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**Article**

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# Structural change and labour productivity trend in the non-agricultural sector: a study of Asia

Amrita Roy\*

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## Abstract

Over the course of structural transformation in the production and employment front, trend in labour productivity ratio between non-agricultural and agricultural sectors has been noted to behave differently for many developing countries. This study develops a two-sector dual economy model to explain the different trends in labour productivity of the non-agricultural sector relative to the agricultural sector in a labour surplus economy. In this model, the rates of growth of output of the agricultural and the non-agricultural sectors are exogenously given and the rate of growth in labour productivity in the high productivity sector is exogenously determined by the pace of technological progress. Alternatively, labour productivity in the agricultural sector which acts as a residual sector in terms of employment generation is endogenously determined by the release of surplus labour from the agricultural sector and its absorption in the non-agricultural sector. The long run relative labor productivity of the agricultural sector with respect to the non-agricultural sector approaches unity depending on growth rate of labor force, productivity growth in non-agriculture, and growth rate of agriculture itself. To check for the validity of the postulations of the model, using data from eight East Asian countries over 1970-2014, we have estimated the relationship between labour productivity ratio of the agricultural and the non-agricultural sectors and labour absorption capacity of the non-agricultural sector, controlling for technological development of the country and growth of the sectors. In our estimation results we find a strong significant relation between labour absorption in the non-agricultural sector and labour productivity ratio of the agricultural and the non-agricultural sectors.

JEL classification: O4, O5

Keywords: Economic development, Relative labour productivity, Developing countries, Asian countries, Agricultural sector, Non-agricultural sector

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## 1. Structural change and relative labour productivity in different sectors

For most developed countries, the structures of production and employment have generally been seen to transform in a similar manner over the course of economic development. With development, the importance of the agricultural sector declines both in terms of its share in national income and employment and the non-agricultural sector becomes the driving force of the economy (Fuchs 1969; Kuznets 1979).

Over the last few decades, many of the developing countries have transformed from one, based on agriculture to a service sector dominated economy. But contrary to the general trend noted in the developed countries, the gap between output and employment shares of the service sector has remained wide in many developing countries in Asia. For example, in 2010 in South Asia, average contribution of the service sector in national income was 54 percent in contrast to its 27 percent share in total employment

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(World Bank (2012)<sup>1</sup>). Considering the experience of India, it has been noted that the service sector has not been able to generate enough employment in India even though it accounts for the major share of national income (Bhattacharya and Mitra 1990; Gordon and Gupta 2004; Banga 2005; Dasgupta and Singh 2006; Joshi 2004, 2008). Similar to India, in case of China, there exists a considerable gap between the output share and employment share of the service sector but it is not as wide as observed in India.

We also see that compared to the early industrialized countries of East Asia (e.g. Japan and South Korea), in the late industrialisers of East Asia (e.g., Philippines and Thailand) and also in India and China, the employment shares of the leading sectors (industry and service sector) are rising less than proportionately to their output shares. All these East Asian countries starting out as predominantly agrarian economies are now in different phases of development. This provides us the scope for comparing the development phases of these countries while looking at the relative productivity trends of their different economic activities.

Main problem related to a continuous increase in the gap between output and employment shares (or disproportionate growth) in the non-agricultural sector is that it might result in worsening of income distribution. If this disproportionate growth in the non-agricultural sector is regarded as a short run phenomenon, which was also a part of the process of development in the presently developed countries, then in the long run ultimately the process will reverse. However, if such a rising trend signals a long-run tendency for the gap between output and employment shares of the non-agricultural sector to persist or widen over time then this is a matter of serious concern. With a rising gap between the output and employment shares, a large proportion of the population in the economy might remain trapped in a state of increasing relative poverty. At the same time, with sufficiently low rates of employment growth in the non-agricultural sector, a state of absolute poverty might exist as well.

In many developing countries, agricultural sector acts as a residual sector and absorbs the surplus labour that do not get employed in the non-agricultural sector. In this situation, given a constant rate of growth of labour force in the economy, a declining labour productivity of the agricultural sector might indicate a disproportionate growth of different sectors. Further, the gap between the labour productivities of the agricultural

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<sup>1</sup> [databank.worldbank.org/ddp/home](http://databank.worldbank.org/ddp/home)

and non-agricultural sectors might indicate the severity of the disproportionate growth. One way to look at the issue of disproportionate growth, therefore, is to study the change in the labour productivity ratio between these two sectors over time.

In this paper, we develop a model that explains the different trends in labour productivity of the non-agricultural sector relative to the agricultural sector. We consider a simple two-sector model, involving a high productivity sector (non-agricultural sector) and low productivity sector (agricultural sector), of a dual economy. This model predicts that even though technological development accounts for the relationship between changes in sectoral output and employment shares in an economy, in the developing countries the importance of low productivity sector in absorbing surplus labour also affects this relationship. The long run labor productivity of non- agriculture relative to agriculture approaches unity depending on growth rate of labor force and productivity growth both outside and within the agricultural sector.

To check for the validity of the postulations of the model, using data of eight East Asian countries over 1970-2014, we have estimated the relationship between labour productivity ratio of the agriculture and the non-agricultural sectors and labour absorption capacity of the non- agricultural sector, controlling for technological development of the country and growth of the sectors. In our estimation results, we find that controlling for other factors, non-agricultural employment relative to total labour force is positively related to the labour productivity ratio of the agricultural sector and the non-agricultural sector. At the same time, we also find that labour productivity in the non-agricultural sector has a significant and negative relation to the labour productivity ratio of the two sectors.

The paper is organized as follows: In section 2, we consider the trends in labour productivity ratio between the non-agricultural sector and the agricultural sector for a set of East Asian countries for the period 1970 to 2014. In section 3, we present the historical evidence on the relation between changes in employment structure and changes in production in the course of development. In section 4, we construct a simple two-sector model of a dual economy to study the direction of movement in labour productivity in the non-agricultural sector of an economy. Empirical analysis of the model discussed in section 4 has been done in section 5. Conclusions based on these analyses have been summarized in section 6.

## **2. Trends of labour productivity ratio between the agriculture and the non-agricultural sectors**

In the last four decades, the labour productivity in the agricultural sector was significantly lower compared to the industrial and the service sectors in India, China, Indonesia, Malaysia, Philippines, Thailand, Japan and South Korea. Further, the agricultural sector witnessed a continuous decline in labour productivity and its share in national income. At the same time, throughout this period the agricultural sector has been much more important as a source of employment generation than as a source of income. It has acted as the primary residual sector for employment generation. Briones and Felipe (2003) noted that since the 1970s, while the output share in Asia declined at 2.5 percent per annum, the employment share declined at about 1.7 percent. Therefore, the role of the agricultural sector in the Asian countries has been very different compared to the industrial and the service sectors.

In Figure 2.1, we present the labour productivity ratio between the agricultural and the non- agricultural sectors in India, China, Indonesia, Malaysia, Philippines, Thailand, Japan and South Korea<sup>2</sup>.

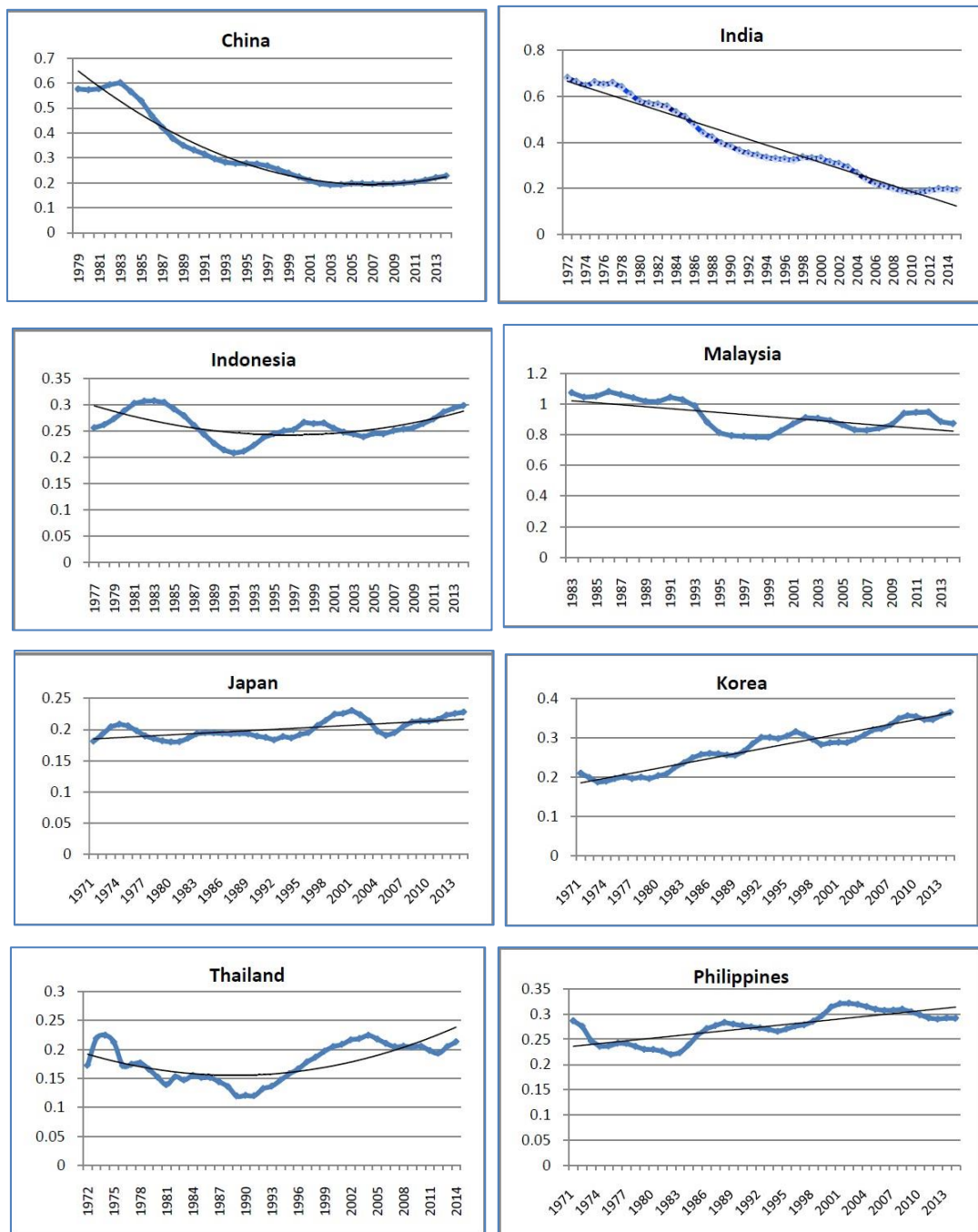
Looking at the trends, we observe that the labour productivity ratio is changing significantly over time. This changing pattern of the labour productivity ratio is different for different countries. For example, the ratio shows a declining trend in China, India and Malaysia. In case of Japan, Korea and Philippines we find an increasing trend. For Indonesia and Thailand the trend takes an “U” shape.

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<sup>2</sup> For most of the countries data is available for output share and employment share and it can be shown that the ratio of output share to employment share of any two sectors can be used to obtain the labour productivity ratio between the sectors.

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Figure 2.1: Trends of labour productivity ratio between agricultural and non-agricultural sectors



Data Source: APO productivity database (2016). Note: Y-axis shows labour productivity in agriculture relative to the non-agricultural sector. X-axis represents year.

### **3. Historical evidence on the relation between changes in the employment structure and changes in production in the course of development**

The inter-sectoral movement of labour associated with the changing structure of production in an economy constitutes a different aspect of structural change. Based on the historical experiences of the developed countries, studies have noted that patterns of structural change in production and employment are quite similar in an economy. Changes in the employment shares of different sectors generally move in line with changes in the output shares of those sectors with a time lag.

Data reported in the studies of Fuchs (1969) and Kuznets (1979) show that in the early phase of development, countries considered to be developed today witnessed a huge decline in the contribution of the agricultural sector both in national income and in total employment. The labour released from this sector was absorbed in the industrial and the service sectors. Finally, as the process of deindustrialization started in these developed countries, labour released from the industrial sector was absorbed in the service sector. Considering the non-agricultural sector we see that in the early phase of transition, the rise in output share of the non-agricultural sector was greater than the corresponding increase in employment share in these developed countries. Movement of labour from one sector to the other in accordance with changing output shares occurred with a time lag. Eventually, employment share of the non-agricultural sector converges to the output share of the non-agricultural sector. This is clearly evident from the experience of the 13 developed countries that Kuznets considered (depending on availability of data) over a period from the late seventeenth century to the middle of the 1960s (reported in the Appendix Table A.1).

Except for France and Italy, ratio of output share to employment share in the non-agricultural sector for these developed countries has taken either ‘an inverted U’ shape (indicating the time lag in the movement of labour from the agricultural sector to the non-agricultural sector) or a clear declining trend over time and the tendency is to move towards the value one. The ratio in the agricultural sector was less than one for all of these countries over the same period. The declining trend in the gap between output share and employment share in the non-agricultural sector is also seen in the early industrialized countries of East Asia (Japan and South Korea).

One possible reason for the declining gap between output share and employment share in the non-agricultural sector of the developed countries might be the historical shift in the composition of national income from the industrial sector to the service sector. If the service sector is more labour intensive compared to the industrial sector then shift in production from the industrial sector to the service sector would result in an increase in employment share of the non- agricultural sector. Chenery and Syrquin (1975) note that at a significantly high income level, the pattern of production and the use of labour changes. Due to greater difficulty in substituting capital for labour and lower rates of technological improvements in the service sector compared to the commodity producing sector, service sector employs a larger share of labour force than its contribution in national income.

From the output composition of the non-agricultural sector, in the later period (Table 3.1) for the same set of developed countries that Kuznets (1979) considered (Table A.1), we observe that the ratio of the output share to employment share in the non-agricultural sector is close to one or has declined in these countries over time. This also indicates declining gap between output share and employment share in the non-agricultural sector.



**Table 3.1: Declining gap between output share and employment share in the non-agricultural sector associated with the declining output share of the industrial sector**

Country	Year	Non-agricultural Output share	Non-agricultural employment share	Relative labour productivity in non-agriculture	Output share of service sector	Output share of industrial sector
UK	1980	98	97	1.01	55	43
	2008	99	99	1	76	23
	2014	99	98	1.01	79	20
France	1980	95	91	1.04	63	32
	2008	98	97	1.01	78	20
	2014	98	96	1.02	79	20
Netherlands	1980	96	95	1.01	62	34
	2008	98	97	1.01	73	25
	2014	98	90	1.08	78	20
Denmark	2008	99	97	1.02	---	-----
	2014	98	97	1.01	23	76
Norway	1980	96	91	1.05	55	41
	2008	99	97	1.02	54	45
	2014	98	98	1	60	38
Sweden	1980	96	94	1.02	63	33
	2007	98	98	1	70	28
	2014	99	98	1	73	26
Italy	1980	94	86	1.09	53	41
	2008	98	96	1.02	71	27
	2014	98	97	1	74	23
US	1980	97	96	1.01	63	34
	2007	99	99	1	77	22
	2014	99	98	1	78	20
Japan	1980	96	89	1.08	55	41
	2008	99	96	1.03	69	30
	2014	99	95	1	74	25

*Source: WDI (2017)*

Based on a regression analysis done for 72 developed and developing countries for the 1960s, Chenery and Syrquin (1975) found that labour productivity in the primary sector (relative to average national productivity) falls significantly over the early stage of development (as the fall in the share of primary output is more rapid compared to the fall in employment share). In the middle income range, the productivity gap between the primary sector on the one hand and industry and services on the other is the greatest. At a high income level, with the adoption of advanced technology in the agricultural sector and as surplus labour of the agricultural sector gets absorbed in the other sectors, relative

labour productivity in the primary sector gradually rises. Thus at a high income level, the productivity gap between primary production and the industrial and the service sectors gets reduced substantially. Chenery and Syrquin (1975) note that the low productivity of labour in the primary sector in low income countries indicates the use of backward technologies and the immobility of productive factors.

The experience for the developing countries has not always been the same. For example, Bosworth and Collins (2008) observed a substantial and growing sectoral differences in output per worker (labour productivity) for India and China over the period 1978-2004. They also noted that in 1978, labour productivity in industrial and services sectors was almost identical, and significantly higher than the agricultural sector in both the countries. In the following decades, labour productivity gap with respect to the agricultural sector has further widened. In particular, the service sector in India has witnessed a higher labour productivity than the industrial sector. Therefore, the concern is that given the output share of the non-agricultural sector in national income, with the observed widening gap in labour productivity, employment share of the non- agricultural sector might actually decline.

Park and Shin (2012) looked at the process of evolution of the service sector in 12 major Asian countries (China, Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Singapore, Taiwan, Thailand and Vietnam) over the period 1960 to 2010. They found that the gap between the average labour productivity growth rate of the services and industry sectors narrowed sharply over the period 2000-2010 in these countries. This was contrary to the general notion that productivity growth in services is inherently difficult to achieve. They also found that the lower the initial level of per capita income, the higher the subsequent growth rate of labour productivity in the service sector.

For the developing countries, therefore, rather than the changing composition of non-agricultural output, there might be another more important factor determining the trend in labour productivity of the non-agricultural sector. Many of the developing countries are characterized by dualism and substantial amount of disguised unemployment in the agricultural sector. The agricultural sector acts as the residual sector to absorb the additional labour not employed in the non-agricultural sector. On the other hand, if the additional employment generated in the non- agricultural sector is greater than the additional labour force created in the economy, then the shortage of

labour force in the economy is met from the existing surplus labour in the agricultural sector. In the following, we therefore try to answer the question as to what explains the movement of labour productivity in the non-agricultural sector in an economy where agriculture acts as the residual sector with respect to employment.

#### 4. Labour productivity in a two sector model

As discussed in the previous sections, the trend in labour productivity ratio in the non- agricultural sector relative to agricultural sector varies considerably over time and among countries. Here, using a simple two-sector model we have analyzed how the labour productivity ratio between these sectors change with time. We have also discussed if current trends in output growth and technological change are leading to labour productivity ratio moving in a certain direction then if the current trends persist, will the ratio maintain its course or change in the long run.

##### Notations:

High productivity sector	Sector H
Low productivity sector	Sector L
Labour force in the economy	$N$
Rate of growth of labour force	$n = \dot{N} / N$
Total employment in economy	$E$
Total employment in sectors H and L	$E_H$ and $E_L$
Shares in total employment of sectors H and L	$s_H = E_H / E$ and $s_L = E_L / E$
Actual labour productivities in sectors H and L	$y_H$ and $y_L$
Rate of growth of labour productivity in sector H	$\alpha_H = \dot{y}_H / y_H$
Rate of growth of labour productivity in sector L	$\alpha_L = \dot{y}_L / y_L$
Output in sectors H and L	$Y_H$ and $Y_L$
Rate of growth of output in sector H and L	$g_H = \dot{Y}_H / Y_H$ and $g_L = \dot{Y}_L / Y_L$

#### 4.1. Assumptions

1) There are two sectors in the economy which differ in levels of labour productivity: the high productivity sector H (non-agricultural sector) and the low productivity sector L (agricultural sector).

2) The rate of growth of labour force,  $n$  in the economy is constant.

3) There is a constant rate of unemployment in the economy<sup>3</sup>. By definition,

$$\frac{E_H}{E} + \frac{E_L}{E} = 1 \quad \text{or,} \quad s_H + s_L = 1. \text{ It follows from the assumption that rate of growth of}$$

$$\text{employment} \quad \frac{\dot{E}}{E} = \left(\frac{\dot{E}_H}{E_H}\right)s_H + \left(\frac{\dot{E}_L}{E_L}\right)s_L = n.$$

4) Actual labour productivity  $y_H$  in H, is equal to its technologically determined productivity (as there is no labour hoarding) and is exogenously given at any point of time. Labour productivity in sector H grows at a constant rate, i.e.,  $\alpha_H = \text{constant}$ .

5) Sector L acts as the residual sector for employment in the economy. That is, employment in sector L always adjusts to maintain equality between the rate of growth of total employment and the rate of growth of the labour force. The implicit assumption is that there is a hoard of labour existing in sector L in the form of the disguised unemployment which can always be adjusted to ensure that the economy has a constant rate of open unemployment. Thus, withdrawal of a part of the labour force from sector L would leave total output in sector L unchanged even when the other factors remain unchanged (Sen, 1966). Employment in sector L adjusts itself to the changes in employment growth in sector H to maintain a constant rate of unemployment in the economy as a whole. This is irrespective of the rate of growth of output in sector L and its technologically determined labour productivity<sup>4</sup>.

6) The output share of sector H is increasing over time<sup>5</sup>. That is,  $g_H > g_L$ . Therefore, in this model, the rate of growth of labor productivity in non-agriculture, rate of growth of the labor force and growth rates of output in both the sectors are exogenously given. Alternatively, the rate of growth of labour productivity in the

<sup>3</sup> Alternatively, one can assume that there is full employment in the economy.

<sup>4</sup> Sen (1966) notes that specific form of production function is not necessary for the existence of surplus labour as this existence does not depend on marginal productivity of labour and hence could be compatible to any production function. Further, considerable wage gap might exist between the agricultural sector and the non-agricultural sector in a labour surplus economy, determining the movement of labour from one sector to the other. To keep the model simple, we have not included the labour market interactions and wage rates in our model.

<sup>5</sup> This assumption is based on the empirical findings discussed in section 3 that output share of sector H is increasing over time.

agricultural sector and labour productivity in the non-agricultural sector relative to the agricultural sector are endogenously determined.

#### 4.2. Conditions explaining changing labour productivity ratio

The labour productivity ratio between sector H and sector L is  $\frac{y_H}{y_L}$ . Let us

now consider the growth rate of the labour productivity ratio:

$$\widehat{\left(\frac{y_H}{y_L}\right)} = \frac{d}{dt} \left[ \ln \left( \frac{y_H}{y_L} \right) \right] = \frac{\dot{y}_H}{y_H} - \frac{\dot{y}_L}{y_L} = \alpha_H - \frac{\dot{y}_L}{y_L} = \alpha_H - g_L + \frac{\dot{E}_L}{E_L}.$$

The above equation can be rewritten as

$$\widehat{\left(\frac{y_H}{y_L}\right)} = \alpha_H + \frac{\dot{E}_L}{E_L} - g_L \quad (1)$$

By assumption (3)

$$n = \left( \frac{\dot{E}_H}{E_H} \right) s_H + \left( \frac{\dot{E}_L}{E_L} \right) s_L \quad (2)$$

From the definition of  $\frac{\dot{y}_H}{y_H}$  it follows that  $\frac{\dot{E}_H}{E_H} = g_H - \alpha_H$ . Using this, Eq. (2) can

be rewritten as,

$$n = (g_H - \alpha_H) s_H + \frac{\dot{E}_L}{E_L} s_L \quad \text{or,} \quad n - (g_H - \alpha_H) s_H = \frac{\dot{E}_L}{E_L} s_L.$$

Therefore, 
$$\frac{\dot{E}_L}{E_L} = \frac{n - (g_H - \alpha_H) s_H}{s_L}$$

Substituting the above expression for  $\frac{\dot{E}_L}{E_L}$  into Eq. (1) and using  $s_L = 1 - s_H$  we obtain

$$\begin{aligned} \widehat{\left(\frac{y_H}{y_L}\right)} &= (\alpha_H - g_L) + \frac{n - s_H(g_H - \alpha_H)}{s_L} \\ &= \frac{n - s_H(g_H - \alpha_H) - s_L(g_L - \alpha_H)}{s_L} = \frac{n + (\alpha_H - g_L) - s_H(g_H - g_L)}{s_L}. \end{aligned}$$

Since  $0 < s_L < 1$ ,  $\widehat{\left(\frac{y_H}{y_L}\right)} \geq 0$  or  $< 0$  according to whether

$$n \geq s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H) \text{ or } n < s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H) \quad (3)$$

Equation (3) can be expressed as  $n + (\alpha_H - g_L) - s_H(g_H - g_L) \geq 0$  or  $< 0$ , from which we have the following proposition.

**Proposition 1:** *The labour productivity ratio of sector H with respect to sector L increases, remains constant, or decreases with time according to whether the employment share in sector H is less than,*

*equal to, or greater than  $\frac{n + \alpha_H - g_L}{g_H - g_L}$ .*

The quantity  $(g_H - \alpha_H)$ , appearing in Eq. (3), is the rate of growth of employment in sector H. Thus,  $s_H(g_H - \alpha_H)$  is the contribution of sector H to growth in total employment. To keep the labour productivity ratio between sectors H and L constant, labour productivity in sector L must also grow at the rate  $\alpha_H$ . Thus  $(g_L - \alpha_H)$  and  $s_L(g_L - \alpha_H)$  are, respectively, the rate of growth of employment in sector L and the contribution of sector L to growth in total employment. To maintain a constant rate of unemployment in the economy, the rate of growth of employment,  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$ , should be equal to the rate of growth of labour force in the economy, i.e.,  $n$ .

If  $n > s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$ , the rate of growth of labour force in the economy is greater than the rate of growth of employment (when the labour productivity ratio  $y_H / y_L$  remains unchanged). As the contribution of sector H to employment growth i.e.,  $s_H(g_H - \alpha_H)$  does not change, the contribution of sector L to employment growth must now be larger than  $s_L(g_L - \alpha_H)$  to maintain a fixed rate of unemployment. That is, sector L, which acts as the residual sector, must absorb the extra labour which doesn't get employed in sector H. Thus the actual rate of growth of labour productivity in sector L must fall below  $\alpha_H$  and labour productivity ratio ( $y_H / y_L$ ) must rise.

Similarly, if  $n < s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$  then rate of growth of labour force in the economy is less than the growth rate of employment. Then, the contribution of sector L to employment growth must be less than  $s_L(g_L - \alpha_H)$  and the demand for extra labour which is not met from the growth of the labour force is taken from sector L. As surplus labour gets released from sector L, labour productivity in sector L becomes more than it is required to maintain the labour productivity ratio constant. Thus the rate of growth of labour productivity in sector L is greater than  $\alpha_H$  and relative labour productivity ratio falls.

We also note that if  $n \geq (g_H - \alpha_H)$  then  $\frac{\alpha_H + n - g_L}{g_H - g_L}$  is greater than or equal to one. Since,  $0 < s_H < 1$ , it follows that  $s_H$  is less than  $\frac{\alpha_H + n - g_L}{g_H - g_L}$ . Thus, if

$n \geq (g_H - \alpha_H)$  then the rate of growth of the relative labour productivity of sector H is positive. This means that whatever the rate of growth of the technologically defined maximum labour productivity in sector L, the rate of growth of actual labour productivity in sector L must always lag behind the rate of growth of labour productivity in sector H. Thus we get:

**Corollary 1:** *If the rate of growth of labour force in the economy is greater than the rate of growth of employment in sector H then labour productivity in sector H must be increasing relative to sector L.*

From our earlier discussion of Proposition 1, we know that the rate of growth of employment in the economy must be  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$  if the labour productivity ratio between sector H and sector L is to remain unchanged. Since,  $g_H > g_L$ , if  $n \geq (g_H - \alpha_H)$  then  $n \geq (g_L - \alpha_H)$  and as  $0 < s_L < 1$  and  $s_H + s_L = 1$ , it follows that  $n > s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$ . The actual rate of growth of employment in the economy is  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_L)$ . Again, to maintain constant rate of unemployment:  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_L) = n > s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$ .

This implies  $\alpha_L < \alpha_H$ , i.e., actual rate of growth of labour productivity in sector L is less than the rate of growth of labour productivity in sector H. Thus, if the rate of growth of the labour force in the economy is greater than the rate of growth of employment in sector H then labour productivity in sector H must be increasing relative to sector L.

Similarly, if  $n \leq g_L - \alpha_H$  then  $\frac{\alpha_H + n - g_L}{g_H - g_L}$  is less than or equal to zero and  $s_H$  is greater than  $\frac{\alpha_H + n - g_L}{g_H - g_L}$ . Thus, if  $n \leq g_L - \alpha_H$  then rate of growth of labour productivity in sector H relative to sector L is negative. Accordingly, we get:

**Corollary 2:** *If the sum of the rate of growth of the labour force and the rate of growth of productivity in sector H is less than or equal to the rate of growth of output in sector L then the labour productivity in sector H must be decreasing relative to sector L.*

Since,  $g_H > g_L$  we have  $(g_H - \alpha_H) > (g_L - \alpha_H)$ . Multiplying both sides by  $s_H$  and using  $s_H + s_L = 1$  we obtain  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H) > (g_L - \alpha_H) \geq n$ . Therefore,  $n = s_H(g_H - \alpha_H) + s_L(g_L - \alpha_L) < s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H)$  and this implies  $\alpha_L > \alpha_H$ . So, if the sum of the rate of growth of the labour force and the rate of growth of productivity in sector H is less than or equal to the rate of growth of output in sector L then labour productivity ratio  $y_H / y_L$  must be decreasing.

Now consider the intermediate case where  $g_L - \alpha_H < n < g_H - \alpha_H$ .



$$\text{Let } z = \frac{n + \alpha_H - g_L}{g_H - g_L}.$$

Taking partial derivatives of  $z$  with respect to  $\alpha_H, g_H, g_L$  and  $n$  we obtain:

$$(i) \quad \frac{\partial z}{\partial \alpha_H} = \frac{1}{(g_H - g_L)} > 0 \quad (\text{since } g_H > g_L)$$

$$(ii) \quad \frac{\partial z}{\partial n} = \frac{1}{(g_H - g_L)} > 0$$

$$(iii) \quad \frac{\partial z}{\partial g_H} = \frac{(g_L - \alpha_H) - n}{(g_H - g_L)^2} < 0 \quad (\text{since } n > g_L - \alpha_H)$$

And

$$(iv) \quad \frac{\partial z}{\partial g_L} = \frac{n - (g_H - \alpha_H)}{(g_H - g_L)^2} < 0 \quad (\text{since } n < g_H - \alpha_H)$$

From Proposition 1 it follows that  $z$  represents the critical value of  $s_H$  (employment share of sector H) that determines the sign of the growth rate of the labour productivity ratio between sector H and sector L. The signs of derivatives (i)-(iv) imply that the critical value is increasing with the growth rate of labour productivity in sector H and growth rate of labour force in the economy. On the other hand, the critical value is decreasing with the growth rates of output of both the sectors. As  $z$  is the value of  $s_H$  for which  $s_H(g_H - \alpha_H) + s_L(g_L - \alpha_H) = n$ ,  $z$  must satisfy  $z(g_H - \alpha_H) + (1 - z)(g_L - \alpha_H) = n$ . Now, if  $\alpha_H$  increases then to satisfy the above condition,  $z$  will increase (as  $g_H > g_L$ ). Similarly, if  $n$  increases then  $z$  must increase to satisfy the condition.

Now, suppose that  $g_H$ ,  $g_L$  and  $\alpha_H$  are all constant over time. Then, the time path of labour share in the high productivity sector is:  $s_H = Ce^{(g_H - \alpha_H - n)t}$  (where we can assume that we are considering an initial value of  $s_H$  and a time interval for which  $s_H$  lies between 0 and 1). When the growth rate of employment in sector H, ( $g_H - \alpha_H$ ), is larger than the growth rate of labour force, ( $n$ ), the share of employment in sector H increases over time. If  $s_H$  increases and  $g_H$ ,  $g_L$ ,  $\alpha_H$  and  $n$  remain constant over time then in the long run  $s_H$  will ultimately reach its critical value  $z = \frac{n + \alpha_H - g_L}{g_H - g_L}$ . Therefore we have the following corollary to Proposition 1.

**Corollary 3:** *Consider that in an economy rates of growth of - output in sectors H and L, labour productivity in sector H, and the labour force remain constant over time. In such a situation, if the growth rate of employment in sector H is greater than the growth rate of the labour force in the economy, the ratio of the labour productivity in sector H with respect to sector L must ultimately decline.*

In our model, the rates of growth of labour productivity in the agricultural sector and the non- agricultural sector relative to the agricultural sector are endogenously determined. We assume that the rate of technological change in the non-agricultural sector, the rates of growth of output of the agricultural and the non-agricultural sectors and the rate of unemployment are exogenously given and constant. Then the above corollary implies that if the rate of growth of employment in the non-agricultural sector is greater than the constant rate of growth of labour force in the economy then labour productivity of the non-agricultural sector will ultimately decline.

## 5. Empirical analysis

In this section we have estimated the relationships between labour productivity in the agricultural sector and the non-agricultural sector and employment share of the non-agricultural sector while controlling for growth of the agricultural sector, labour force, labour productivity in the non- agricultural sector and also technological development of the economy. The model that we have estimated here takes the form:

Labour productivity in agriculture relative to non-agricultural sector =  $a + \beta_1$  (growth of labour force) +  $\beta_2$  (non-agricultural employment relative total labour force) +  $\beta_3$  (growth of agricultural sector) +  $\beta_4$  (productivity of non-agricultural sector) +  $\beta_5$  (time).

Here,  $a$ ,  $\beta_1, \beta_2, \beta_3, \beta_4$  and  $\beta_5$  are the parameters that we want to estimate.

For the purpose of our estimation, we have done a panel data analysis for the eight countries of our interests over the period 1970 to 2014. Data that we have used in this estimation have been collected from APO productivity database (2016) (Asian Productivity Organisation, Japan)<sup>6</sup>. We have considered the time period based on the maximum availability of data. Three-year moving average values have used for all the variables that we have considered here to get rid of the problem of fluctuations in the data.

Estimation results have been reported in Table 5.1. To test for the robustness of the regression results, we have considered alternate models while considering different sets of variables. In model 3 (as reported in column no.3), we have considered all the variables of our main model. In model 1, we have dropped the variable, productivity in non-agricultural sector. In model 2, we have excluded time. We have reported the regression results both for the fixed effect and the random effect models. Here, the dependent variable is labour productivity in agriculture relative to non-agricultural sector.

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<sup>6</sup> <http://www.apo-tokyo.org/publications/wp-content/uploads/sites/5/APO-Productivity-Databook-2016.pdf>

**Table 5.1: Relationship between labour productivity in agriculture relative to non-agricultural sector and employment in the non-agricultural sector**

Variable	Fixed Effect			Random Effect		
	1	2	3	1	2	3
Labour force growth rate	-.01 (.22)	.01 (.37)	-.01 (.27)	-.008 (.49)	.01 (.19)	-.008 (.43)
Non- agricultural employment relative to total labour force	.76*** (0.00)	.74*** (0.00)	.89*** (0.00)	.73*** (0.00)	.77*** (0.00)	.89*** (0.00)
Agricultural output growth	.07 (.48)	.002 (.98)	.08 (.42)	.06 (.53)	.0006 (.99)	.07 (.45)
Non-agricultural productivity	-----	-.002*** (0.00)	-.001*** (0.00)	-----	-.002*** (0.00)	-.001*** (0.00)
Time	-.006*** (0.00)	-----	-.004*** (0.00)	-.006*** (0.00)	-----	-.004*** (0.00)
Constant	13.10*** (0.00)	.14* (0.07)	9.89*** (0.00)	12.11*** (0.00)	.11 (0.23)	9.15*** (0.00)
No. Of observations	248	248	248	248	248	248
F-statistic/Wald $\chi^2$	17.68 (0.00)	12.82 (0.00)	16.26 (0.00)	62.86 (0.00)	50.06 (0.00)	76.58 (0.00)

Note: \*\*\* implies significant at one percent level and \* implies significant at 10 percent level. Values in the parentheses are the corresponding p-values.

In our estimation results we find that controlling for the other factors, non-agricultural employment relative to total labour force is found to be highly significant and positively related to the labour productivity ratio of the agricultural sector and the non-agricultural sector. This supports our postulation that as the increasing proportion of labour force gets employed in the non-agricultural sector, pressure of surplus labour on the agricultural sector reduces and labour productivity in agriculture relative to the non-agricultural sector increases. At the same time, we also find that labour productivity in the non-agricultural sector is significant and negatively related to the labour productivity ratio of the two sectors. It might reflect the fact that as labour productivity in the non-agricultural sector increases, to produce a given output in the non-agricultural sector, requirement of labour will decline and thus employment generation in the non-agricultural sector will also decline. Therefore, the extra labour without getting any employment

opportunity in the non-agricultural sector might remain in the agricultural sector ultimately resulting in decline in the labour productivity ratio.

In our estimation, we have also controlled for technological change while including time trend as an explanatory factor. In our results, we find that even if we control for the effect of technological change, labour productivity ratio is determined by the labour absorption capacity of the non-agricultural sector.

Time trend appears to be significant and negatively related to the productivity ratio in the regression results. The negative coefficient of time trend (captured by the variable year) might indicate that adoption of new technologies is generally higher in the non-agricultural sector relative to the agricultural sector especially in the developing countries. The adoption of advanced technologies is restricting the growth of employment in the non-agricultural sector. This also gets reflected in our regression results if we include the interaction term between non-agricultural productivity and year. The interaction term also appears with a negative sign (we have not reported the results here).

The regression results do not change with the alternate models that we have considered here. Further, the results are quite similar in fixed effect and random effect models. All these validate the robustness of our regression results and the strong relation between labour productivity ratio and labour absorption capacity of the non-agricultural sector.

## **6. Conclusions**

Over the last few decades, many of the developing countries have transformed from one, based on agriculture to a service sector dominated economy. It has also been noted that the employment shares of the leading sectors (industry and service sector) are rising less than proportionately to their output shares. However, the disproportional growth of output and employment shares of the non-agricultural sector in these developing countries has been a matter of concern.

We find that over the last four decades, the trend in labour productivity ratio of the non-agricultural sector relative to the agricultural sector has been different for different countries in Asia. In this paper, we developed a two-sector dual economy model to explain the different trends in relative labour productivity of the non-agricultural sector observed in a set of Asian countries, Indonesia, Malaysia, Philippines, Thailand, China,

India, Japan and South Korea. In this model, the rates of growth of output of the low productivity and the high productivity sectors are exogenously given and the rate of growth in labour productivity in the high productivity sector is exogenously determined by the pace of technological progress. Labour productivity in the low productivity sector is endogenously determined by the release or absorption of surplus labour required to maintain a fixed rate of unemployment in the economy.

Our model suggests that rate of growth of labour productivity of the non-agricultural sector (relative to the agricultural sector) tends to decline, remain unchanged or increase according to whether the employment share of the non-agricultural sector is greater than, equal to or less than a critical value. This critical value is equal to the difference between the growth rate of output of the non-agricultural sector required to maintain its employment share and the growth rate of output of the agricultural sector divided by the difference between the growth rates of output of the non-agricultural sector and the agricultural sector  $([n + \alpha_H - g_L] / [g_H - g_L])$ . Within this framework, we have found that given the rates of technological change, growths of labour force, and output in the agricultural and the non-agricultural sectors, labour productivity in the non-agricultural sector with respect to the agricultural sector will decline if the rate of growth of employment in the non-agricultural sector is greater than the rate of growth of labour force in the economy.

Therefore, based on our model we can argue that if current trends in growth in outputs and technological change continue and if rate of growth of employment in the non-agricultural sector is greater than the rate of growth of labour force, then eventually in the long run the gap between labour productivity in the non-agricultural and the agricultural sectors will get reduced. This would happen especially where the agricultural sector acts as the residual sector in terms of employment.

Based on the model, in our estimation results for a panel of eight Asian countries over the period 1970-2014, we find that controlling for other factors, non-agricultural employment relative to total labour force of the economy is positively related to the labour productivity ratio of the agricultural sector and the non-agricultural sector. The results hold good even after controlling for technological development of the economy.

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## Appendix:

Table A.1. Historical evidence of declining relative labour productivity in non-agricultural sector in the developed countries (1801-1955)

Country	Year	Non-agricultural Output share	Non-agricultural employment share	Relative labour productivity in non-agriculture	Output share of service sector	Output share of industrial sector
UK	1801	68	65	1.04	45	23
	1841	78	77	1.01	44	34
	1901	94	91	1.03	54	40
	1924	96	93	1.03	45	51
	1955	95	95	1	39	56
France	1866	58	57	1.01	28	30
	1911	65	70	0.93	28	37
	1951	88	80	1.1	36	52
Netherlands	1899	84	72	1.17	51	33
	1947	87	83	1.05	40	47
Denmark	1901	76	58	1.31	---	-----
	1952	82	81	1.01	----	-----
Norway	1875	66	51	1.29	45	21
	1910	76	62	1.23	50	26
	1950	87	75	1.16	34	53
Sweden	1870	61	45	1.35	44	17
	1910	65	59	1.10	27	38
	1950	90	81	1.11	35	55
Italy	1871	45	49	0.92	25	20
	1911	53	55	0.96	31	22
	1951	75	65	1.15	27	48
US	1840	31	32	0.97		31
	1870	51	49	1.04	47	33
	1910	88	68	1.29	50	38
	1950	91	88	1.03	52	39
Japan	1872	37	15	2.47	21	16
	1925	74	48	1.54	36	38
	1950	86	52	1.65	35	51

Source: Kuznets (1979).