Why Have Asia and Latin America Grown Differently? Labor Structural Transformation and Labor Productivity Growth

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Abstract

Asian and Latin American countries have experienced similar percentages of labor moving out of agriculture since 1950. However, this reallocation is associated with high long-term productivity growth in Asia but not in Latin America. This paper examines this stylized fact and explores how different drivers of reallocation contribute to long-term productivity gains. The results suggest that reallocation driven by productivity growth of the non-agricultural sector, i.e., labor pull effect, is the key feature of the countries experiencing large productivity gains from reallocation. Accordingly, labor pull is an indispensable driver of reallocation that results in significant long-term growth and income convergence.

Keywords: Productivity growth; Labor structural transformation; Convergence.

JEL Classification: O11; O47; O57.

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1 Introduction

Labor movement out of the agricultural sector is a key feature of modern economic growth (Kuznets, 1973). This movement often immediately raises aggregate productivity without any technological advance, and thus results in its growth because the non-agricultural sector is often more productive than the agricultural sector. Restuccia et al. (2008) and Vollrath (2009a) document a widely accepted fact related to labor structure and economic growth across countries, that there is a negative relationship between the share of labor in the agricultural sector and GDP per capita (or per worker). However, from the growth experiences of Asia and Latin America, we find that simply reducing the share of labor in the agricultural sector does not necessarily allow a relatively income country to grow rapidly and become a relatively high income country. In this paper, we document this growth fact and demystify growth success and failure from the viewpoint of labor reallocation.

We document the stylized fact that following World War II (WWII), Asian and Latin American countries experienced similar magnitudes of decline in the percentage of labor working in the agricultural sector, but the growth of output per worker (hereafter productivity growth) in Asia is higher than that in Latin America. See Fig. 1. Between 1975 and 2003, the magnitude of the decline in the share of labor in agriculture is similar between Asian and Latin American countries, as shown by Fig. 1(a). Moreover, the average annual growth rate of labor productivity in Asia is higher than in Latin America (Asia: 1.9% vs. Latin America: 0.3%).[1] This stylized fact raises an immediate question as to why the reallocation in Latin America is associated with lower long-term growth than in Asia.

We then address the central issue—why reallocation generates different growth effects in Asia and Latin America (from the 1950s/1960s/1970s to the 2000s)—from two perspectives. We first adopt sectoral decomposition analysis to pin down the key element that differentiates the productivity growth attributable to reallocation in these two regions. Then we use a two-sector model to provide three guidelines for identifying the main drivers of reallocation. We find that the main driver of Asia is different from the one of Latin America, thus resulting in different growth gain from reallocation.

The sectoral decomposition splits each economy of the nineteen economies (i.e., the ten Asian countries and the nine Latin American countries) into agricultural and non-agricultural

[1] In these figures, we sum the aggregate GDP from Penn World Table 7.0 for 10 Asian countries (Hong Kong, Indonesia, India, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand, and Taiwan) as the total output for Asia. Moreover, we sum the number of employee reported in the Groningen Growth and Development Centre (GGDC) for these countries as the total number of employees. We also compute the total output and the total number of employees for nine Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela). These are all the countries studied in this paper. We restrict attention to the period 1975-2003, the years for which all the countries have employment data.

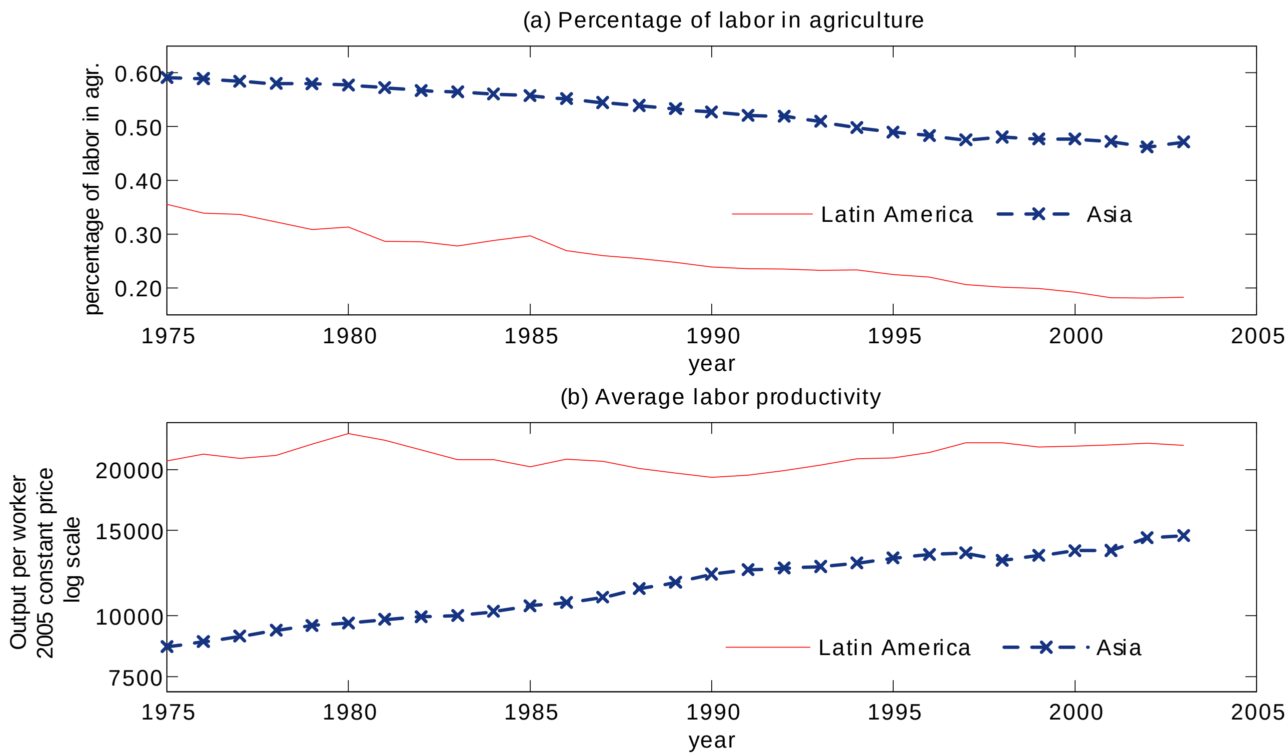

Figure 1: Percentage of labor in agriculture and average labor productivity, 1975-2003

sectors and decomposes the productivity growth rate of each country into three components: (1) the weighted average of the productivity growth rate of each sector; (2) the immediate productivity change due to reallocating labor to a sector with different productivity level; and (3) the subsequent productivity growth gain/loss because more resources are used in a sector whose productivity is higher/lower than the originated sector, i.e., the *amplification effect*.[2] The results reveal that the productivity gain from reallocation in Asia is high because the labor movement results in both an immediate jump in productivity and a high amplification effect. For Latin American countries, the amplification effect is small. In particular, the amplification effects are negative for several Latin American countries, i.e., Argentina, Bolivia, Brazil, and Venezuela. Therefore, the amplification effect is the key element that differentiates the contribution of reallocation to growth in Asia and Latin America.[3] This is the main result

[2]This approach is similar to that adopted by Syrquin (1984, 1986), Chenery and Syrquin (1989), Ark (1996), Maudos, Pastor and Serrano (2008), Timmer and Vries (2009), and McMillan and Rodrik (2011) among others. This study differs from theirs in that the formula used decomposes the growth rate of productivity rather than the level changes of productivity, and the equation is interpreted differently. Moreover, we further decompose the growth attributable to reallocation into two growth effects: (1) productivity increase; and (2) the subsequent growth gain/loss.

[3]This result—that the amplification is the key element—remains the same when we split the economy into agriculture, industry and services, and explore the growth attributes to reallocation among the three sectors. Moreover, we also run another analysis that sets a demarcation point at 1980 to study the early development

of the paper.

Next, we use a two-sector model to provide three guidelines for identifying the main driver of reallocation. This two-sector model—similar to Hayashi and Prescott (2008)—endogenizes the labor movement, which is driven by a combination of three exogenous drivers: labor push, labor pull, and reallocation cost reductions. As shown by Gollin et al. (2007), the labor structural transformation triggered by labor push is initiated by productivity growth in the agricultural sector, which releases farm labor from producing food for satisfying food needs, thereby permitting labor to move out of the agricultural sector, i.e., relaxing the food problem constraint. The labor structural transformation triggered by labor pull is initiated by productivity growth in the non-agricultural sector, which generates forces that pull labor to a sector with a higher marginal product of labor. Hansen and Prescott (2002) provide a model characterizing a version of labor pull effect. Finally, reallocation cost reductions, which are reductions in the costs associated with workers switching from agricultural to non-agricultural sectors (such as acquiring relevant skills, job search costs, or migration costs), reduce labor barriers for reallocation, thus triggering the labor structural transformation. Hayashi and Prescott (2008) provide a reduced-barrier mechanism of this type.

Our model shows that different drivers result in different types of productivity gains from reallocation, thus providing guidelines for identifying the main driver of reallocation. We show that that if the food problem constraint is not binding, labor push cannot be the main driver of labor reallocation. Moreover, labor-pull driven reallocation results in a positive amplification effect in general, whereas reallocation driven by reductions in reallocation costs results in a negative amplification effect. Since each driver has different data characteristics, we identify the main driver by checking the food problem constraint and the signs of the amplification effect.

Next, we apply the guidelines, identify each country's main driver of reallocation, and find that labor pull and reallocation cost reductions are the two main driver of labor reallocation. Labor pull is the major driver of labor reallocation in all Asian countries. However, for the Latin American countries, the labor pull effect is relatively weak. Furthermore, reallocation cost reduction is the main driver of the reallocation in Argentina, Bolivia, Chile, and Venezuela. Thus, we show evidence supporting that labor pull is the main driver of the Asian cases, whereas reallocation cost reductions also contributes to reallocation in Latin America. This result implies that labor pull is an indispensable driver of reallocation that can generate a large productivity gain and income convergence in Asia.

This result suggests that policies facilitating labor movement from agriculture to non-

and late development scenario. The amplification effect remains the key element that differentiates growth outcomes. For simplicity, I focus on the growth attributable to the labor reallocation from agriculture to non-agriculture in the main text and leave the other scenarios to Appendix A.

agriculture do not necessarily allow the underdeveloped countries to achieve income convergence with developed ones. Therefore, adopting policies that aim to reduce labor market frictions, such as abolishing barriers to labor structural transformation, has limited contribution to long-term economic performance. Instead, to generate large long-term productivity gain from reallocation, governments need policies that generate large labor pull effect. In other words, fostering sustainable growth in the non-agricultural sector, i.e., the sector to which labor or resources are reallocated is necessary for large long-term growth and income convergence.

This paper contributes to the literature that associates labor structural transformation with productivity growth. For example, a large body of work in the recent literature on misallocation (e.g., Jeong and Townsend, 2007; Hsieh and Klenow, 2009) shows that efficient allocation of labor contributes to TFP growth. Restuccia et al. (2008) and Vollrath (2009a) further point out that the cross-country income differences are attributed to barriers of reallocation that prevent resources for most efficient usage. We contribute to this literature by demonstrate that eradicating misallocation (in form of reducing reallocation cost) has a limited effect on long-term growth. This is because the reallocation-cost-reduction triggered reallocation generates a negative amplification effect, which cancels out the positive productivity gain due to moving resources to a more productive sector. Accordingly, this result raises an open question on the importance of labor allocation in explaining cross-country income differences.

Our work also contributes to the literature that explores the mechanism facilitating or hindering the labor reallocation out of the agricultural sector (e.g., Hayashi and Prescott, 2008; Alvarez-Cuadrado and Poschke, 2011; Üngör, 2012). Our work identifies the major driver of reallocation using an indicator different from that used in Alvarez-Cuadrado and Poschke (2011) and finds that labor pull is the main driver for Asian reallocation. This result is different from that of Alvarez-Cuadrado and Poschke. Moreover, Üngör assumes that the employment share is determined only by subsistence food needs and agricultural productivity, and finds that labor push can explain most of the labor structural transformation in ten Asian, nine Latin and nine Organisation for Economic Co-operation and Development (OECD) countries. Our work differs from his because we also allow non-agricultural productivity growth to affect the employment share in agriculture. Thus, we find a much larger role of labor pull. Finally, in line with Vollrath (2009b), our result suggests that the productivity growth of the non-agricultural sector is critical to long-run income convergence.

The remainder of this paper is organized as follows. Section 2 documents the stylized fact and describes the data. Section 3 discusses the arithmetic decomposition framework and the related results. Section 4 discusses the model used for identifying the main driver of reallocation. Section 5 determines the major driver of labor reallocation in Asia and Latin America using the decomposition results in Section 3 and the guidelines in Section 4. Section 6 offers concluding remarks.

2 Data sources and the stylized fact

We now describe the data used for measuring productivity (Section 2.1.) and document the stylized fact (Section 2.2).

2.1 The data sources

We adopt average labor productivity (ALP), i.e., output per worker, as the measurement for productivity. Accordingly, the data required are the number of employees and output by sector, e.g., the agricultural and non-agricultural sectors.

The data are obtained from the ten-sector database of the Groningen Growth and Development Centre (GGDC) as of June 2007 (Timmer and de Vries, 2007). This dataset contains data for ten Asian countries (Hong Kong, Indonesia, India, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand, Taiwan), and nine Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela).[4] Hereafter, Asia refers to these ten Asian countries and Latin American refers to these nine Latin American countries. We use constant price GDP as output and number of employees as labor input when computing the average labor productivity of these 19 countries.[5]

Finally, for pinning down the main driver of labor reallocation, we need data on the agricultural output per capita. Therefore, we also need the data for total population, which is obtained from Penn World Table 7.0.

2.2 The stylized fact

Based on this dataset, we find that Asian and Latin American countries have experienced a similar decline in the share of labor in agriculture (see Fig. 2). All countries in Asia, except S. Korea and Taiwan, can be matched with comparable countries in Latin American that have

[4] Table 1 summarizes the ALP growth and the percentage of labor in agriculture at the beginning and the end of the sampled period. We include the data for Singapore and Hong Kong, even though they are unique urban areas. This is because their percentage of labor in agriculture is still above 3% in the early 1970s, which is higher than that for developed countries such as the U.S. and the U.K.

[5] We use the output measured in local currency rather than the Purchasing Power Parity (PPP)-adjusted price because this study focuses on a time series rather than a cross-country comparison, and the study results are not subject to changes in exchange rates.

experienced similar magnitudes of decline after WWII.[6] Moreover, as shown in Table 1, due to the shorter sampled periods for Asia countries, the declines in the share of labor in agriculture in Asian countries are not necessarily larger than the declines in Latin American countries. (Asia: 2.92%-55.12% versus Latin America: 18.83%-45.78%).

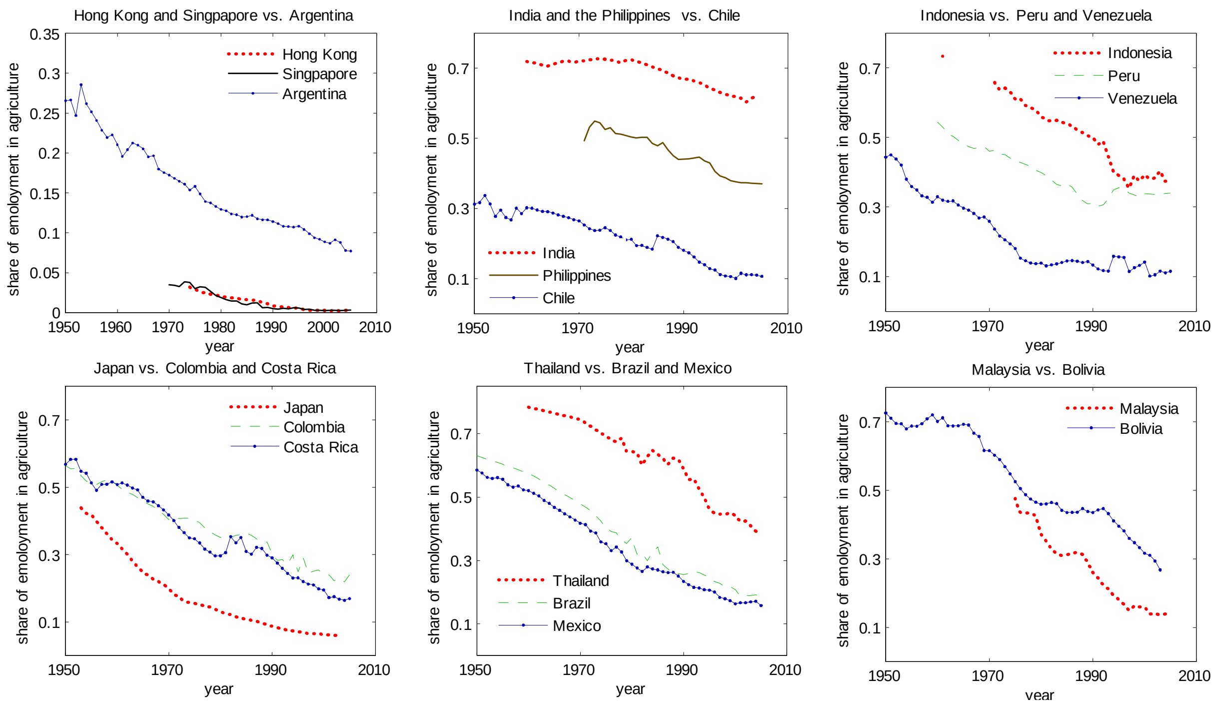

Figure 2: Percentage of labor in agriculture, country level (exclude S. Korea and Taiwan)

We now turn to the growth rate of ALP. We find that in general, the growth of ALP in Asia is higher than that of Latin America (see Table 1). The average annual growth rate of productivity in most Latin American countries (except Brazil) has been less than 2%, whereas that of most Asian countries (except India and the Philippines) has been more than 3%. Moreover, of the countries that have ALP growth rates lower than the first quartile, four of the five are Latin American countries.

Consequently, the Gross Domestic Product (GDP) per capita of Asian countries has significantly converged with that of developed countries, whereas few signs of convergence have been observed in Latin America. According to Penn World Table 7.0, on average, the income level of Asia relative to that of the U.S. increased from 14% (in 1960) to 43% (in 2005); that of Latin America relative to the U.S. decreased from 27% (in 1960) to 20% (in 2005).

[6] For Indonesia, the percentage point decline in the share of labor in agriculture, especially before 1990, is similar to that of Peru; moreover, the decline during 1971-2005 is similar to Venezuela's decline during 1956-1990. Malaysia's decline during 1975-2005 is similar to that of Bolivia during 1965-1995.

Table 1: Changes in the percentage of labor in agriculture and productivity growth

Country	Period	% of labor in agriculture, first year (1)	% of labor in agriculture, end year (2)	Changes (3)=(1)-(2)	ALP g (4)
Hong Kong	1974-2005	3.20%	0.28%	2.92%$^{\wedge}$	3.59%
Indonesia	1971-2005	65.85%	38.17%	27.69%	3.28%
India	1960-2004	71.88%	62.26%	9.61%$^{\wedge}$	2.59%
Japan	1953-2003	43.88%	5.96%	37.91%	3.89%‡
S.Korea	1963-2005	63.23%	8.12%	55.12%‡	4.42%‡
Malaysia	1975-2005	47.64%	13.94%	33.70%	3.90%‡
Philippines	1971-2005	49.25%	37.09%	12.16%$^{\wedge}$	0.87%$^{\wedge}$
Singapore	1970-2005	3.46%	0.32%	3.14%$^{\wedge}$	3.73%
Taiwan	1963-2005	50.52%	5.95%	44.57%‡	5.27%‡
Thailand	1960-2005	78.48%	38.62%	39.86%	3.96%‡
Argentina	1950-2005	26.54%	7.71%	18.83%$^{\wedge}$	0.81%$^{\wedge}$
Bolivia	1950-2003	72.56%	26.77%	45.78%‡	0.89%$^{\wedge}$
Brazil	1950-2005	63.06%	18.68%	44.38%‡	2.30%
Chile	1950-2005	31.26%	10.67%	20.58%	1.77%
Colombia	1950-2005	56.44%	23.89%	32.55%	1.47%
Costa Rica	1950-2005	56.79%	16.90%	39.90%	1.93%
Mexico	1950-2005	58.57%	15.77%	42.80%‡	1.70%
Peru	1950-2005	54.47%	34.08%	20.38%	1.09%$^{\wedge}$
Venezuela	1950-2003	44.32%	11.55%	32.77%	0.05%$^{\wedge}$

Notes:

1. There are 19 countries. We mark the numbers lower than the first quartile with $\wedge$, whereas the numbers higher than the third quartile are marked with $\ddagger$.
2. (1) and (2): number of employees in agriculture as a share of the aggregate. Data sourced from GGDC (see Section 2 for the description).
3. (3) =(1)-(2): This is the traditional measurement for the degree of labor structural transformation.
   (4): This is the growth rate of the average labor productivity. See Section 2.1 for the details.
4. The table shows that significant decline in the share of employment in agriculture does not guarantee high productivity growth.

Therefore, the data reveal that a similar magnitude of decline in the share of employment in agriculture does not necessary correspond to similar ALP growth and income convergence. For example, although the declines in their agricultural employment shares are similar, the ALP growth in Japan is much higher than that in Costa Rica (Japan: 3.9% vs. Costa Rica: 1.9%). Similarly, the ALP growth of Thailand is much higher than those of Brazil and Mexico (Thailand: 4.0% vs. Brazil: 2.3%, Mexico: 1.7%).

3 The decomposition analysis

We first discuss the decomposition formula (Section 3.1) and then show the decomposition results (Section 3.2). We find that the amplification effect is the key component that is different across Asian and Latin American countries, thus resulting in lower productivity gain from reallocation in Latin America. Accordingly, we examine why the amplification effect is larger in Asia than in Latin America (Section 3.3) and discuss why productivity growth in agriculture has limited contribution to long-term growth (Section 3.4).

3.1 The decomposition formula

We examine the formulas for average labor productivity under a two-sector framework to quantify the aggregate productivity growth arising from labor reallocation. We define average labor productivity and its growth rate under a two-sector framework. Then we show the arithmetic decomposition that allows us to identify the productivity growth originating from labor reallocation.

Recall that average labor productivity (ALP), which is defined as output divided by employment, is a measure of productivity. When ALP is expressed in a two-sector framework, the aggregate ALP is the weighted average of ALP in the agricultural and non-agricultural sectors. The weights assigned are the share of labor in each sector. The decomposition is as follows:

$$ALP_t^{agg} \equiv \frac{Y_t}{L_t} = \frac{q_t \cdot Y_t^F + Y_t^{NF}}{L_t^F + L_t^{NF}} = \frac{q_t \cdot Y_t^F}{L_t^F} \cdot \frac{L_t^F}{L_t^F + L_t^{NF}} + \frac{Y_t^{NF}}{L_t^{NF}} \cdot \frac{L_t^{NF}}{L_t^F + L_t^{NF}}, \tag{1}$$

$$\text{for } F_t \equiv \frac{L_t^F}{L_t^F + L_t^{NF}};\ ALP_t^F \equiv \frac{q_t \cdot Y_t^F}{L_t^F};\ ALP_t^{NF} = \frac{Y_t^{NF}}{L_t^{NF}},$$

$$\therefore ALP_t^{agg} = ALP_t^F \cdot F_t + ALP_t^{NF} \cdot (1 - F_t)\,. \tag{2}$$

Y_t represents output, and L_t is the number of workers. For all variables, subscript "t" means the variable is for time "t." Superscript "agg" means aggregate, "NF" represents the non-agricultural sector, and "F" is the agricultural sector. Next, q is the relative price (the price of non-agricultural output is 1) and F_t is the share of labor in the agricultural sector at time t.

Now we begin to decompose the ALP growth rate to identify the contribution of labor reallocation to aggregate ALP growth.

We first decompose ALP growth rate into two components: the total reallocation effect and productivity improvement, as shown by Eq. (3)[7]:

$$\frac{ALP_t^{agg}}{ALP_0^{agg}} - 1 = \left\{(F_0 - F_t) \cdot \left[\frac{ALP_0^{NF}}{ALP_0^{agg}} \cdot \frac{ALP_t^{NF}}{ALP_0^{NF}} - \frac{ALP_0^{F}}{ALP_0^{agg}} \cdot \frac{ALP_t^{F}}{ALP_0^{F}}\right]\right\} + W_0 \cdot \left[\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right] + (1 - W_0) \cdot \left[\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right], \quad (3)$$

where $W_0 \equiv F_0 \cdot \frac{ALP_0^F}{ALP_0^{agg}}$. From Eq. (2), one can obtain $1 - W_0 = (1 - F_0) \cdot \frac{ALP_0^{NF}}{ALP_0^{agg}}$.

The total reallocation effect—the first component on the right-hand side of Eq. (3)—represents the contribution of labor reallocation to the aggregate ALP growth rate. The remaining two components are the weighted average of the ALP growth rates in the agricultural and non-agricultural sectors; this is the productivity improvement.

Furthermore, we separate the total reallocation effect into the pure reallocation effect and the amplification effect. We further decompose the total reallocation effect because this term is our focus—our primary goal is to explain why labor reallocation in Asia has generated greater aggregate ALP growth than in Latin America. We transform Eq. (3) into Eq. (4) as follows:

$$\begin{aligned} \frac{ALP_t^{agg}}{ALP_0^{agg}} - 1 = & \left\{(F_0 - F_t)\left[\frac{ALP_0^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{F}}{ALP_0^{agg}}\right]\right\} \\ + & \left\{(F_0 - F_t)\left[\frac{ALP_0^{NF}}{ALP_0^{agg}}\left(\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right) - \frac{ALP_0^{F}}{ALP_0^{agg}}\left(\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right)\right]\right\} \\ + & W_0 \cdot \left[\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right] + (1 - W_0) \cdot \left[\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right]. \end{aligned} \quad (4)$$

The pure reallocation effect is the first component in Eq. (4), and its value can be obtained by setting the productivity growth rate in each sector to zero. This term captures the immediate increase in productivity resulting from moving labor from a relatively low productivity sector to a relatively high productivity sector. This is generally a movement from agriculture to non-agriculture.

The amplification effect is the second term on the right-hand side of Eq. (4), and its value is the difference between the total reallocation effect and the pure reallocation effect. This amplification is the productivity growth resulting from the reallocating labor from one sector to a sector with a larger productivity increase. Based on the formula, the amplification effect can be positive even when the growth rates in the agricultural and non-agricultural sectors are the same, as long as the initial non-agricultural ALP is larger than the initial agricultural ALP. This is because the sector with larger initial ALP needs larger changes in ALP to obtain

[7] The detailed procedure of the decomposition is in Appendix B.

the same growth rate as the sector with smaller initial ALP.

In sum, ALP growth is decomposed into the following three parts: (1) the growth attributed to productivity growth but not due to labor reallocation (*productivity improvement*); (2) the growth attributed to a one-time productivity jump resulting from reallocating labor from a relatively low to a relatively high productivity sector (the *pure reallocation effect*); and (3) the growth attributed to labor reallocated to a sector that has larger productivity increase than the originating sector (the *amplification effect*). The sum of the pure reallocation effect and the amplification effect is the *total reallocation effect*.

3.2 The decomposition results

We now apply data to the decomposition formula to identify which variable underlying the ALP growth rate is the key element that differentiates the ALP growth rates in Asian and Latin American countries. We first decompose ALP growth into productivity improvements and the total reallocation effect (Section 3.2.1). Then we focus on the growth attributable to labor reallocation and decompose the total reallocation effect into the pure reallocation effect and the amplification effect (Section 3.2.2). The results are shown in Table 2.

3.2.1 First layer of decomposition

Now we separate ALP growth rate into two components: productivity improvements and total reallocation effects. The results are shown in Table 2. Overall, Asian ALP growth rates were high because both components, i.e., the productivity improvement and the total reallocation effect, are relatively large compared with those of Latin American countries.

More specifically, when examining the contribution of labor reallocation to ALP growth, i.e., the total reallocation effect, we find that this effect was generally much larger in Asian countries than in Latin American countries. The exception is for Hong Kong, Singapore, and the Philippines, whose values fall below the first quartile. See column (3) in Table 2. The total reallocation effect in Asia ranges from 0.12% to 2.27%, whereas that in Latin American ranges from 0.04% to 0.96%. In particular, for Thailand and Taiwan, the labor reallocation raises the annualized productivity growth by more than 2 percentage points. Such augmentation is significant compared with the aggregate productivity growth of the other countries (column (1) in Table 2). For most of the Latin American countries (except Brazil), the annualized ALP growth rate was $0.05\% - 1.93\%$.

Thus, we conclude that labor reallocation had a larger impact in Asian countries than in Latin American countries even though Asian and Latin American countries have experienced a similar decline in their share of employment in agriculture.

Table 2: Results of ALP decomposition

Country	Period	ALP g	Productivity improvement	Total reallocation	Pure reallocation	Amplification
		(1)	(2)	(3)	(3.1)	(3.2)
Hong Kong	1974-2005	3.59%	3.47%‡	0.12%$^\wedge$	0.02%$^\wedge$	0.10%
Indonesia	1971-2005	3.28%	1.92%	1.36%‡	0.64%	0.72%‡
India	1960-2004	2.59%	1.95%	0.64%	0.10%$^\wedge$	0.54%
Japan	1953-2003	3.89%‡	2.61%	1.28%‡	0.27%	1.01%‡
S.Korea	1963-2005	4.42%‡	3.20%‡	1.22%‡	0.63%	0.59%‡
Malaysia	1975-2005	3.90%‡	2.92%‡	0.98%	0.49%	0.49%
Philippines	1971-2005	0.87%$^\wedge$	0.56%$^\wedge$	0.30%$^\wedge$	0.25%$^\wedge$	0.05%
Singapore	1970-2005	3.73%	3.62%‡	0.12%$^\wedge$	0.02%$^\wedge$	0.09%
Taiwan	1963-2005	5.27%‡	3.21%‡	2.06%‡	0.37%	1.69%‡
Thailand	1960-2005	3.96%‡	1.69%	2.27%‡	0.84%‡	1.43%‡
Argentina	1950-2005	0.81%$^\wedge$	0.78%$^\wedge$	0.04%$^\wedge$	0.26%	−0.23%$^\wedge$
Bolivia	1950-2003	0.89%$^\wedge$	0.33%$^\wedge$	0.56%	1.71%‡	−1.15%$^\wedge$
Brazil	1950-2005	2.30%	1.34%	0.96%	0.79%‡	0.17%
Chile	1950-2005	1.77%	1.53%	0.23%$^\wedge$	0.23%$^\wedge$	0.00%$^\wedge$
Colombia	1950-2005	1.47%	1.04%	0.43%	0.41%	0.02%
Costa Rica	1950-2005	1.93%	1.40%	0.53%	0.52%	0.01%$^\wedge$
Mexico	1950-2005	1.70%	0.81%	0.88%	0.81%‡	0.08%
Peru	1960-2005	1.09%$^\wedge$	0.48%$^\wedge$	0.61%	0.57%	0.04%
Venezuela	1950-2005	0.05%$^\wedge$	−0.30%$^\wedge$	0.35%	0.94%‡	−0.59%$^\wedge$

Notes:
1. There are 19 countries in the sample. We mark the numbers lower than the first quartile with $\wedge$, whereas the numbers higher than the third quartile are marked with ‡. "Total reallocation" refers to the total reallocation effect. "Pure reallocation" refers to the pure reallocation effect and "Amplification" is the amplification effect.
2. The numbers reported are in terms of average annual growth rate
3. Sources:
(1): the average annual growth rate of average labor productivity (ALP).
(1) = (2) + (3);
(3) = (3.1) + (3.2)
See Section 3 for the details.
4. This table demonstrates that the high total reallocation effect in Asia is attributable to the high amplification effect.

3.2.2 Second layer of decomposition

We then separate the total reallocation effect into the pure reallocation effect and the amplification effect to find out which component is critical in generating relatively high productivity gains from reallocation in Asia and relatively low productivity gain in Latin America.

We find a pure reallocation effect of similar size across Asian and Latin American countries. The pure reallocation effect contributes positively to long-term aggregate ALP growth, and variations across countries are relatively small (more than 2/3 of the samples have values of $0.25\% - 0.85\%$). Moreover, the annualized growth rate created by the pure reallocation effect is $0.02\% - 0.84\%$ in Asia and $0.23\% - 1.71\%$ in Latin America.

In contrast to the similarities mentioned above, we find that the amplification effect—the other component of the total reallocation effect—is larger in Asia than in Latin America. All Asian countries have a positive amplification effect, accounting for more than 0.4 percentage points of the annual growth rate in seven out of ten Asian countries (with the exception of Hong Kong, Singapore, and the Philippines). Conversely, no Latin American country has an amplification effect larger than 0.4%. In fact, four out of nine Latin American countries experienced a negative amplification effect.

To summarize, the decomposition analysis demonstrates that a high amplification effect in Asia and a low amplification effect in Latin American is the key difference underlying different ALP growth due to reallocation in Asia and Latin America. In other words, in Latin America, the labor reallocation only generated a one-time productivity jump. Although this jump can be large, the average of this one-time ALP growth and the low ALP growth rate of the reallocated sector in the subsequent years is small, thus resulting in a small long-term effect.

3.3 More on the amplification effect

We now reexamine the decomposition formula to explore why the amplification effect of the selected Asian countries is much higher than that of the selected Latin American countries. From Eq. (4), one can see that the large amplification effect should come from either (1) high ALP growth of the non-agricultural sector relative to that of the agricultural sector, or (2) the relatively high ALP of the non-agricultural sector in the first year of the sample period. Since the pure reallocation effect captures the second effect and this study has already shown that the pure reallocation effect is similar in Asian and Latin American countries, we then examine the hypothesis that the amplification effect in Asia is high because their relative productivity growth in the non-agricultural sector to the agricultural sector is high.

To support this hypothesis, we show the ratio of the ALP growth rate of the non-agricultural sector to that of the agricultural sector in Asia and Latin America (see column (3) in Table 3). As can be seen, the ratio is greater than 0.6 for Asian countries, and less than 0.5 for Latin American countries. Moreover, the non-agricultural ALP growth of Bolivia and Venezuela are negative (column (1) in Table 3). This fact implies that for Latin American countries, the relatively low ALP growth in the non-agricultural sector contributes to the relatively small amplification effect, thus resulting in Latin America's small gain from reallocation and slow income convergence with developed countries.

Table 3: ALP growth ratio and gap: agriculture vs. non-agriculture

Country	ALP growth in non-agricultural sector (1)	ALP growth in agricultural sector (2)	ALP growth ratio non-agriculture to agriculture (3)=(1)/(2)	ALP gap ratio end year/first year (4)
Hong Kong	3.55%	0.40%	8.86	5.52
Indonesia	2.27%	2.36%	0.96	2.12
India	3.24%	0.73%	4.44	6.64
Japan	3.19%	3.32%	0.96	4.69
S.Korea	3.00%	4.87%	0.62	1.94
Malaysia	3.02%	3.79%	0.79	1.99
Philippines	0.58%	0.62%	0.93	1.20
Singapore	3.69%	1.93%	1.91	5.34
Taiwan	4.20%	4.23%	0.99	5.61
Thailand	2.33%	2.76%	0.84	2.71
Argentina	0.41%	2.93%	0.14	0.14
Bolivia	−0.82%	2.23%	−0.37	0.33
Brazil	1.05%	3.14%	0.33	1.22
Chile	1.32%	3.32%	0.40	0.99
Colombia	0.81%	1.73%	0.47	1.04
Costa Rica	1.07%	2.51%	0.43	1.02
Mexico	0.63%	2.15%	0.29	1.09
Peru	0.37%	1.38%	0.27	1.07
Venezuela	−0.81%	2.83%	−0.29	0.37

Notes:

1. Sources:

(1): the average labor productivity growth of the non-agricultural sector, average annual growth rate

(2): the average labor productivity growth of the agricultural sector, average annual growth rate

(3)= (1)/(2): the average labor productivity growth ratio of non-agriculture to agriculture

(4): $\frac{\text{the non-agricultural ALP minus the agricultural ALP at the first year}}{\text{the non-agricultural ALP minus the agricultural ALP at the end year}}$ (Values larger than 1 implies that the gap enlarges.)

2. The table shows that in Asia, the relative growth of non-agricultural to agriculture is high (relative to Latin America) and the productivity gap enlarges (while the gap remains roughly the same or reduced in Latin America countries).

3.4 The role of the agricultural productivity growth

Now we focus on how the growth of the agricultural sector contributes to long-term growth. The agricultural ALP growth rate of most countries is in the range of $1\% - 4\%$, except Hong Kong (0.4%), India (0.7%), South Korea (4.9%), the Philippines (0.6%), and Taiwan (4.2%). See column (2) in Table 3. This result suggests that the agricultural productivity growth of Latin America is not significantly different from that of Asia.

Then, we reexamine the decomposition formula to address the issue of why agricultural productivity growth does not significantly contribute to long term ALP growth. There are two reasons. First, the weight (w_0) assigned to agricultural ALP growth in computing aggregate ALP growth is the product of two variables: the share of employment in agriculture and the ALP in the agricultural sector relative to the aggregate ALP in the first year. For most of the countries in our sample (except India), the ratio of agricultural ALP to aggregate ALP is typically less than 0.6 in the first year, even though the share of employment in agriculture can be more than 50%. Thus, the weight assigned to agricultural ALP growth in computing aggregate ALP growth is small. The weight is less than 0.35 for 17 out of 19 countries. See Table 4.

Second, relatively high productivity growth in the agricultural sector can result in a negative amplification effect. When agricultural productivity change is larger than non-agricultural productivity change, reallocating labor from the agricultural sector to the non-agricultural sector implies that workers are reallocated to the sector with smaller productivity increase than their originating sector. Such a dynamic results in a negative amplification effect (we will discuss this issue in detail in Section 4.2), which cancels out the positive contribution of the pure reallocation effect to total reallocation effect, and thus undermines the contribution of labor reallocation to productivity gain.

4 The model used for identifying the main driver of reallocation

We use a two-sector model, similar Hayashi and Prescott (2008), to identify the mechanisms driving the labor reallocation after WWII. We first set up the model (in Section 4.1), and then discuss the model's implication for the main driver of labor reallocation (Section 4.2). Finally, we list the guidelines for identifying the main driver of labor reallocation based on the model's propositions (Section 4.3).

4.1 The Model

The model economy is a two-sector model, comprising the agricultural and non-agricultural sectors. This economy is composed of a representative household and producers in a perfect foresight environment. Based on Hayashi and Prescott (2008) research, which examines the role of labor barriers created by a patriarchal system, we modify the model by assuming that labor barriers are created due to the need for food (which is the focus of the literature on labor push) and that there is a cost of acquiring access to the non-agricultural sector. In this model, the household endogenously determines the percentage of labor to be allocated to the

Table 4: The composite of the weight (w_0)

Country	Period	% of labor in agriculture, first year (1)	ALP ratio, agriculture to aggregate (2)	weight (w_0) (3)=(1) × (2)
Hong Kong	1974-2005	3.20%	0.59	0.02
Indonesia	1971-2005	65.85%	0.52	0.34
India	1960-2004	71.88%	0.77	0.56
Japan	1953-2003	43.88%	0.40	0.18
S.Korea	1963-2005	63.23%	0.51	0.32
Malaysia	1975-2005	47.64%	0.58	0.28
Philippines	1971-2005	49.25%	0.59	0.29
Singapore	1970-2005	3.46%	0.54	0.02
Taiwan	1963-2005	50.52%	0.41	0.21
Thailand	1960-2005	78.48%	0.46	0.36
Argentina	1950-2005	26.54%	0.29	0.08
Bolivia	1950-2003	72.56%	0.31	0.22
Brazil	1950-2005	63.06%	0.29	0.18
Chile	1950-2005	31.26%	0.28	0.09
Colombia	1950-2005	56.44%	0.54	0.30
Costa Rica	1950-2005	56.79%	0.46	0.26
Mexico	1950-2005	58.57%	0.30	0.18
Peru	1960-2005	54.47%	0.26	0.14
Venezuela	1950-2005	44.32%	0.11	0.05

Notes:
1. Sources:
(1): $F_{0,}$ share of labor in agriculture in the first year. Data sourced from GGDC. (See Section 2 for the description)
(2): the average labor productivity of agricultural sector relative to the aggregate in the first year (Self claculation)
(3)= (1)×(2): the weight w_0 (See Section 3.1 for the description.)
2. The table shows that the weights assigned to compute the contribution of agricultural productivity growth to aggregate productivity growth are small in general.

agricultural sector and non-agricultural sectors by equating the marginal benefits of working in the agricultural and the non-agricultural sectors while satisfying a minimum level of food need. Therefore, the model has the feature that the sectoral reallocation can be driven by changes in sectoral productivity and changes in reallocation costs.

This model has two production technologies: one is the technology adopted in the agricultural sector, and the other is adopted in the non-agricultural sector. Both technologies exhibit diminishing returns to labor. As in Alvarez-Cuadrado and Poschke (2011), we abstract from capital so that we can focus on the labor reallocation across sectors, which is

$$Y_{1t} = TFP_{1t}L_{1t}^{\eta}, \tag{5}$$
$$Y_{2t} = TFP_{2t}L_{2t}^{\theta}, \tag{6}$$

where Y_{it} is output at time t for sector i={1,2}={agricultural and non-agricultural sectors}; TFP_{it} is the total factor productivity (TFP) at time t for each sector; and L_{it} is labor in each sector at time t. The parameters η and θ are the labor share of agricultural and non-agricultural production, respectively. Since this study focuses on labor allocation, for simplicity, we assume no financial intermediation costs exist, which differs from the study by Hayashi and Prescott (2008). The first-order conditions, which equate the marginal productivity of Eqs. (5) and (6) to wages, are as follows:

$$\text{Agriculture: } w_{1t} = \eta \cdot q_t \cdot TFP_{1t} \cdot L_{1t}^{\eta-1} \tag{7}$$
$$\text{Non-agriculture: } w_{2t} = \theta \cdot TFP_{2t} \cdot L_{2t}^{\theta-1}, \tag{8}$$

where q_t is the price of agricultural goods relative to that of non-agricultural goods.

An infinitely-lived representative family with N_t working-age members at time t exists. The size of this household evolves over time with an exogenous growth rate. The utility function is as follows:

$$\sum_{t=0}^{\infty} \beta^t N_t u\left(c_{1t}, c_{2t}\right) = \sum_{t=0}^{\infty} \beta^t N_t \left\{a \log\left(c_{1t} - \overline{c}\right) + (1-a) \log\left(c_{2t}\right)\right\}, \tag{9}$$

where c_{1t} and c_{2t} are per member consumption of agricultural and non-agricultural goods in period t, respectively, and $\overline{c} > 0$ is the subsistence level of agricultural goods. The household takes L_t ($L_t = L_{1t} + L_{2t}$) as given and then decides how to divide its labor into agricultural ($L_{1t} = F_t \cdot L_t$) and non-agricultural sectors ($L_{2t} = (1 - F_t) \cdot L_t$). The discount factor is β. The period budget constraint is

$$q_t N_t c_{1t} + N_t c_{2t} = w_{1t} F_t L_t + w_{2t} \cdot (1-\xi)\left(1 - F_t\right) L_t + \pi_t, \tag{10}$$

where δ is the depreciation rate, π_t is profit, and ξ is the cost of acquiring access to the non-agricultural sector (e.g., education) in each period per working member, $\xi \leq 1$. ξ is exogenously given and only applies to labor working in the non-agricultural sector. As the cost of labor moving to the non-agricultural sector increases, the value of ξ increases.

Of particular note, F_t, the share of labor in the agricultural sector, is determined by relative wages in the agricultural and non-agricultural sectors.

$$F_t \cdot L_t = \begin{cases} \left(\frac{N_t \bar{c}}{TFP_{1t}}\right)^{\frac{1}{\eta}} & if \frac{w_{1t}}{w_{2t} \cdot (1-\xi)} < 1 \\ L_t & if \frac{w_{1t}}{w_{2t} \cdot (1-\xi)} > 1 \\ \in \left[\left(\frac{N_t \bar{c}}{TFP_{1t}}\right)^{\frac{1}{\eta}}, 1\right] & if \frac{w_{1t}}{w_{2t} \cdot (1-\xi)} = 1. \end{cases} \tag{11}$$

4.2 Propositions

The model shows that various forces, i.e., labor push, labor pull, and reallocation cost reductions, each of which has different growth implications, drive labor structural transformation from agriculture to non-agriculture. Under this model, the labor market equilibrium can be reduced to the following three scenarios: (1) $w_{1t} < w_{2t} \cdot (1 - \xi)$; (2) $w_{1t} > w_{2t} \cdot (1 - \xi)$; and, (3) $w_{1t} = w_{2t} \cdot (1 - \xi)$. We will discuss what each force, i.e., labor push, labor pull and reallocation cost reductions, implies about the sign of amplification effect.

First, when $w_{1t} < w_{2t} \cdot (1 - \xi)$, the household prefers to allocate a higher percentage of labor to the non-agricultural sector than to the agricultural sector, but the food problem characterized by Schultz (1953) keeps labor in the agricultural sector. Then, technological improvement in the agricultural sector generates a force that pushes labor out of the agricultural sector, i.e., the labor push scenario. This scenario has the following data characteristics:

Proposition 1 *If there is no technological improvement in the non-agricultural sector, a dominant "labor push" driving force for labor structural transformation leads to a negative amplification effect.*

Under this labor push scenario, agricultural technology improves while the non-agricultural technology remains the same. Improved agricultural technology, which manifests as TFP improvement in this model, raises the agricultural ALP, and thus initiates the labor reallocation because fewer workers are needed to produce enough food. As additional labor moves to the non-agricultural sector, the ALP of the non-agricultural sector declines and the ALP of the agricultural sector further increases. The negative ALP growth in the non-agricultural sector and the positive ALP growth in the agricultural sector corresponds a negative amplification effect.

When $w_{1t} > w_{2t} \cdot (1 - \xi)$, the household prefers to allocate a higher percentage of labor to the agricultural sector than to the non-agricultural sector. If this inequality holds in equilibrium, all laborers would choose to work in the agricultural sector because the wage is higher. Then, we should observe all laborers working on farms. Since the data do not show that all laborers work on farms, this scenario is excluded.

When $w_{1t} = w_{2t} \cdot (1 - \xi)$, based on Eqs. (7) and (8), this equality is transformed to Eq. (12):

$$\eta \frac{q_t Y_{1t}}{L_{1t}} = \theta \left(1 - \xi\right) \frac{Y_{2t}}{L_{2t}}. \tag{12}$$

Based on Eq. (12), a relatively large technological improvement in the non-agricultural sector, which manifests as a non-agricultural TFP improvement in this model, can lead to the movement of labor from the agricultural sector to the non-agricultural sector and, thus, the equality relationship is restored, ceteris paribus. Such movement is the so-called labor pull effect. This leads to the second proposition:

Proposition 2 *If there is no technological improvement in the agricultural sector, a dominant "labor pull" driving force for labor structural transformation leads to a positive amplification effect (as long as productivity of the non-agricultural sector is higher than that of the agricultural sector before the reallocation process begins).*

Under the "labor pull" scenario, non-agricultural technology improves while the agricultural technology remains the same. In this scenario, labor moves out of the agricultural sector to restore the equilibrium. Eventually, based on Eq. (12), the ALP growth rates for both the agricultural and non-agricultural sectors converge to the same rate so that the equilibrium is restored. When non-agricultural ALP is higher than agricultural ALP before the labor reallocation process begins and ALP grows at the same rate in both agriculture and non-agriculture, the increase of non-agricultural ALP is larger than that of agricultural sector. Thus, labor pull is associated with a positive amplification effect (see Appendix C for a numerical proof).

Finally, abolition of labor barriers for labor reallocation from the agricultural sector to the non-agricultural sector manifests as a declining ξ in the model. A barrier reduction includes, but is not limited to, a cost reduction for job searches in the non-agricultural sector, reduced migration costs from rural to urban areas, and reduced costs of acquiring skills to work in the non-agricultural sector. This leads to Proposition 3:

Proposition 3 *When the cost of labor reallocation (ξ) is reduced, the labor reallocation in response to such a change generates a negative amplification effect, ceteris paribus.*

When the cost of labor reallocation is reduced, the right-hand side of Eq. (12) becomes larger than the left-hand side. To restore equilibrium, labor moves from the agricultural sector to the non-agricultural sector. Such labor movement results in an increase of the agricultural ALP and a decline of the non-agricultural ALP. Consequently, such dynamics result in a negative amplification effect.

4.3 The guideline for identifying the main driver

Based on the propositions, we suggest three guidelines for identifying the main drivers of labor reallocation (labor pull, labor push, and the reduction of reallocation cost).

The model suggests that labor push can drive labor out of the agricultural sector when the food problem prevails. Then, as the agricultural technology improves, more laborers are released to the non-agricultural sector, holding the agricultural output per capita constant. Under this scenario, the agricultural output per capita does not grow though agricultural ALP rises. Therefore, the growth rate of agricultural output per capita can be used to examine the existence of a food problem as well as the effect of labor push on labor reallocation. This conclusion leads to the first guideline.

Guideline 1 *When agricultural productivity growth is positive, changes in per capita agricultural output precludes the existence of labor push.*

The model implies that labor push exists only when $Y_{1t} = N_t \cdot \bar{c}$. If the agricultural output grows slower than the population, it implies that the amount of food produced in the earlier period is more than sufficient for fulfilling the food need. Thus, the food problem does not exist at all and there is no room for labor push to function. By contrast, if agricultural output per capita grows, it implies that the amount of food produced in the later period is more than sufficient for fulfilling the food need. Thus, the food problem does not exist either and again there is no room for labor push to function.

Now we turn to the scenarios in which the food problem does not exist: labor pull and reallocation cost reductions. We have guideline 2 for identifying the existence of labor pull and reallocation cost reductions.

Guideline 2 *When we observes laborers move from agriculture to non-agriculture but labor push does not exist, a positive ALP growth rate in non-agriculture implies the existence of labor pull, and a negative ALP growth rate in non-agriculture implies the existence of reallocation cost reductions.*

In Section 4.2 we suggest that labor pull results in rising non-agricultural ALP and that reallocation cost reductions lead to falling non-agricultural ALP. Therefore, the sign (positive/negative) of the ALP growth rate in non-agricultural sector can be used as the indicator for the existence of labor pull or reallocation cost reductions.

Finally, after determining the existence of each driver, we can further pin down the main driver of labor reallocation using guideline 3:

Guideline 3 *A positive amplification effect implies that labor pull is the main driver of labor reallocation. A negative amplification effect implies that labor push or reallocation cost reductions are the main driver of labor reallocation.*

The sign of the amplification effect is used to pin down the main driver of labor reallocation. Based on proposition 2, when labor pull is the main driver of reallocation, we observe a positive amplification effect. This feature is unique among all the drivers. Therefore, when the sign of the amplification effect is positive, we conclude that labor pull is the dominant driver. On the other hand, recall that propositions 1 and 3 suggest that for either labor push or reallocation cost reductions being the main driver, we observe negative amplification effect. Finally, recall, to differentiate labor push versus reallocation cost reductions, we rely on guideline 1 because labor push exists only when food problem prevails.

5 The drivers of labor reallocation

Now we use the guidelines to identify the main drivers of labor reallocation in Asia and Latin America (Section 5.1). Then we provide some supporting evidence (Section 5.2) and discuss the policy implication of the result (Section 5.3).

5.1 Identify the main driver

The ALP growth of the agricultural sector is positive for all of the countries examined (see column (2) in Table 3) and growth rates of total agricultural output per capita are always nonzero. As shown in Figure 3, agricultural output per capita varies over time for all countries. Although the time paths for Argentina and Mexico are relatively flat, their growth rates still exceed 0.1%. Therefore, based on Guideline 1, we conclude that the labor push effect cannot be the main driver of labor reallocation for the period studied and Eq. (12) holds for all countries.

Moreover, the data show that (1) all the countries examined have experienced labor movement from the agricultural to the non-agricultural sector to some extent (see Table 1) and (2) the ALP growth of the non-agricultural sector is positive for most of the countries, except for

Bolivia and Venezuela (see column (1) in Table 3). Therefore, labor pull is triggering some labor reallocation in most countries (based on Guideline 2).

We now pin down the major mechanism that triggers the labor reallocation. Based on the above discussion, we can pin down the main driver following Guideline 3 because we rule out the labor push scenario. We find that labor pull is the dominant driver of labor reallocation in all Asian countries because their amplification effect is positive. On the other hand, reallocation cost reductions play the main role in Argentina, Bolivia, Chile and Venezuela because their amplification effect is negative.[8]

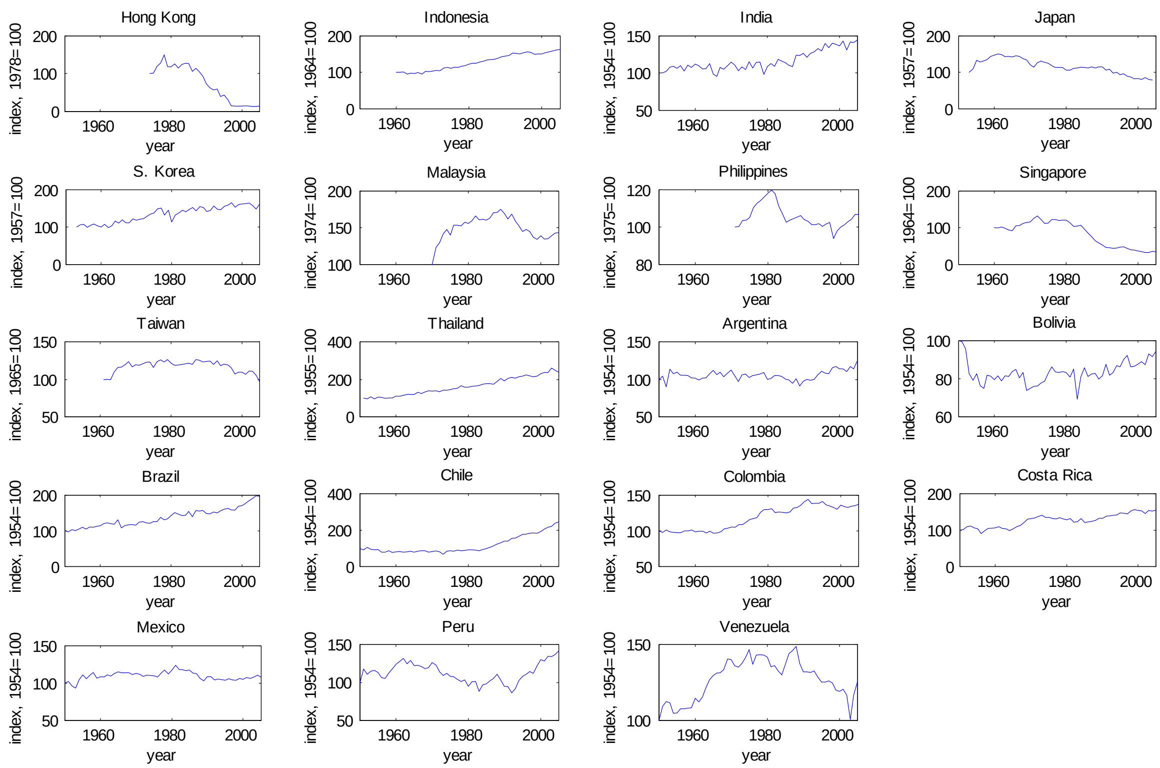

Figure 3: Agricultural output per capita

[8]This result is different from Alvarez-Cuadrado and Poschke (2011), in which they conclude that labor push is the dominant effect after WWII for S. Korea, Japan, and some European countries. Their conclusion is based on the observation that the relative price of non-agricultural goods to agricultural goods had a clear rising trend after WWII (they use a model to illustrate that a rising/falling relative price signifies that labor push/labor pull is the dominant force of labor reallocation). Their approach has at least three disadvantages: First, the price changes are subject to factors other than productivity changes. Second, their approach has the limitation that there cannot be any technological decline. Finally, as they admit, they cannot clearly determine whether labor push effects dominate unless the price increase is strong. Thus, how strong is strong is semantic. We improve on their approach by first examining the data to see whether the food problem exists, then using a different measurement, i.e., the change of the amplification effect, to identify the dominant force driving the labor reallocation. The only assumption we make is that when the period begins, the agricultural productivity is lower than the non-agricultural productivity, which is a prevailing phenomenon early in development. Thus, this condition holds for all the countries in the sample.

5.2 Supporting evidences

We explore the evidence supporting a stronger reallocation-cost-reduction effect in Latin America than in Asia. Moreover, we discuss the evidence that supports the existence of a stronger labor pull effect in Asia.

We use Eq. (12) to pin down the evolution of the reallocation cost and find that the reallocation cost has generally fallen more dramatically in Latin America than in Asia. We assume that the labor share of the agricultural sector is 0.46 and that of the non-agricultural sector is 0.67. (According to Table 2 in Valentiniyi and Herrendorf, 2008, the capital share for agriculture and non-agriculture are 0.54 and 0.33, respectively. This choice of the parameter values only affects the levels, not the trend, of the cost.)

Figure 4 shows the imputed reallocation cost of 19 countries. As can be seen, the cost has increased for some Asian Countries: Hong Kong, India and Singapore. For the rest of the Asian countries, the cost has reduced by 0.24% (Taiwan) to 10.26% (Malaysia), except for S. Korea. For Latin American countries, the cost has reduced by 14.68% (Mexico) to 55.84% (Argentina), except Peru (which reduced by 6.07%). Therefore, the effect of reallocation cost reductions is larger in Latin America than in Asia in general.

Moreover, we find significant cost reduction in Argentina, Bolivia, and Chile (more than 30%). This result supports our finding that the reallocation cost reductions are the main driver of the reallocation in these countries.

However, there are two special cases: S. Korea and Venezuela. The reallocation cost reductions in S .Korea are similar to Venezuela but our guideline suggests that the labor pull effect is the main driver for S. Korea's reallocation and reallocation cost reductions are the main driver of Venezuela's reallocation. This is because the ALP growth of the non-agricultural sector in S. Korea is 3%, which creates a strong labor pull effect, thus canceling out the negative amplification effect generated by reallocation cost reductions. By contrast, the Venezuela's non-agricultural ALP growth rate is negative, thus reallocation cost reductions are the dominant force driving the reallocation, despite that its cost reduction is similar to S. Korea.

Next, we show that there are at least two pieces of evidence that support the strong labor pull effect in Asia. First, recall that if there were no productivity growth in the non-agricultural sector, implying no labor pull effect, the labor released to the non-agricultural sector decreases the non-agricultural ALP. Accordingly, the first piece of evidence we find is that the Asian non-agricultural ALP does not decrease. The ALP growth rates are larger than 2% for each of the Asian countries except for the Philippines (0.58%). See column (1) in Table 3.

Second, we find that in Asia, the productivity gap across sectors expanded despite the fact that there has been significant labor movement from agriculture to non-agriculture. Large scale

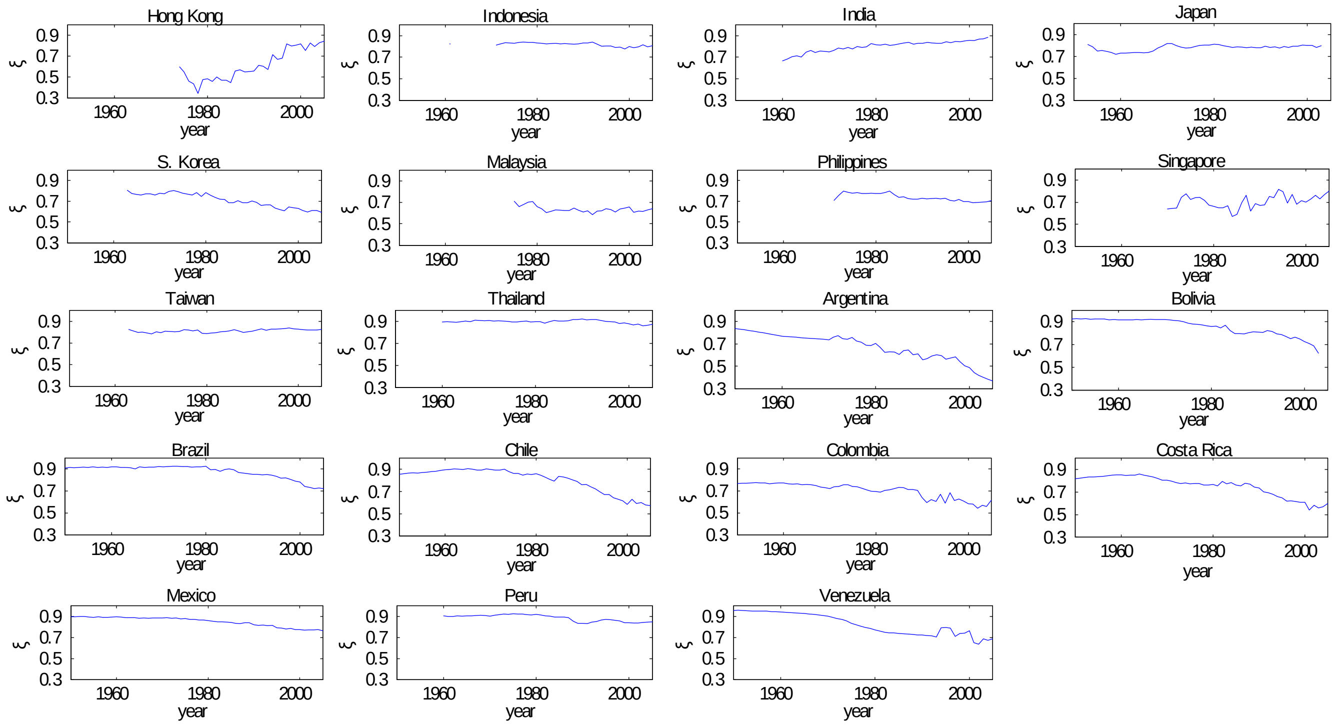

Figure 4: The imputed reallocation cost

labor movement from agriculture to non-agriculture should raise the agricultural productivity and reduce the non-agricultural productivity, thus reducing the productivity gap across sectors. We report the ratio of the difference between the ALP of the non-agriculture and agriculture sectors in the last year to the first year in column (4) of Table 3. The values greater than one imply that the gap has increased, whereas the values less than one imply that the gap has narrowed. As can be seen, the productivity gap across the agricultural and non-agricultural sectors increased for all Asian countries.

This productivity gap increase implies that there must be some technological improvement, e.g., TFP increases, in the non-agricultural sector working behind the scenes that allows the non-agricultural sector to "absorb" a significant number of workers moving out of the agricultural sector without reducing non-agricultural ALP or shrinking the ALP gap for a substantial length of time. This indicates the existence of strong labor pull effects in Asia.

These Asian patterns differs markedly from those in Latin America. The Latin American ALP growth rates of the non-agricultural sector and changes in the productivity gap over time together suggest that labor pull effects are relatively weak in Latin American countries. First, the growth rates in the non-agricultural sector are relatively small. The data show that the ALP growth rates are less than 1.4%; the value are even negative for Bolivia and Venezuela (see column (1) in Table 3). Moreover, the productivity gap across the agricultural and non-agricultural sectors of Latin American countries has reduced in Argentina, Bolivia, Chile, and

Venezuela. (See column (4) in Table 3). These are the same four countries whose reallocations are driven mainly by reallocation cost reductions. For all other Latin American countries the gap increased but the markups is less than 10%, except for Brazil (whose markup is 22%).

5.3 Policy Implication

We find that the main driver of labor reallocation is different across Asian and Latin American countries. The results suggest a policy implication: policies promoting productivity growth in the agricultural sector and lowering the barriers for labor movement across sectors are insufficient for sustaining long-term ALP growth or for achieving income convergence. Such policies create an incentive for labor to move from agriculture (the low productivity sector) to non-agriculture (the high productivity sector); however, labor reallocations triggered by these two mechanisms do not enhance long-term growth and income convergence.

Although reallocating labor from a sector with low productivity to a sector with high productivity can generate immediate productivity improvements, the resources may be allocated to a sector that grows relatively slowly and the one-time large productivity growth is averaged with multi-year low growth of subsequent years (when focusing on long-term growth).[9] Thus, labor reallocation contributes minimally to income convergence, unless the sector to which it is reallocated has sustained growth. In other words, reallocating resources to a sector with a high productivity growth rate rather than to a sector with high productivity is preferable when the goal is to generate sustained long-term growth. Accordingly, labor pull is an indispensable driving force for achieving high long-term growth and income convergence.

6 Concluding remarks

Resource reallocation, such as labor moving from a low-productivity to a high-productivity sector, can generate aggregate productivity growth without any productivity improvements in either sector. Although Asian and Latin American countries have experienced a similar magnitude of decline in the share of labor in agriculture, labor reallocation has resulted in higher aggregate ALP growth in Asia than in Latin America.

We have adopted arithmetic decomposition to identify the key elements differentiating the development outcomes in these two regions. We have decomposed the ALP growth rate and find that in Latin American countries, although labor structural transformation reallocated resources to a more productive sector, the growth rate of the sector to which labor was reallocated was low. Therefore, labor reallocation has only a small long-term effect on aggregate ALP growth. Conversely, in Asian countries, labor structural transformation reallocated re-

[9] A highly productive sector does not necessarily have a high productivity growth rate.

sources to a relatively more productive sector, and the productivity increase of that sector was large. Consequently, the interaction between labor structural transformation and productivity increases in the non-agricultural sector, i.e., the amplification effect, generates the large productivity gain from reallocation in Asia. This fact is the key difference between economic growth rates of Asian and Latin American countries.

We also identify the mechanisms driving the labor reallocation. We established a two-sector model that endogenizes the choices of allocating labor across the agricultural and non-agricultural sectors. The model results are used for identifying the main drivers of labor reallocation. We find that labor reallocation triggered by labor pull fits most cases, especially those of Asian countries, whereas reallocation cost reductions are the main driver for Argentina, Bolivia, Brazil and Venezuela. Thus, the different output growth due to reallocation may arise from the fact that the driver of reallocation differs.

Our findings—that a significant amount of labor moving out of agriculture does not ensure high productivity growth in the long run—raise an open question for existing work that focuses on the dual economy or labor reallocation as a significant explanation for cross-country income differences. Our analytical results suggest that labor pull effect is an indispensable driver of reallocation that allows labor reallocation to achieve income convergence. This result suggests a policy implication: policies that promote sustained productivity improvement in the non-agricultural sector are important for poor countries to achieve income convergence. Reallocation cost reductions have a limited effect on long-term growth.

This study's results should not be interpreted to suggest that productivity growth in the agricultural sector is unimportant. Instead, the discussion must focus on how different dominant forces, which generate similar labor structural transformations, result in different long-term growth rates. Since the economic development process is itself a complex progression, this study focuses on the growth arising from labor reallocation, especially that from agriculture to non-agriculture. Why each country's reallocation costs evolve differently, why the productivity of the non-agricultural sector is high, and how reallocation within the non-agricultural sector contributes to its high growth are interesting questions for future research.

Appendices

A Different aggregation

A.1 Decomposition of the economy into agriculture, industry and services.

We also decompose the economy into three sectors: agriculture, industries and services. See Table A.1 for the results. Again, we find that the pure reallocation effect for Asia and Latin America fall into a similar range, whereas the amplification effect is larger for Asia than for Latin America. Therefore, the gains from reallocation are much higher in Asia due to its higher amplification effect.

Table A.1: Results of ALP decomposition: three sectors

Country	Period	ALP g	Productivity improvement	Total reallocation	Pure reallocation	Amplification
		(1)	(2)	(3)	(3.1)	(3.2)
Hong Kong	1974-2005	3.59%	2.65%	0.94%	0.90%‡	0.03%
Indonesia	1971-2005	3.28%	1.82%	1.45%‡	0.71%	0.74%‡
India	1960-2004	2.59%	1.95%	0.64%	0.10%^	0.55%
Japan	1953-2003	3.89%‡	2.69%‡	1.21%‡	0.32%	0.89%‡
S.Korea	1963-2005	4.42%‡	3.23%‡	1.19%‡	0.63%	0.55%‡
Malaysia	1975-2005	3.90%‡	2.87%‡	1.03%	0.53%	0.49%
Philippines	1971-2005	0.87%^	0.74%^	0.13%^	0.12%^	0.01%
Singapore	1970-2005	3.73%	3.62%‡	0.11%^	0.02%^	0.09%
Taiwan	1963-2005	5.27%‡	3.20%‡	2.07%‡	0.37%	1.70%‡
Thailand	1960-2005	3.96%‡	1.60%	2.36%‡	0.84%‡	1.52%‡
Argentina	1950-2005	0.81%^	1.06%	−0.24%^	0.30%^	−0.55%^
Bolivia	1950-2003	0.89%^	0.38%^	0.51%	1.65%‡	−1.13%^
Brazil	1950-2005	2.30%	1.59%	0.71%	0.82%‡	−0.11%
Chile	1950-2005	1.77%	1.91%	−0.14%^	0.25%^	−0.39%^
Colombia	1950-2005	1.47%	1.18%	0.29%	0.41%	−0.12%
Costa Rica	1950-2005	1.93%	1.45%	0.48%	0.54%	−0.05%
Mexico	1950-2005	1.70%	0.81%^	0.89%	0.84%‡	0.05%
Peru	1960-2005	1.09%^	0.75%^	0.34%	0.61%	−0.26%^
Venezuela	1950-2005	0.05%^	0.00%^	0.05%^	0.57%	−0.52%^

A.2 Setting a demarcation point for the period of study

When setting 1980 as the demarcation point for the period of study, we show that the productivity growth rates of all the countries are positive before 1980 but some became negative after 1980. In particular, the productivity gains from reallocation in Asia is not larger than that in Latin America before 1980 but is larger after 1980. See Tables A.2-1 and A.2-2.

Table A.2-1: Results of ALP decomposition before 1980

Country	Period	ALP g	Productivity improvement	Total reallocation	Pure reallocation	Amplification
		(1)	(2)	(3)	(3.1)	(3.2)
Hong Kong	1974-1980	1.97%^	1.92%	0.05%^	0.07%^	−0.02%^
Indonesia	1971-1980	4.98%‡	3.19%	1.79%‡	1.23%	0.56%
India	1960-1980	1.43%^	1.48%	−0.05%^	−0.02%^	−0.03%^
Japan	1953-1980	5.48%‡	3.70%‡	1.79%	0.56%	1.23%‡
S.Korea	1963-1980	4.19%	2.02%	2.17%‡	1.60%‡	0.57%‡
Malaysia	1975-1980	4.91%‡	3.41%‡	1.50%	1.51%‡	−0.01%
Philippines	1971-1980	3.39%	3.54%‡	−0.15%^	−0.09%^	−0.06%^
Singapore	1970-1980	3.89%	3.79%‡	0.10%^	0.06%^	0.04%
Taiwan	1963-1980	6.48%‡	4.05%‡	2.43%‡	1.26%‡	1.17%‡
Thailand	1960-1980	4.51%	2.47%	2.04%‡	1.13%	0.91%‡
Argentina	1950-1980	1.37%^	1.03%^	0.34%^	0.36%	−0.01%
Bolivia	1950-1980	2.26%	0.72%^	1.54%	1.59%‡	−0.05%^
Brazil	1950-1980	4.69%‡	2.53%	2.16%‡	0.79%	1.37%‡
Chile	1950-1980	2.12%	1.68%	0.43%	0.25%^	0.18%
Colombia	1950-1980	2.12%^	1.45%^	0.67%	0.55%	0.12%
Costa Rica	1950-1980	3.04%	1.90%	1.15%	0.71%	0.44%
Mexico	1950-1980	3.14%	1.55%	1.60%	1.03%	0.57%
Peru	1960-1980	2.53%	1.25%^	1.28%	0.92%	0.36%
Venezuela	1950-1980	0.98%^	0.11%^	0.87%	1.41%‡	−0.54%^

Notes:
1. There are 19 countries in the sample. We mark the numbers lower than the first quartile with ∧, whereas the numbers higher than the third quartile are marked with ‡. "Total reallocation" refers to the total reallocation effect. "Pure reallocation" refers to the pure reallocation effect and "Amplification" is the amplification effect.
2. The numbers reported are in terms of average annual growth rate

We then decompose the ALP growth rate for two sub-periods: before 1980 (see Table A.2-1) and after 1980 (see Table A.2-2). The new results show that the baseline results still hold for the period after 1980—the pure reallocation effect is not larger in Asia than in Latin America but the amplification effect is larger in Asia than in Latin America. However, before 1980 both regions have countries experiencing a negative amplification effect.

Now we pin down the major driver of reallocation for each sub-period. Before 1980, we find that the growth rate of the agricultural output per capita is larger than 0.1% in absolute terms for all countries in two sub-periods except for Argentina (0.004%) during 1950-1980 (see Table A.2-3). Based on the guidelines, since the growth of Argentina's agricultural output per head is effectively zero and its amplification effect is negative, we conclude that before 1980, labor push plays the major role in the reallocation in Argentina. Moreover, since the

Table A.2-2: Results of ALP decomposition after 1980

Country	Period	ALP g (1)	Productivity improvement (2)	Total reallocation (3)	Pure reallocation (3.1)	Amplification (3.2)
Hong Kong	1980-2005	3.98%‡	3.90%‡	0.09%∧	0.01%∧	0.08%
Indonesia	1980-2005	2.67%	1.68%	0.99%‡	0.68%‡	0.31%‡
India	1980-2004	3.57%	2.47%	1.11%‡	0.43%	0.68%‡
Japan	1980-2003	2.06%	1.77%	0.29%	0.20%∧	0.09%
S.Korea	1980-2005	4.57%‡	3.83%‡	0.74%‡	0.52%	0.22%
Malaysia	1980-2005	3.69%‡	2.96%‡	0.73%‡	0.36%	0.37%‡
Philippines	1980-2005	−0.03%∧	−0.41%∧	0.39%	0.54%‡	−0.16%∧
Singapore	1980-2005	3.67%‡	3.60%‡	0.07%∧	0.02%∧	0.05%
Taiwan	1980-2005	4.46%‡	3.75%‡	0.71%	0.24%	0.46%‡
Thailand	1980-2005	3.53%	1.67%	1.86%‡	1.24%‡	0.62%‡
Argentina	1980-2005	0.14%	0.13%	0.02%∧	0.13%∧	−0.11%
Bolivia	1980-2003	−0.86%∧	−1.24%∧	0.38%	1.14%‡	−0.76%∧
Brazil	1980-2005	−0.50%∧	−0.97%∧	0.47%	1.05%‡	−0.58%∧
Chile	1980-2005	1.35%	1.15%	0.20%∧	0.34%	−0.14%∧
Colombia	1980-2005	0.69%	0.45%	0.24%	0.28%	−0.04%
Costa Rica	1980-2005	0.61%	0.36%	0.25%	0.39%	−0.14%
Mexico	1980-2005	−0.02%	−0.40%∧	0.38%	0.54%	−0.16%∧
Peru	1980-2005	−0.05%∧	−0.29%	0.25%	0.32%	−0.07%
Venezuela	1980-2005	−1.06%∧	−1.11%∧	0.05%∧	0.08%∧	−0.03%

Notes:

1. There are 19 countries in the sample. We mark the numbers lower than the first quartile with ∧, whereas the numbers higher than the third quartile are marked with ‡. "Total reallocation" refers to the total reallocation effect. "Pure reallocation" refers to the pure reallocation effect and "Amplification" is the amplification effect.
2. The numbers reported are in terms of average annual growth rate

amplification effect is negative for Hong Kong, Malaysia, Bolivia and Venezuela, and their growth rates of agricultural output per capita are non-zero, we conclude that the reallocation cost reductions play a major role in the reallocation in these countries. For the remaining countries, labor pull plays a dominating role.[10]

After 1980, the major driving force of labor reallocation in Asia is different from that in Latin America. Labor pull plays a dominant role in labor reallocation in Asia, except in the Philippines. This conclusion is made based on two facts about these countries: (1) their agricultural output per capita exceeds 0.1% in absolute term, which implies that the food constraint is not binding for the entire period, and (2) their amplification effect is positive. On the other hand, reallocation cost reductions play a dominant role in labor reallocation in

[10] We exclude India and the Philippines from this discussion. These two countries experienced a reverse labor structural transformation before 1980—that is, the percentage of labor in the agricultural sector increased. Since the focal point of this paper is on the labor structural transformation from agriculture to non-agriculture, we exclude these two cases.

Table A.2-3: The annual growth rate of agricultural output per capita

Country	period before 1980	growth rate (1)	period after 1980 (2)	growth rate (3)
Hong Kong	1974-1980	2.74%	1980-2005	−8.24%
Indonesia	1971-1980	1.67%	1980-2005	1.16%
India	1960-1980	−0.14%	1980-2004	1.09%
Japan	1953-1980	0.19%	1980-2003	−1.19%
S.Korea	1963-1980	0.60%	1980-2005	1.40%
Malaysia	1975-1980	2.20%	1980-2005	−0.35%
Philippines	1971-1980	1.88%	1980-2005	−0.40%
Singapore	1970-1980	0.42%	1980-2005	−4.96%
Taiwan	1963-1980	1.16%	1980-2005	−0.90%
Thailand	1960-1980	1.88%	1980-2005	1.66%
Argentina	1950-1980	0.00%	1980-2005	0.90%
Bolivia	1950-1980	−0.61%	1980-2003	0.49%
Brazil	1950-1980	1.20%	1980-2005	1.27%
Chile	1950-1980	−0.25%	1980-2005	3.98%
Colombia	1950-1980	2.34%	1980-2005	0.23%
Costa Rica	1950-1980	0.84%	1980-2005	0.75%
Mexico	1950-1980	0.54%	1980-2005	−0.35%
Peru	1960-1980	−1.32%	1980-2005	1.61%
Venezuela	1950-1980	1.17%	1980-2005	−0.48%

all Latin American countries. This conclusion is made based on two facts about the Latin America countries: (1) their per capita agricultural output growth exceeds 0.1% in absolute term, which implies that the food constraint is not binding; and (2) their amplification effect is negative.

In sum, the sub-period results suggest that the growth gains from reallocation in Asia is not obviously higher than that in Latin America before 1980 but much higher after 1980. See column (3) in Tables A.2-1 and A.2-2. Similarly, we find that the amplification effect is not obviously higher in Asia than in Latin America before 1980 but much higher after 1980. Therefore, we conclude that the large productivity gain from reallocation for the entire period (before 1980 and after 1980 combined) in Asia is due to the large amplification effect, whose reallocation is driven by labor pull, especially in the later stages of development after WWII.

.

B Decomposing Average Labor Productivity

$$
\begin{aligned}
ALP_t^{agg} &= \frac{q_t Y_t^F + Y_t^{NF}}{L_t^F + L_t^{NF}} = \frac{q_t Y_t^F}{L_t^F} \cdot \frac{L_t^F}{L_t^F + L_t^{NF}} + \frac{Y_t^{NF}}{L_t^{NF}} \cdot \frac{L_t^{NF}}{L_t^F + L_t^{NF}} \\
&= \frac{q_t Y_t^F}{L_t^F} \cdot F_t + \frac{Y_t^{NF}}{L_t^{NF}} \cdot (1 - F_t) = ALP_t^F \cdot F_t + ALP_t^{NF} \cdot (1 - F_t) \qquad \text{(B.1)}
\end{aligned}
$$

ALP_t is the average labor productivity, Y_t represents output, and L_t is the number of workers. For all variables, subscript "t" means the variable is for time "t." Superscript "agg" means aggregate, "NF" represents the non-agricultural sector, and "F" is the agricultural sector. Next, q is relative price (the price of non-agricultural output is 1) and F_t is the share of labor in the agricultural sector at time t, i.e., $F_t \equiv \frac{L_t^F}{L_t^F + L_t^{NF}}$. From (B.1) one can obtain

$$
\begin{aligned}
& ALP_t^{agg}/ALP_0^{agg} - 1 \\
=\ & \left[ALP_t^{agg} - ALP_0^{agg}\right]/ALP_0^{agg} \\
=\ & \left\{ALP_t^F \cdot F_t + ALP_t^{NF} \cdot (1 - F_t) - \left[ALP_0^F \cdot F_0 + ALP_0^{NF} \cdot (1 - F_0)\right]\right\}/ALP_0^{agg} \\
=\ & \frac{ALP_t^F \cdot ALP_0^F}{ALP_0^F \cdot ALP_0^{agg}} \cdot F_t + \frac{ALP_t^{NF}}{ALP_0^{agg}} - \frac{ALP_t^{NF} \cdot ALP_0^{NF}}{ALP_0^{NF} \cdot ALP_0^{agg}} \cdot F_t - \frac{ALP_0^F}{ALP_0^{agg}} \cdot F_0 - \frac{ALP_0^{NF}}{ALP_0^{agg}} + \frac{ALP_0^{NF}}{ALP_0^{agg}} \cdot F_0 \\
=\ & -F_t \left[\frac{ALP_t^{NF} \cdot ALP_0^{NF}}{ALP_0^{NF} \cdot ALP_0^{agg}} - \frac{ALP_t^F \cdot ALP_0^F}{ALP_0^F \cdot ALP_0^{agg}}\right] - \frac{ALP_0^F}{ALP_0^{agg}} \cdot F_0 \\
& + \frac{ALP_0^{NF}}{ALP_0^{agg}} \cdot F_0 + \frac{ALP_t^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{NF}}{ALP_0^{agg}} \\
=\ & (F_0 - F_t)\left[\frac{ALP_t^{NF} \cdot ALP_0^{NF}}{ALP_0^{NF} \cdot ALP_0^{agg}} - \frac{ALP_t^F \cdot ALP_0^F}{ALP_0^F \cdot ALP_0^{agg}}\right] \\
& - \frac{ALP_t^{NF}}{ALP_0^{agg}} \cdot F_0 + \frac{ALP_t^F}{ALP_0^{agg}} \cdot F_0 - \frac{ALP_0^F}{ALP_0^{agg}} \cdot F_0 + \frac{ALP_0^{NF}}{ALP_0^{agg}} \cdot F_0 + \frac{ALP_t^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{NF}}{ALP_0^{agg}} \\
=\ & (F_0 - F_t)\left[\frac{ALP_t^{NF} \cdot ALP_0^{NF}}{ALP_0^{NF} \cdot ALP_0^{agg}} - \frac{ALP_t^F \cdot ALP_0^F}{ALP_0^F \cdot ALP_0^{agg}}\right] \\
& + (1 - F_0)\left[\frac{ALP_t^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{NF}}{ALP_0^{agg}}\right] + F_0\left[\frac{ALP_t^F}{ALP_0^{agg}} - \frac{ALP_0^F}{ALP_0^{agg}}\right] \\
=\ & (F_0 - F_t)\left[\frac{ALP_t^{NF} \cdot ALP_0^{NF}}{ALP_0^{NF} \cdot ALP_0^{agg}} - \frac{ALP_t^F \cdot ALP_0^F}{ALP_0^F \cdot ALP_0^{agg}}\right] \\
& + (1 - F_0) \cdot \frac{ALP_0^{NF}}{ALP_0^{agg}}\left[\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right] + F_0 \cdot \frac{ALP_0^F}{ALP_0^{agg}}\left[\frac{ALP_t^F}{ALP_0^F} - 1\right] \qquad \text{(B.2)}
\end{aligned}
$$

From Eq. (B.1), one can find that $(1 - F_0) \cdot \frac{ALP_0^{NF}}{ALP_0^{agg}} + F_0 \cdot \frac{ALP_0^F}{ALP_0^{agg}} = 1$

For $W_0 \equiv F_0 \cdot \frac{ALP_0^F}{ALP_0^{agg}}$, we can get $1 - W_0 = (1 - F_0) \cdot \frac{ALP_0^{NF}}{ALP_0^{agg}}$. Then, Eq. (B.2) is transformed into Eq (4) in the paper:

$$
\begin{aligned}
& ALP_t^{agg}/ALP_0^{agg} - 1 \\
= \; & (F_0 - F_t)\left[\frac{ALP_t^{NF}\cdot ALP_0^{NF}}{ALP_0^{NF}\cdot ALP_0^{agg}} - \frac{ALP_t^{F}\cdot ALP_0^{F}}{ALP_0^{F}\cdot ALP_0^{agg}}\right] + (1-W_0)\cdot\left[\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right] + W_0\left[\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right] \\
= \; & (F_0 - F_t)\left[\frac{ALP_0^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{F}}{ALP_0^{agg}}\right] + (F_0 - F_t)\left[\frac{ALP_0^{NF}}{ALP_0^{agg}}\left(\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right) - \frac{ALP_0^{F}}{ALP_0^{agg}}\left(\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right)\right] \\
& + (1-W_0)\cdot\left[\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right] + W_0\left[\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right]
\end{aligned}
$$

Q.E.D.

C Proofs for Proposition 2

1. Before the productivity of the non-agricultural sector increases: $\eta\frac{q_t Y_{1t}}{L_{1t}} = \theta\left(1-\xi\right)\frac{\mathsf{Y}_{2t}}{L_{2t}}$.
2. When productivity of non-agricultural sector rises, Y_{2t} becomes Y_{2t}' where $Y_{2t}' > Y_{2t}$.
3. Then, $\eta\frac{q_t Y_{1t}}{L_{1t}} < \theta\left(1-\xi\right)\frac{\mathsf{Y}_{2t}'}{L_{2t}}$. If labor is free to move and $\widetilde{L}$ moves to restore equilibrium, $\eta\frac{q_t \mathsf{Y}_{1t}'}{L_{1t}-\widetilde{L}} = \theta\left(1-\xi\right)\frac{\mathsf{Y}_{2t}'}{L_{2t}+\widetilde{L}}$. ($Y_{1t}'$ is the new agricultural output.)
4. Moreover, $\frac{q_t \mathsf{Y}_{1t}'}{L_{1t}-\widetilde{L}} = q_t TFP_{1t}(L_{1t}-\tilde{L})^{\eta-1} > q_t TFP_{1t}K_{1t}^{\eta}(L_{1t})^{\eta-1} = \frac{q_t Y_{1t}}{L_{1t}}$ $(\because \eta - 1 < 0)$.
5. Thus, from 1, 3, 4: $\frac{q_t \mathsf{Y}_{1t}'/\left(L_{1t}-\widetilde{L}\right)}{q_t Y_{1t}/L_{1t}} = \frac{\mathsf{Y}_{2t}'/\left(L_{2t}+\widetilde{L}\right)}{Y_{2t}/L_{2t}} \equiv 1+g > 1$.
6. Since in general, $\frac{q_t Y_{1t}}{L_{1t}} < \frac{Y_{2t}}{L_{2t}}$,we get $\frac{ALP_0^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{F}}{ALP_0^{agg}} > 0$,
7. Thus, $\left[\frac{ALP_0^{NF}}{ALP_0^{agg}}\left(\frac{ALP_t^{NF}}{ALP_0^{NF}} - 1\right) - \frac{ALP_0^{F}}{ALP_0^{agg}}\left(\frac{ALP_t^{F}}{ALP_0^{F}} - 1\right)\right] = \left[\frac{ALP_0^{NF}}{ALP_0^{agg}} - \frac{ALP_0^{F}}{ALP_0^{agg}}\right]\cdot g > 0$.

Q.E.D.

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