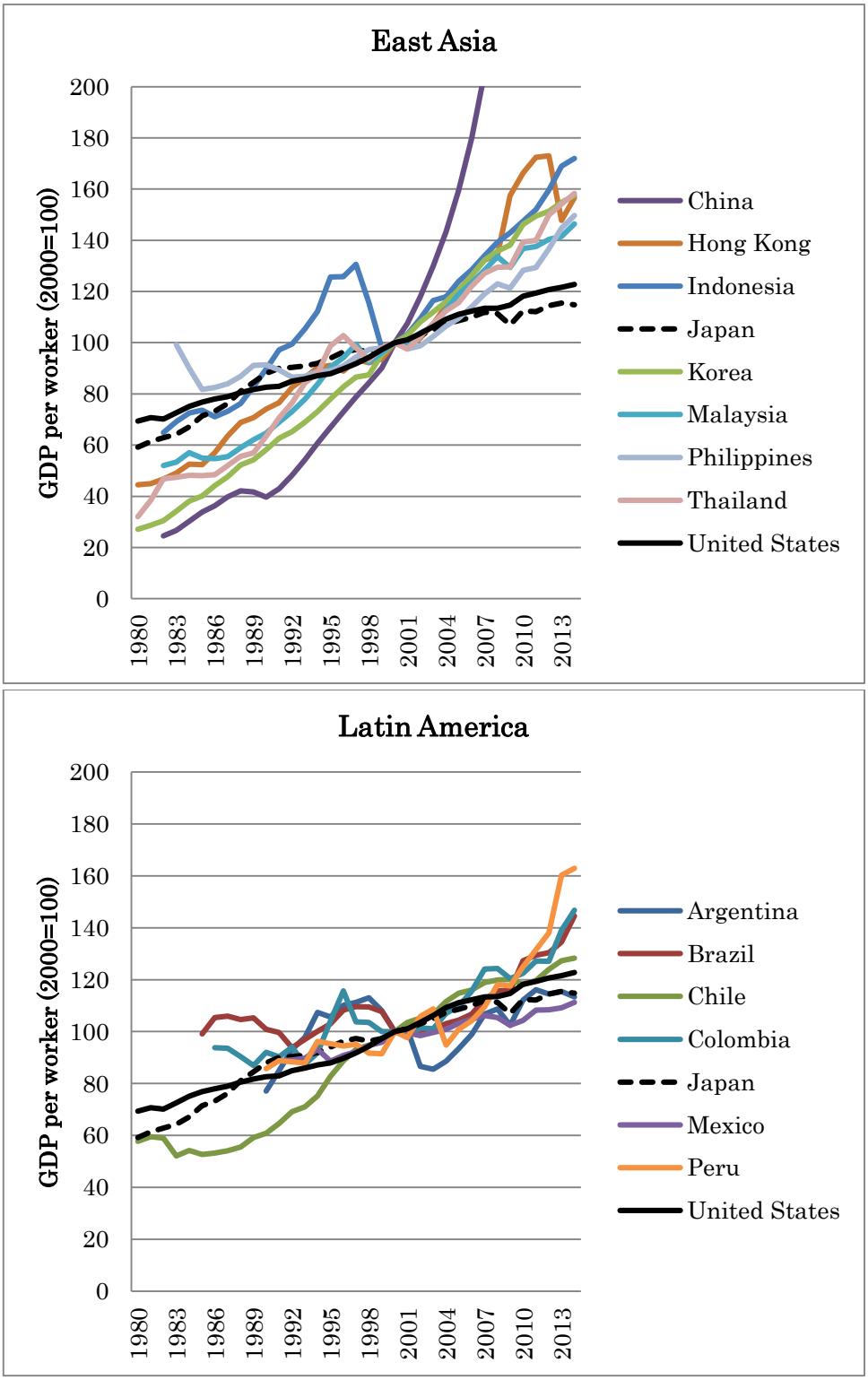
| | OECD | EM | | OECD | EM |
|---|---|---|---|---|---|
| **Total** | | | **Trade** | | |
| Slope | -0.019 *** | -0.006 * | Slope | -0.022 *** | -0.006 ** |
| | (0.003) | (0.003) | | (0.004) | (0.005) |
| constant | 0.228 *** | 0.077 ** | constant | 0.254 *** | 0.061 ** |
| | (0.03) | (0.031) | | (0.046) | (0.041) |
| **Agriculture** | | | **Transportation** | | |
| Slope | -0.012 ** | 0.000 | Slope | -0.017 *** | -0.006 |
| | (0.005) | (0.003) | | (0.004) | (0.005) |
| constant | 0.163 *** | 0.025 | constant | 0.224 *** | 0.089 |
| | (0.053) | (0.024) | | (0.046) | (0.049) |
| **Mining** | | | **Finance** | | |
| Slope | -0.023 | -0.023 *** | Slope | -0.034 *** | -0.022 |
| | (0.021) | (0.007) | | (0.008) | (0.006) |
| constant | 0.334 | 0.285 *** | constant | 0.405 *** | 0.222 * |
| | (0.236) | (0.073) | | (0.088) | (0.055) |
| **Manufacturing** | | | **Government** | | |
| Slope | -0.011 * | -0.015 ** | Slope | -0.023 *** | -0.012 *** |
| | (0.006) | (0.006) | | (0.004) | (0.005) |
| constant | 0.161 ** | 0.164 *** | constant | 0.255 *** | 0.116 *** |
| | (0.067) | (0.058) | | (0.048) | (0.04) |
| **Utility** | | | **Service** | | |
| Slope | -0.021 *** | -0.010 | Slope | -0.026 *** | 0.001 ** |
| | (0.006) | (0.006) | | (0.006) | (0.004) |
| constant | 0.289 *** | 0.148 ** | constant | 0.283 *** | 0.004 *** |
| | (0.077) | (0.066) | | (0.06) | (0.03) |
| **Construction** | | | | | |
| Slope | -0.013 *** | -0.011 ** | | | |
| | (0.004) | (0.005) | | | |
| constant | 0.144 *** | 0.101 ** | | | |
| | (0.044) | (0.045) | | | |

Note: Dependent variables: aggregate and sectoral labor productivity growth. Explanatory variables: natural log of aggregate and sectoral labor productivity, i.e. value added per worker. OECD: Austria, Australia, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxemburg, Netherland, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, United States. EM (Emerging market economies): Asia: China, Hong Kong (China), India, Indonesia, Korea (Republic of), Malaysia, Philippines, Singapore, Taiwan, Thailand, and Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Venezuela.

Data: GGDC 10-Sector Database.

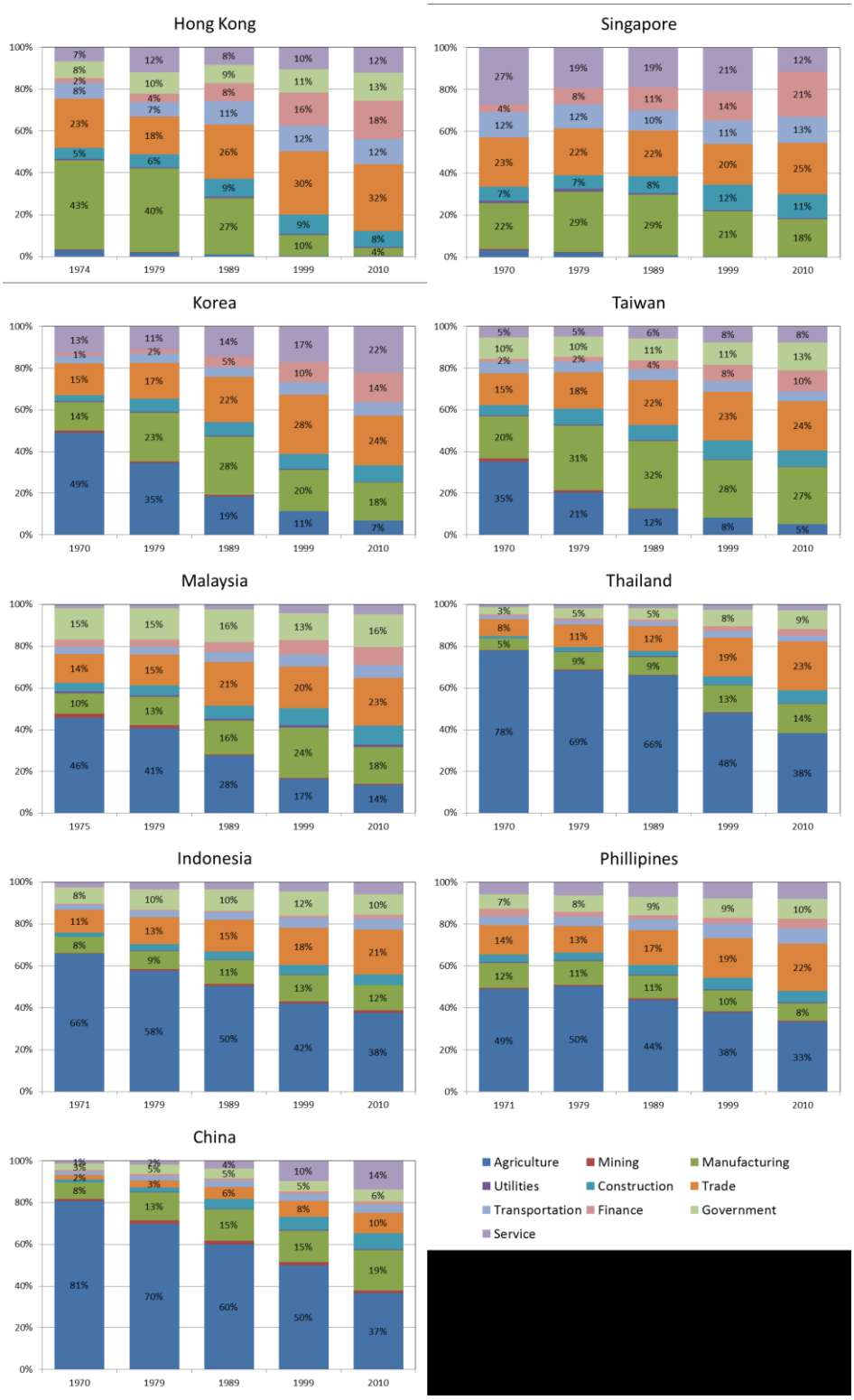
Source: Authors' calculation.

**Figure 1. Labor productivity convergence: East Asia and Latin America**



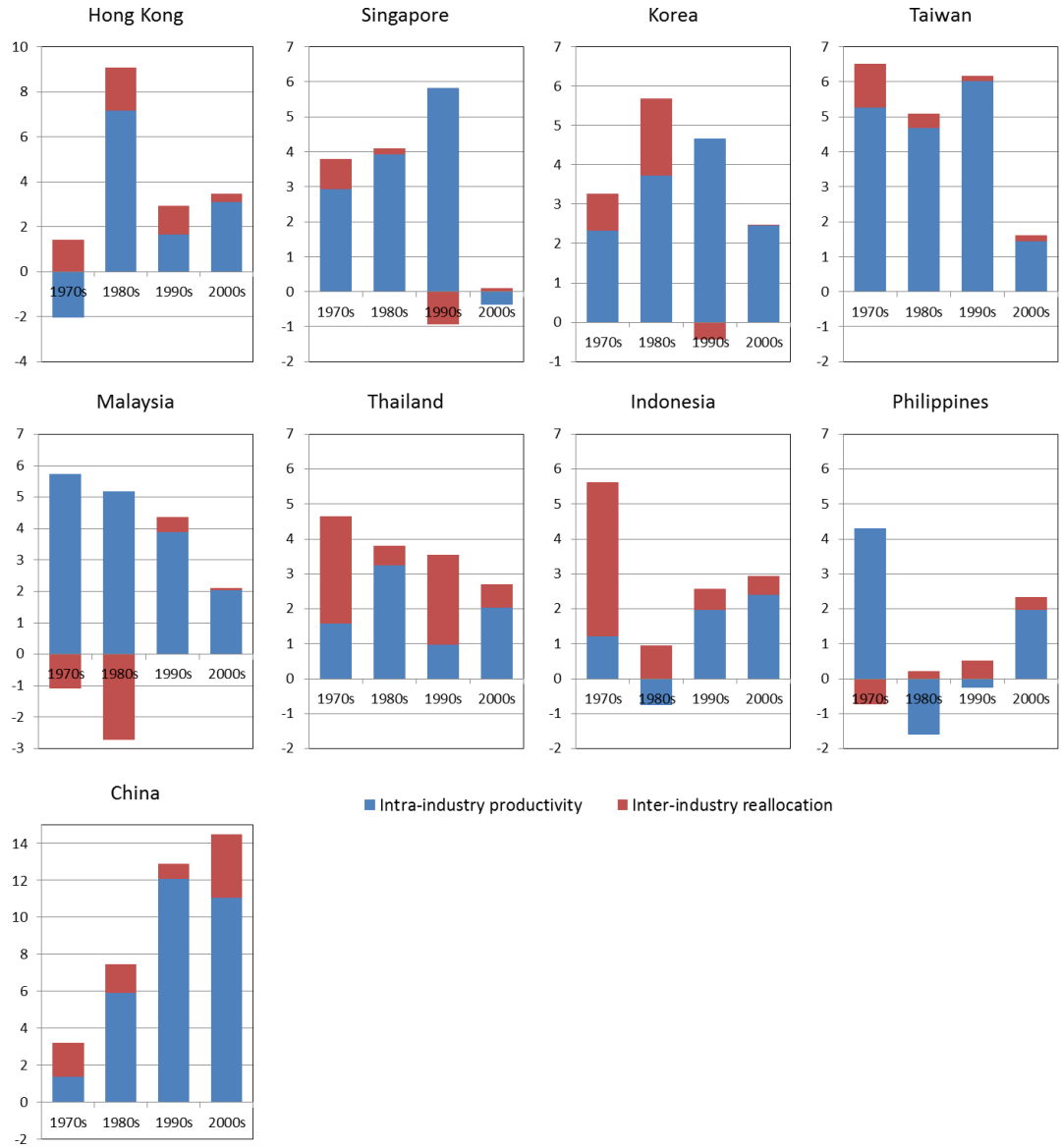

Source: Authors' calculation.

**Figure 2. Structural transformation**




Source: Authors' calculation.

**Figure 3: Decomposition of Aggregate Labor Productivity Growth**




Source: Authors' calculation.

**Figure 4. Structural transformation: dynamics**

**Figure 4 (2)**

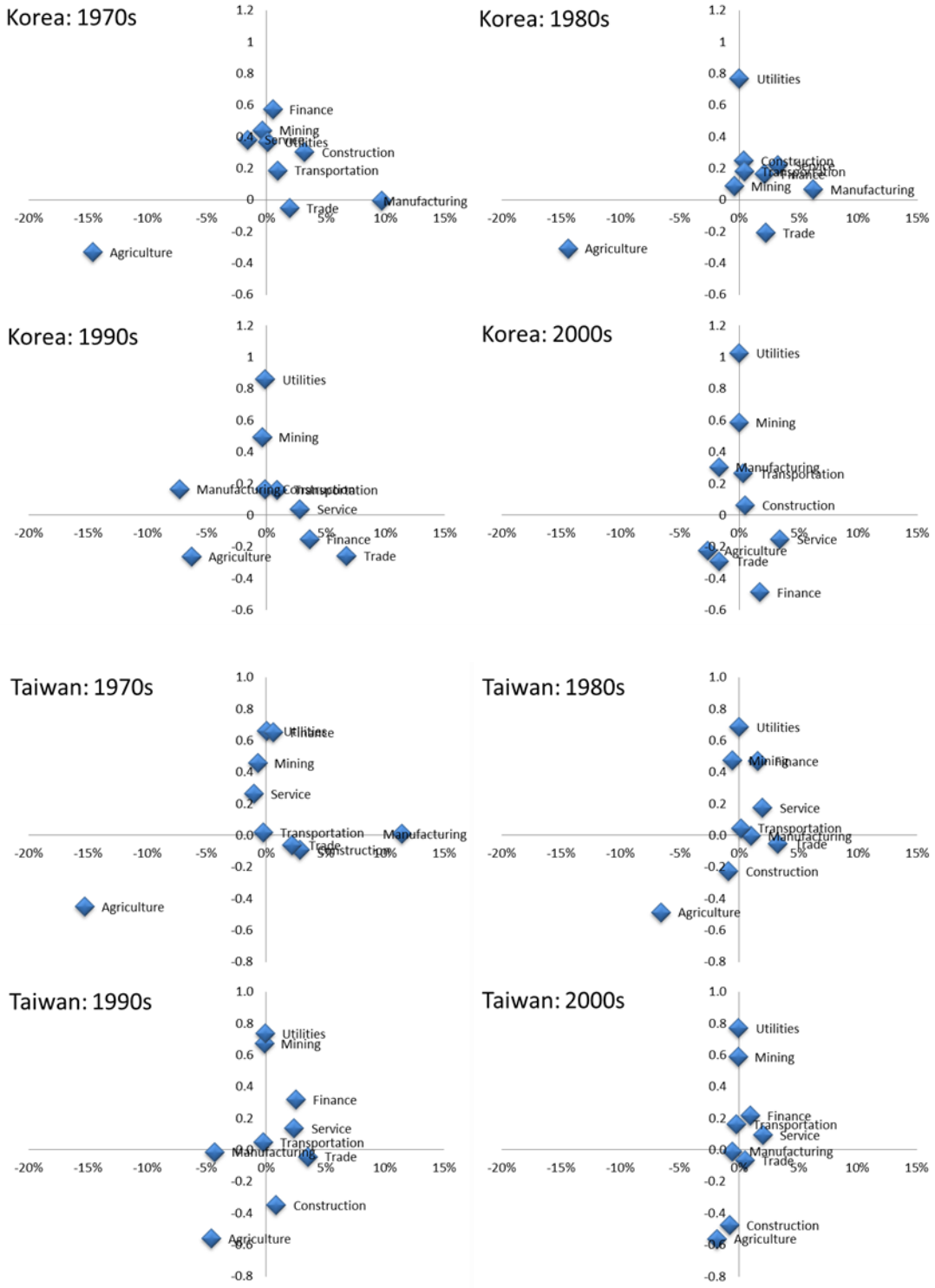

Korea: 1970s
Finance
Mining
Construction
Transportation
Manufacturing
Trade
Agriculture
Korea: 1980s
Utilities
Mining
Manufacturing
Trade
Agriculture
Korea: 1990s
Utilities
Mining
Service
Finance
Trade
Agriculture
Korea: 2000s
Utilities
Mining
Transportation
Construction
Service
Agriculture
Trade
Finance
Taiwan: 1970s
Mining
Service
Transportation
Manufacturing
Agriculture
Taiwan: 1980s
Utilities
Service
Transportation
Construction
Agriculture
Taiwan: 1990s
Utilities
Mining
Finance
Service
Transportation
Trade
Construction
Agriculture
Taiwan: 2000s
Utilities
Mining
Finance
Transportation
Service
Manufacturing
Trade
Construction
Agriculture

**Figure 4(3)**

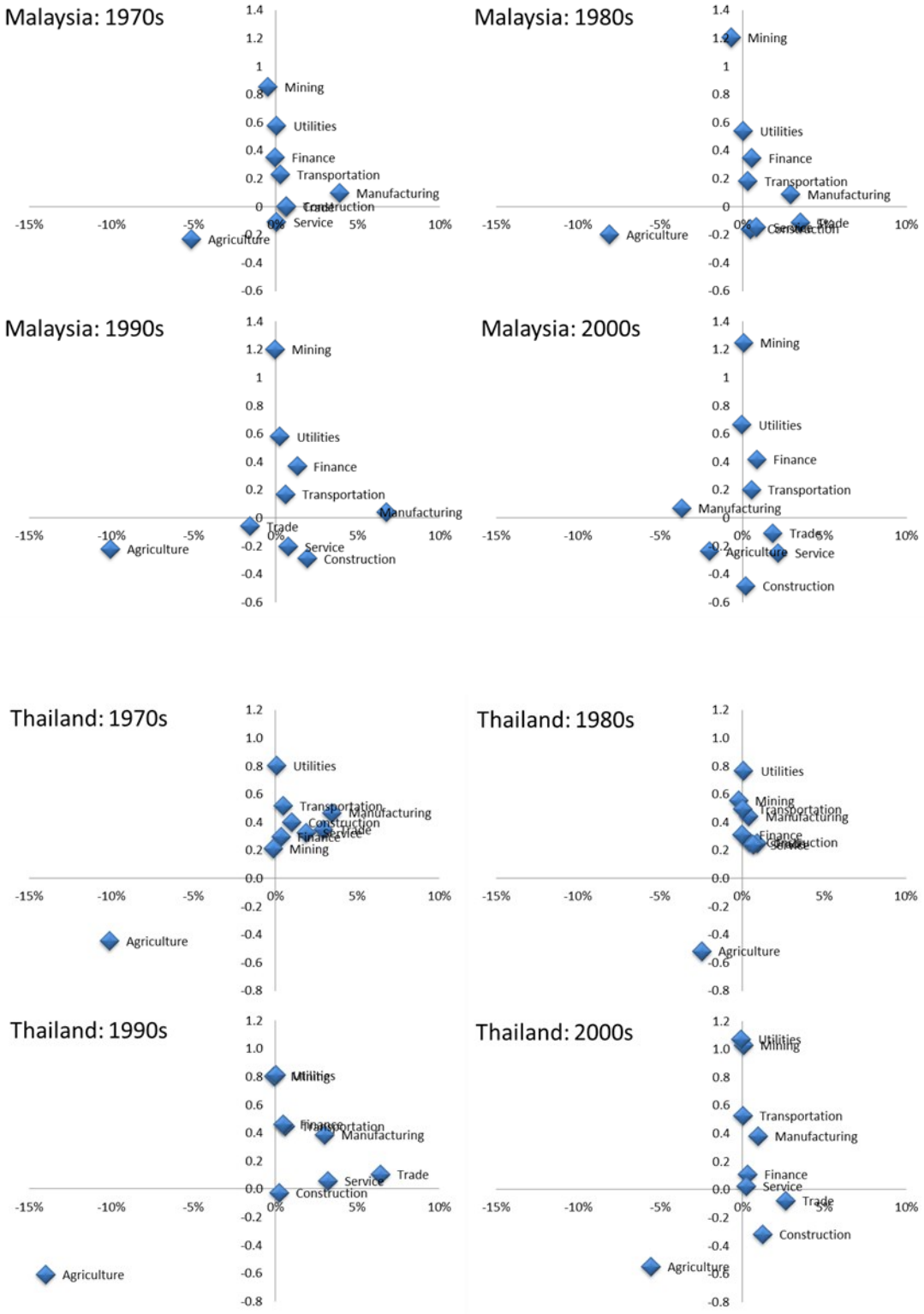
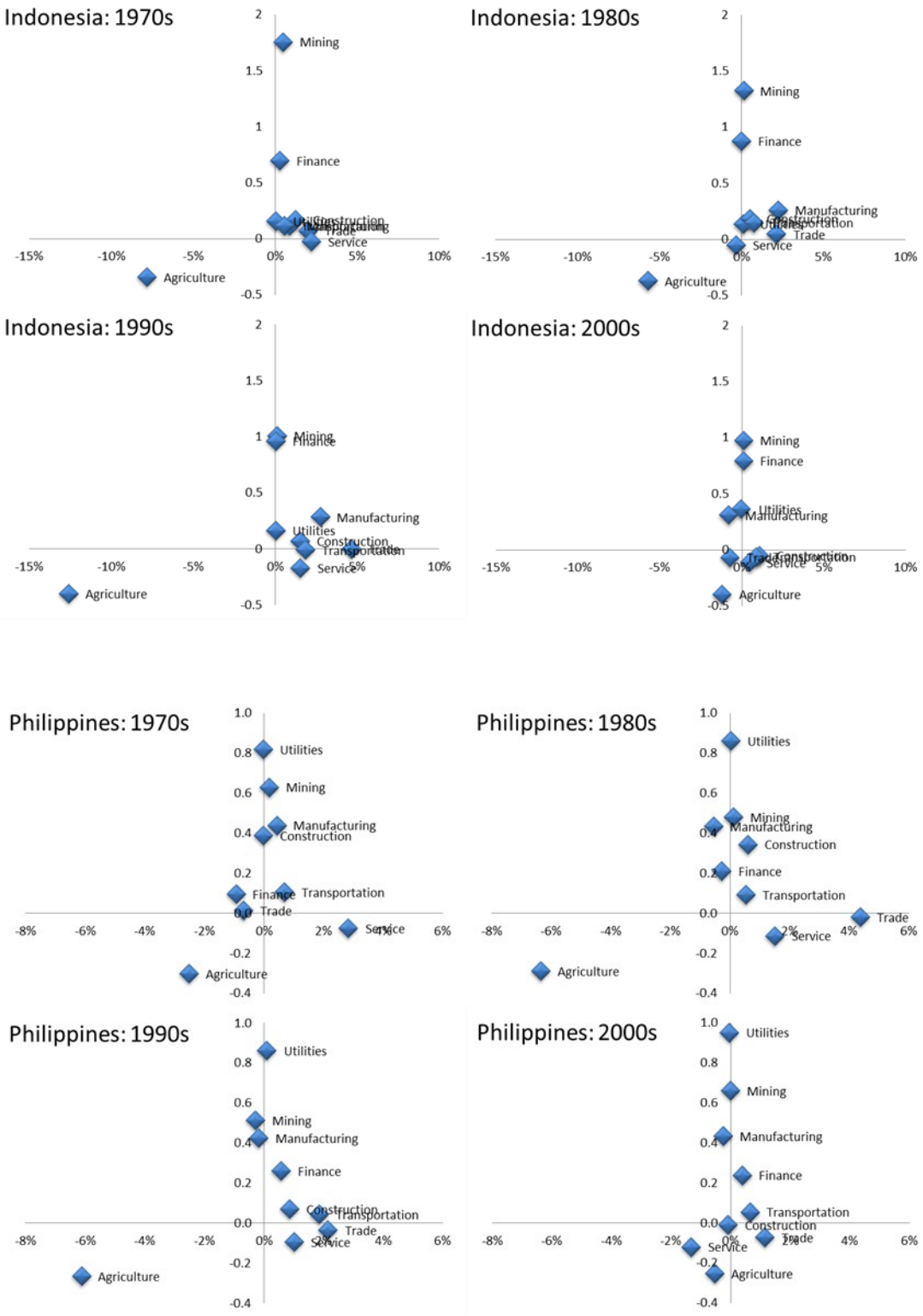
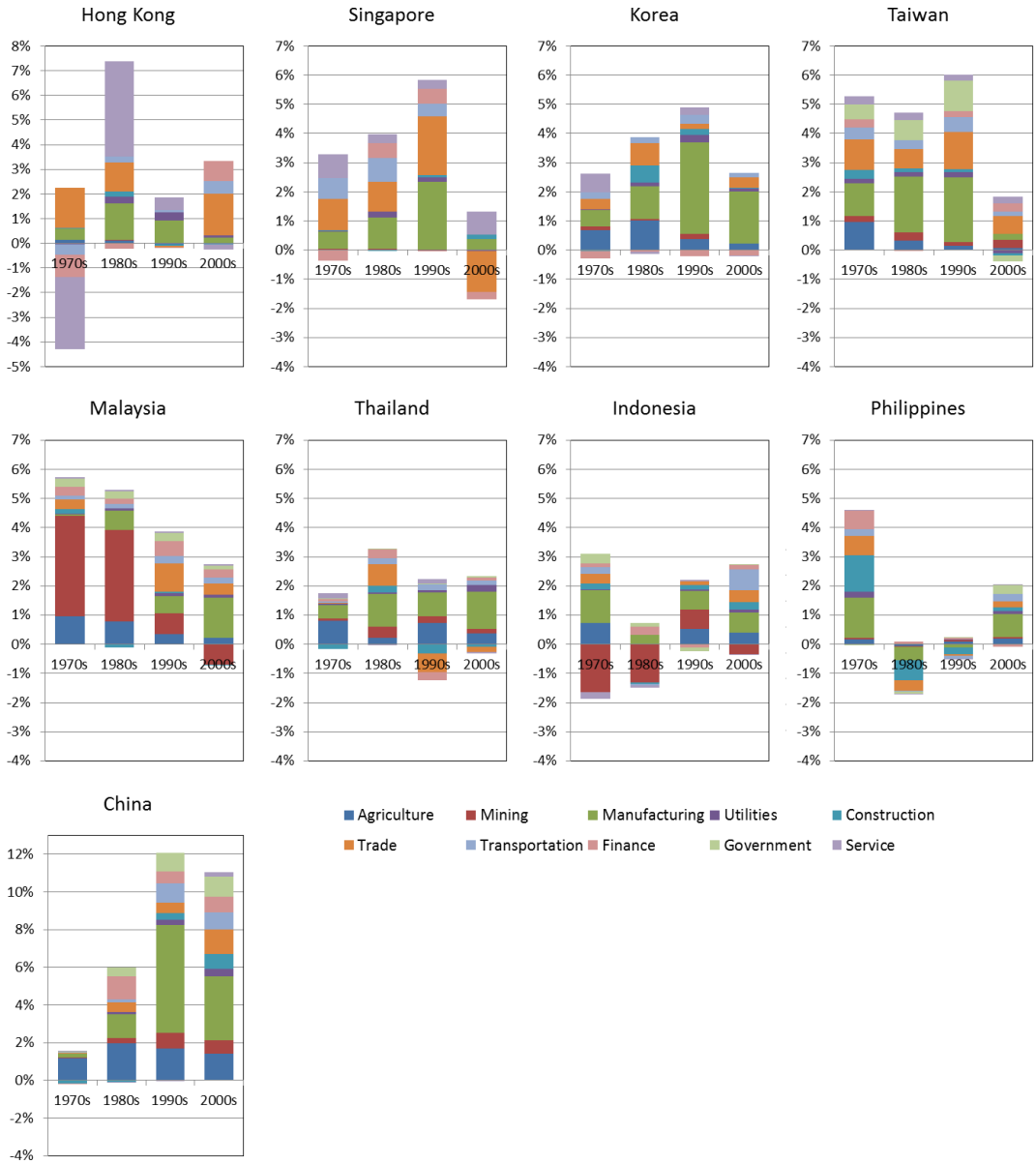

Malaysia: 1970s
Mining
Utilities
Finance
Transportation
Manufacturing
Service
Agriculture
Malaysia: 1980s
Mining
Utilities
Finance
Transportation
Manufacturing
Agriculture
Malaysia: 1990s
Mining
Utilities
Finance
Transportation
Manufacturing
Trade
Agriculture
Service
Construction
Malaysia: 2000s
Mining
Utilities
Finance
Transportation
Manufacturing
Trade
Agriculture
Service
Construction
Thailand: 1970s
Utilities
Transportation
Manufacturing
Construction
Mining
Agriculture
Thailand: 1980s
Utilities
Mining
Agriculture
Thailand: 1990s
Manufacturing
Trade
Service
Construction
Agriculture
Thailand: 2000s
Utilities
Transportation
Manufacturing
Finance
Service
Trade
Construction
Agriculture

**Figure 4(4)**



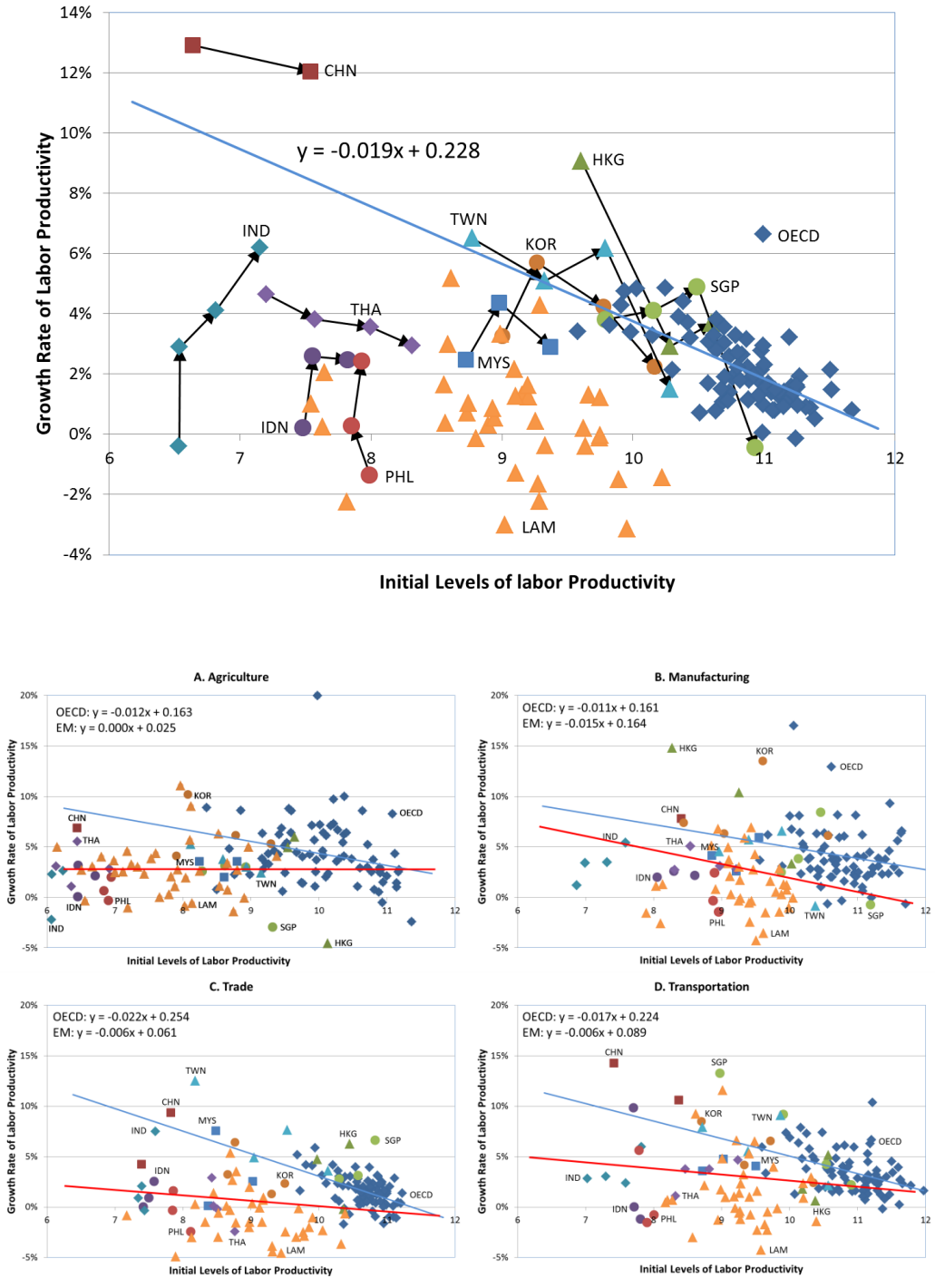

Source: Authors' calculation.

**Figure 5: Decomposition of Contribution of Intra-industry Productivity Growth**




Source: Authors' calculation.

**Figure 6: Convergence of Labor Productivity**




Source: Authors' calculation.

## Appendix Table 1:
## Decomposition of Contribution of Intra-Industry Productivity Growth

| | Hong Kong | Singapore | Korea | Taiwan | Malaysia | Thailand | Indonesia | Philippines | China |
|---|---|---|---|---|---|---|---|---|---|
| **A. Agriculture** | | | | | | | | | |
| 1) Intra-industry producitivity growth | | | | | | | | | |
| 1970s | 6.5% | 2.5% | 4.1% | 5.3% | 3.7% | 3.1% | 2.5% | 0.9% | 2.2% |
| 1980s | 6.3% | 3.2% | 10.2% | 3.8% | 3.6% | 1.1% | 0.0% | -0.4% | 4.9% |
| 1990s | -4.5% | 3.2% | 6.1% | 3.0% | 2.0% | 5.5% | 3.1% | 0.6% | 5.4% |
| 2000s | -2.4% | -3.9% | 4.9% | 2.2% | 2.5% | 3.2% | 2.8% | 1.5% | 8.5% |
| 2) Employment share (t-k) | | | | | | | | | |
| 1970 | 3.2% | 3.5% | 49.0% | 35.3% | 45.7% | 77.9% | 65.9% | 49.0% | 80.8% |
| 1980 | 1.9% | 1.9% | 32.8% | 18.6% | 35.4% | 68.5% | 56.2% | 50.1% | 68.7% |
| 1990 | 0.7% | 0.5% | 17.0% | 12.3% | 24.8% | 63.4% | 50.1% | 43.9% | 60.1% |
| 2000 | 0.2% | 0.3% | 10.6% | 7.7% | 16.5% | 48.5% | 43.3% | 37.4% | 50.0% |
| 3) Relative productivity (t-k) | | | | | | | | | |
| 1970 | 0.70 | 0.23 | 0.33 | 0.52 | 0.58 | 0.34 | 0.44 | 0.38 | 0.67 |
| 1980 | 1.03 | 0.21 | 0.30 | 0.48 | 0.62 | 0.30 | 0.36 | 0.34 | 0.58 |
| 1990 | 0.87 | 0.21 | 0.37 | 0.42 | 0.69 | 0.21 | 0.33 | 0.36 | 0.52 |
| 2000 | 0.36 | 0.19 | 0.42 | 0.32 | 0.56 | 0.25 | 0.33 | 0.37 | 0.33 |
| 4) Contribution to aggregate intra-industry productivity (=1*2*3) | | | | | | | | | |
| 1970s | 0.1% | 0.0% | 0.7% | 1.0% | 1.0% | 0.8% | 0.7% | 0.2% | 1.2% |
| 1980s | 0.1% | 0.0% | 1.0% | 0.3% | 0.8% | 0.2% | 0.0% | -0.1% | 2.0% |
| 1990s | 0.0% | 0.0% | 0.4% | 0.2% | 0.3% | 0.7% | 0.5% | 0.1% | 1.7% |
| 2000s | 0.0% | 0.0% | 0.2% | 0.1% | 0.2% | 0.4% | 0.4% | 0.2% | 1.4% |
| **B. Manufacturing** | | | | | | | | | |
| 1) Intra-industry producitivity growth | | | | | | | | | |
| 1970s | 6.5% | 2.5% | 7.4% | 4.5% | 0.2% | 2.7% | 12.0% | 4.0% | 1.3% |
| 1980s | 6.3% | 3.8% | 6.3% | 5.7% | 4.1% | 5.1% | 1.9% | -1.5% | 6.0% |
| 1990s | -4.5% | 8.4% | 13.5% | 6.6% | 2.6% | 3.1% | 2.5% | -0.4% | 27.3% |
| 2000s | -2.4% | 1.4% | 5.9% | 0.7% | 4.7% | 3.8% | 2.5% | 3.0% | 9.8% |
| 2) Employment share (t-k) | | | | | | | | | |
| 1970 | 3.2% | 22.0% | 13.6% | 20.2% | 9.9% | 5.4% | 7.9% | 12.0% | 7.8% |
| 1980 | 1.9% | 29.3% | 22.2% | 31.5% | 13.7% | 8.3% | 9.2% | 11.6% | 13.8% |
| 1990 | 0.7% | 28.6% | 27.4% | 30.8% | 17.7% | 9.8% | 11.6% | 10.1% | 14.9% |
| 2000 | 0.2% | 20.7% | 20.3% | 27.7% | 24.4% | 13.6% | 12.7% | 9.9% | 14.5% |
| 3) Relative productivity (t-k) | | | | | | | | | |
| 1970 | 0.70 | 1.09 | 0.57 | 1.21 | 1.37 | 3.02 | 1.20 | 2.89 | 1.75 |
| 1980 | 1.03 | 0.97 | 0.79 | 1.08 | 1.14 | 2.64 | 1.78 | 2.63 | 1.54 |
| 1990 | 0.87 | 0.97 | 0.85 | 1.11 | 1.27 | 2.66 | 2.10 | 2.78 | 1.41 |
| 2000 | 0.36 | 1.29 | 1.49 | 1.10 | 1.20 | 2.46 | 2.19 | 2.63 | 2.38 |
| 4) Contribution to aggregate intra-industry productivity (=1*2*3) | | | | | | | | | |
| 1970s | 0.1% | 0.6% | 0.6% | 1.1% | 0.0% | 0.4% | 1.1% | 1.4% | 0.2% |
| 1980s | 0.1% | 1.1% | 1.1% | 1.9% | 0.6% | 1.1% | 0.3% | -0.4% | 1.3% |
| 1990s | 0.0% | 2.3% | 3.1% | 2.2% | 0.6% | 0.8% | 0.6% | -0.1% | 5.7% |
| 2000s | 0.0% | 0.4% | 1.8% | 0.2% | 1.4% | 1.3% | 0.7% | 0.8% | 3.4% |
| **C. Trade** | | | | | | | | | |
| 1) Intra-industry producitivity growth | | | | | | | | | |
| 1970s | 6.5% | 2.8% | 3.2% | 12.5% | 3.2% | 0.1% | 2.8% | 4.2% | 0.4% |
| 1980s | 6.3% | 3.1% | 6.4% | 4.9% | 0.1% | 2.9% | 0.0% | -2.5% | 5.6% |
| 1990s | -4.5% | 6.6% | 1.3% | 7.6% | 7.6% | -2.4% | 0.9% | -0.3% | 4.2% |
| 2000s | -2.4% | -4.5% | 2.6% | 3.0% | 2.7% | -0.8% | 2.7% | 1.1% | 12.9% |
| 2) Employment share (t-k) | | | | | | | | | |
| 1970 | 3.2% | 23.5% | 15.3% | 15.2% | 13.9% | 8.0% | 11.0% | 14.0% | 2.3% |
| 1980 | 1.9% | 22.0% | 19.4% | 17.9% | 17.1% | 11.1% | 13.1% | 12.5% | 3.6% |
| 1990 | 0.7% | 21.9% | 22.0% | 21.8% | 21.3% | 12.1% | 15.0% | 16.8% | 6.0% |
| 2000 | 0.2% | 19.1% | 27.2% | 23.8% | 20.4% | 18.4% | 18.8% | 19.3% | 7.8% |
| 3) Relative productivity (t-k) | | | | | | | | | |
| 1970 | 0.70 | 1.66 | 0.71 | 0.55 | 0.79 | 3.49 | 1.13 | 1.12 | 3.73 |
| 1980 | 1.03 | 1.52 | 0.61 | 0.76 | 0.70 | 2.34 | 0.94 | 1.13 | 2.55 |
| 1990 | 0.87 | 1.40 | 0.63 | 0.77 | 0.61 | 2.15 | 0.95 | 1.00 | 2.12 |
| 2000 | 0.4 | 1.6 | 0.5 | 0.9 | 0.7 | 1.2 | 0.8 | 0.9 | 1.3 |
| 4) Contribution to aggregate intra-industry productivity (=1*2*3) | | | | | | | | | |
| 1970s | 0.1% | 1.1% | 0.4% | 1.1% | 0.4% | 0.0% | 0.3% | 0.7% | 0.0% |
| 1980s | 0.1% | 1.0% | 0.8% | 0.7% | 0.0% | 0.8% | 0.0% | -0.3% | 0.5% |
| 1990s | 0.0% | 2.0% | 0.2% | 1.3% | 1.0% | -0.6% | 0.1% | -0.1% | 0.5% |
| 2000s | 0.0% | -1.4% | 0.4% | 0.6% | 0.4% | -0.2% | 0.4% | 0.2% | 1.3% |

## Appendix Table 1 (2)

| | Hong Kong | Singapore | Korea | Taiwan | Malaysia | Thailand | Indonesia | Philippines | China |
|---|---|---|---|---|---|---|---|---|---|
| **D. Transportation** | | | | | | | | | |
| 1) Intra-industry producitivity growth | | | | | | | | | |
| 1970s | 6.5% | 13.2% | 8.5% | 8.0% | 3.2% | 1.1% | 8.2% | 4.6% | 0.7% |
| 1980s | 6.3% | 9.1% | 4.2% | 5.5% | 3.5% | 3.8% | -1.2% | -0.8% | 3.4% |
| 1990s | -4.5% | 4.2% | 6.6% | 9.0% | 4.8% | 3.8% | 0.0% | -1.6% | 14.3% |
| 2000s | -2.4% | -0.1% | 2.2% | 2.1% | 2.9% | 2.4% | 15.6% | 4.1% | 11.3% |
| 2) Employment share (t-k) | | | | | | | | | |
| 1970 | 3.2% | 12.1% | 3.6% | 5.5% | 3.3% | 1.7% | 2.4% | 4.3% | 1.5% |
| 1980 | 1.9% | 11.3% | 4.6% | 5.1% | 4.4% | 2.2% | 2.9% | 4.5% | 2.1% |
| 1990 | 0.7% | 9.8% | 5.2% | 5.4% | 5.1% | 2.4% | 3.7% | 5.1% | 3.3% |
| 2000 | 0.2% | 11.1% | 6.0% | 5.1% | 5.5% | 2.9% | 5.2% | 7.2% | 3.4% |
| 3) Relative productivity (t-k) | | | | | | | | | |
| 1970 | 0.70 | 0.44 | 0.74 | 0.95 | 1.13 | 3.07 | 1.15 | 1.15 | 2.96 |
| 1980 | 1.03 | 0.78 | 1.07 | 1.07 | 1.00 | 2.45 | 1.39 | 1.02 | 2.39 |
| 1990 | 0.87 | 1.05 | 0.95 | 1.08 | 1.05 | 2.28 | 1.17 | 1.06 | 2.18 |
| 2000 | 0.36 | 0.98 | 1.20 | 1.33 | 1.14 | 2.53 | 0.89 | 0.87 | 2.30 |
| 4) Contribution to aggregate intra-industry productivity (=1*2*3) | | | | | | | | | |
| 1970s | 0.1% | 0.7% | 0.2% | 0.4% | 0.1% | 0.1% | 0.2% | 0.2% | 0.0% |
| 1980s | 0.1% | 0.8% | 0.2% | 0.3% | 0.2% | 0.2% | 0.0% | 0.0% | 0.2% |
| 1990s | 0.0% | 0.4% | 0.3% | 0.5% | 0.3% | 0.2% | 0.0% | -0.1% | 1.0% |
| 2000s | 0.0% | 0.0% | 0.2% | 0.1% | 0.2% | 0.2% | 0.7% | 0.3% | 0.9% |
| **E. Finance** | | | | | | | | | |
| 1) Intra-industry producitivity growth | | | | | | | | | |
| 1970s | 6.5% | -3.2% | -2.6% | 5.8% | 7.0% | 5.9% | 8.7% | 7.4% | -0.7% |
| 1980s | 6.3% | 4.0% | -0.8% | -0.5% | 3.4% | 19.3% | 14.1% | 1.3% | 39.3% |
| 1990s | -4.5% | 2.7% | -2.1% | 2.8% | 7.2% | -6.3% | -1.8% | 0.6% | 8.4% |
| 2000s | -2.4% | -1.4% | -1.8% | 3.1% | 2.7% | 4.3% | 2.7% | -0.7% | 11.3% |
| 2) Employment share (t-k) | | | | | | | | | |
| 1970 | 3.2% | 3.5% | 1.3% | 1.5% | 3.7% | 0.8% | 0.4% | 3.6% | 0.6% |
| 1980 | 1.9% | 8.2% | 2.5% | 2.5% | 3.9% | 1.0% | 0.6% | 2.4% | 1.0% |
| 1990 | 0.7% | 11.4% | 5.3% | 4.8% | 5.2% | 1.1% | 0.7% | 2.3% | 1.0% |
| 2000 | 0.2% | 14.0% | 10.0% | 7.8% | 6.5% | 2.4% | 1.6% | 2.7% | 1.1% |
| 3) Relative productivity (t-k) | | | | | | | | | |
| 1970 | 0.70 | 3.15 | 7.34 | 2.98 | 1.22 | 1.56 | 3.07 | 2.46 | 4.72 |
| 1980 | 1.03 | 1.61 | 3.45 | 2.61 | 1.29 | 1.60 | 3.40 | 3.24 | 3.23 |
| 1990 | 0.87 | 1.59 | 1.90 | 1.53 | 1.31 | 4.13 | 7.67 | 4.27 | 8.03 |
| 2000 | 0.36 | 1.27 | 0.99 | 1.19 | 1.65 | 1.00 | 3.37 | 4.46 | 6.64 |
| 4) Contribution to aggregate intra-industry productivity (=1*2*3) | | | | | | | | | |
| 1970s | 0.1% | -0.4% | -0.2% | 0.3% | 0.3% | 0.1% | 0.1% | 0.7% | 0.0% |
| 1980s | 0.1% | 0.5% | -0.1% | 0.0% | 0.2% | 0.3% | 0.3% | 0.1% | 1.2% |
| 1990s | 0.0% | 0.5% | -0.2% | 0.2% | 0.5% | -0.3% | -0.1% | 0.1% | 0.6% |
| 2000s | 0.0% | -0.3% | -0.2% | 0.3% | 0.3% | 0.1% | 0.1% | -0.1% | 0.8% |

Source: Authors' calculation.