Discussion Papers in Economics

On Wage Inequality, Trade and Technology: Theory and Empirics

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Discussion Paper 15-09

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1. Introduction:

This paper is intended to contribute in the analysis of the movements of *real wages* of skilled and unskilled labour in Indian manufacturing over the last two decades and thereby trying to provide plausible explanations for the causes of the widening gap between the two wages. A widening gap between the two wages essentially implies increasing *wage inequality*, which is measured as the ratio of the two wages (See, Barua and Pant, 2014). Thus, an increase in the ratio of the skilled to unskilled wages (that is, the *relative wage rate*) would mean that the relative wage movement has been against the unskilled labour. In the same way, a fall in the relative wage rate implies that the wage movement has been in favour of the unskilled labour. However, it is important to recognize at this point that a rise or fall in the relative wage rate is possible even in the context where the *absolute wages* of both skilled and unskilled labour might increase. Of course, it is quite obvious that where both the wages move in opposite directions, the relative wage rate would rise (fall) depending on whether the skilled wage rises (falls) and unskilled wages fall (rise). The early theoretical literature on the analysis of real wage movement had mainly focussed on either the policy induced effects (Stolper – Samuelson, 1941)[1] or the effects of technical change (Hicks, 1932)[2]. Since labour were not distinguished as skilled and unskilled during the time of development of these literatures, the analyses of real wage movements was actually concerning with the movement of *absolute* but not the *relative wage rate*. However, recent years have witnessed an increasing concern for explaining the movements of *relative* rather than the *absolute* wages of skilled and unskilled labour. The available theoretical literature on the issue of *relative wages* had mainly been developed within a trade theoretic framework a la Stolper and Samuelson. The analyses of this kind require us to extend the standard two goods - two

[1] Wolgang Stolper and Paul Samuelson (1941) in their classic paper showed that a policy of trade protection in a capital abundant country, for instance the United States, would lead to a rise in the real returns to the scarce factor (labour) and an fall in the real returns to the abundant factor (capital).

[2] Hicks in his well known book *The Theory of Wages* (1932) argued that while neutral technical change may leave the marginal productivities of labour (and capital) unchanged, the biased technical change may increase or decrease the marginal productivities of the factors. Since wages are determined by the marginal productivities in a neo – classical analysis, the increase in the marginal productivity of labour may induce rise in the real wage rate.

factors model into a two goods - three factors model where the three factors are usually defined as capital, skilled labour and unskilled labour. But such a model is over determined and does not have a unique solution. For a particular desirable solution in such a model one needs to make some special assumptions about factor mobility or factor substitutability. For instance, in a globalized world where capital is freely mobile, the rate of interest becomes uniform everywhere but labour immobility makes wages of skilled and unskilled labour different across countries due to exogenously given differential factor endowments of skilled and unskilled labour. Thus, the model is reduced to a standard two goods two factors model where comparative advantage in production is determined by relative abundance of skilled and unskilled labour. In a model of this kind Leamer (1993, 1995) tried to explain why freer trade might cause a *fall in the relative wages of unskilled labour* in the United States or why there may be a *rise in the relative wages of unskilled* labour in a so – called developing country[3]. In other words, using the terminology of *wage inequality* as define above it can be said that a rise (or fall) in *relative real wages* is synonymous with a fall *(or* rise) *in wage inequality*.

The implication of the above trade theoretic explanation of wage inequality is that as *wage inequality* declines in one country, it must increase in the other country. However, empirical studies, by and large, do not support this hypothesis. Contrary to the above what was being observed was increasing *wage inequality* in both developing and developed countries (Cline, 1997; for an extensive survey see Anne Harrison et.al 2010) following the liberalization of trade. Die hard trade economists trying to see this as a trade induced phenomenon therefore often get puzzled and bewildered confronting with such outcomes, others emphasize that the phenomenon of wage inequality is not as much related to trade as it is related to *technology bias* against unskilled labour (see, Adrian Wood, 1997; Krusell et al, 2000) or outsourcing (See, Batra and Beladi, 2010). Notwithstanding these explanations there is still one perplexing question to be answered: irrespective of the movement of the relative wage rate what makes the absolute wages of both skilled and unskilled labour to rise in both developed and developing countries? In an attempt to explain this phenomenon of wage

[3] There are also other explanations for rising skill wages relative to the unskilled wages. For instance, complementarities between skilled labour and capital could cause this in a trading model (See, Parro, Fernando, 2013); or skill – biased technical change (Per Krusell et al, 2000); or in presence of multiple cones of diversification between countries, increased wage inequality may arise as a theoretical possibility (Deardorff, 2001; Xiang, 2007).

inflation, Barua and Pant (2014) have developed a standard general equilibrium model assuming factor specificity and showed that (1) both skilled and unskilled wages might simultaneously rise due to exposure to trade and (2) rise or fall in wage inequality would depend on differential marginal productivities of skilled and unskilled labour. We take this model as a starting point to examine the scenario of wage movements in the context of the Indian manufacturing and then try to find plausible causes of differential movements of the marginal productivities of skilled and unskilled labour in India.

The paper is organized in the following way: The *second section* provides a very brief survey of the relevant literature on the subject. In the *third section* we restate the basic Barua – Pant (2014) model in order to derive our testable empirical hypotheses. The *fourth section* deals with the data and the hypotheses to be tested. In the *fifth section* we discuss the results of our empirical analyses. Finally, in the *sixth section* we conclude our paper.

2. Literature Survey

There is a large body of literature dealing with the issue of wage inequality. In this section, we briefly review the major findings on this issue.

As for the advanced countries, the United States (US), for instance, had witnessed a steady rise in the income gap between college graduates and high school graduates during 1980s (Murphy and Welch, 1991 and 1992; Bound and Johnson, 1992; Katz and Murphy, 1992). Goldin and Katz (2008). But the wage gap though had decreased in the 1990s and 2000s, the gap was still persisting. A similar trend in wage inequality was found in United Kingdom (Machin and Reenen, 2010)[4]. The phenomenon of rising wage inequality was not entirely confined to the US and the UK, but it was generally observed in most of the developed countries in the 1990s (Reenen, 2011; Atkinson et al., 2011). Three main explanations were proposed to explain the rising wage inequality: one, demand side explanation focusing on how trade or technology factors have induced a rise in the demand for skilled labour (Bojras, Freeman and Katz, 1996; Autor et al., 2008)) causing increase in skill wage; two, the supply side explanation stressing on the fact that a fall in the relative supply of skilled labour might have resulted in the observed increase in the skilled wage rate (Murphy and Welch, 1989)); and the third explanation was based on the institutional factors like the declining power of labour union and the abolition of minimum wage law (Card and

[4] In 1979 while weekly earnings of a worker at the 90th percentile of the distribution was 2.5 times more than a worker at the 10th percentile of the distribution, in 2009 the equivalent figure became 3.7 times more in UK (Machin and Reenen, 2010).

DiNardo, 2002; Western and Rosenfeld, 2011)). However, the first explanation seems to have outnumbered the later two explanations. Within the demand driven explanation of wage inequality in the developed world, some like Murphy and Welch (1991) and Borjas, Freeman and Katz (1996) have argued that the expansion of trade has increased the demand for skilled labour, others, for instance, Lawrence and Slaughter (1993; Krugman and Lawrence (1993) and Autor et al (2008) have argued that the skilled - biased technological change arising due to the computer revolution in late 1970s and early 1980s favoured skilled labour and significantly raised its demand and wage. For some like Reenen (2011), the impact of trade on rising wage inequality is rather indirect in the sense that trade stimulates faster innovation and diffusion and thereby creating an increased demand for skilled labour.

In the context of the developing countries there are numerous studies pertaining to wage inequality as well. In most of the studies it has been observed that the wage inequality in the developing countries was essentially a post- liberalization phenomenon. For example, Robertson (2000), Robins and Ginding (1999), Beyar, Rojas and Verjara (1999), Arbache, Dickerson and Green (2004), Hasan and Jandoc (2010), Han, Liu and Zhang (2012) and Galiani and Sanguinetti (2003) have showed that earning differential between more educated and less educated workers climbed up in Mexico, Costa Rica, Chile, Brazil, Philippines, China and Argentina respectively during the post- liberalization period. In contrast, Amiti and Cameron (2012) had found a reduction in the skill wage premium in Indonesia. It was argued that Indonesia being a highly unskilled labour abundant country had experienced a fall in the skill premium following the trade expansion which was consistent with the prediction of the standard HOS theory. They justified rising trend in wage inequality in other developing countries such as Brazil, Costa Rica, Chile on the ground that these countries are relatively more skilled labour abundant compared to Indonesia. Similar argument has been put forward by Hanson and Harrison (1999) for Mexico. However, the Chinese experience of rising wage inequality nullifies the HOS line of argument[5] as it had been observed that trade liberalization had significant impact on skilled-unskilled wage inequality in China (Anwar and Sun, (2012), Beyar, Rojas and Verjara (1999) and Robertson (2000). On the contrary, Galiani and Sanguinetti (2003) had found that trade had a very minor bearing on rising wage inequality in Argentina. There are others who emphasized upon biased technological change

[5] China is more unskilled labour abundant country compared to any other developing country and therefore following HOS analysis skill wage premium should have increased in China with the opening up of trade.

following the inflow of FDI and import of capital goods to be the causal factor responsible for rise in wage inequality (Feenstra and Hanson, 1997; Robins and Gindings, 1999). Interestingly, Mamon and Marshid (2012) claimed that governments' negligence to primary education was mainly responsible for rising wage inequality in developing countries.

India is no exception to this rising pattern of skilled-unskilled wage inequality. Kijima (2003), for instance, had observed that the wage gap between the skilled - unskilled labour had been persistent in India since the eighties though the inequality has been found to be more pronounced in the post trade liberalization period. This result has been confirmed by other studies as well (See, Banga, 2005; Chamarbagwala, 2006; Sen, 2007 and Ramaswamy, 2008). In a recent paper, Mehta and Hasan (2012) had analyzed the role of trade as well as service liberalization on wage inequality and it had been shown that a 29% increase in wage inequality between 1993 and 2004 had been due to reallocation of labour following trade liberalization.

3. The basic Barua – Pant (2014) model:

The model is a standard general equilibrium trade model with two sectors, manufacturing and service and three factors of production, capital, skilled labour and unskilled labour. Symbolically, the sectors are X_1 (Manufacturing) and X_2 (Service) and the factors are L (skilled labour), L_u (unskilled labour) and K (capital). Skilled labour is employed in both the sectors. Capital is a specific factor in X_1 and unskilled labour is specific in X_2. The production functions are given by

$$X_1 = X^1(K_1, L_1) \qquad (1)$$

$$X_2 = X^2(L_u, L_2) \qquad (2)$$

The full employment conditions are given by

$$L_1 + L_2 = \bar{L} \qquad (3)$$

$$L_u = \bar{L}_u \qquad (4)$$

$$K_1 = \bar{K} \qquad (5)$$

$\bar{L}, \bar{L}_U, \bar{K}$ are the supply of skilled labour, unskilled labour and capital respectively. Equation (4) and (5) indicate unskilled labour and capital are specific factors.

Now, assuming perfect competition in the factor markets, the factor market equilibrium conditions can be written as:

$$W_S = X^1{}_L = PX^2{}_L \qquad (6) \text{ and } (7)$$

$$W_U = PX^2{}_U \qquad (8)$$

In the above equations (6) – (8) the symbols, W_S, W_U, stand for the skilled and unskilled labour wages, which are equated with the value of their respective marginal productivities. P is the relative price of good 2 while the price of good 1 is the numeraire. $X^1{}_L$ and $X^2{}_L$ are the marginal physical products of skilled labour in sector 1 and 2 and and $X^2{}_U$ is the marginal physical product of unskilled labour in sector 2. The above model is solvable since there are 8 endogenous variables $(X_1, X_2, K_1, L_1, L_2, L_U, W_S, W_U)$ and 8 equations, (1) – (8) as shown above.

3.1 The relation between commodity prices and the wages

Following the usual Stolper – Samuelson theory we try to find the effects of the changes in the relative commodity prices on the wage rates of skilled and unskilled labour. For this, we totally differentiating the equations (6) – (8) and using (1) – (5) as shown by Barua and Pant (2014), we get the following equations.

$$\frac{dW_S}{dP} = X^1{}_{LL}\frac{dL_1}{dP} = PX^2{}_{LL}\frac{dL_2}{dP} + X^2{}_L \qquad (9)$$

And

$$\frac{dW_U}{dP} = PX^2{}_{UL}\frac{dL_2}{dP} + X^2{}_U \qquad (10)$$

The equations (9) and (10) determine the effects of a rise in P on the skilled and unskilled wage rates. In order to find the signs of the above expressions we need to find the

sign of $\frac{dL_2}{dP}$ for which we totally differentiate the full employment condition (3) and use the resulting results in (9) to get the equations given below:

$$\frac{dL_2}{dP} = -\left(\frac{X^2{}_L}{X^1{}_{LL} + PX^2{}_{LL}}\right) > 0$$

And

$$\frac{dL_1}{dP} < 0 \qquad (11)$$

The results in (11) state that a rise in P would lead to an increase in the employment of skilled workers in sector 2 and a decrease in the employment of skilled labour in sector 1. Now we use (11) in (9) and (10) to find the sign of the effects of a rise in P on the skilled and unskilled wage rates as given below in equation (12):

$$\frac{dW_S}{dP} > 0$$

And

$$\frac{dw_U}{dP} > 0 \qquad (12)$$

The equation (12) shows that a rise in the relative price of good 2 would result in a rise the wage rates of both skilled and unskilled labour. This is an important result derived by Barua and Pant (2014). This result is in contradiction to what Leamer (1993, 1995) had shown that the two wages move in opposite direction.

We shall be using the above result as the basis of our first empirical hypothesis. The hypothesis states that as a small economy is opening up to trade where the world relative price, P, is higher than the pre – trade domestic price, the wages of both skilled and unskilled labour would rise together provided that skilled and unskilled labour were specific to each industry.

However, the above result does not indicate what will happen to the *relative wages*. That is, if the two wages move in different proportions then the *relative wages* may either rise or fall. In order to determine the *relative wage rate*, Barua and Pant (2014) defined the following variable, W:

$$W = \frac{W_S}{W_U} \qquad (13)$$

Now, W, is the relative wage rate of the skilled labour in terms of the unskilled labour. In order to determine the direction of change of W with respect to the changes in P we totally differentiating equation (13) with respect to P. Using the equations (9) and (10), Barua and Pant (2014) have shown that

$$\frac{dW}{dP} = X^2_L(1+\lambda) - X^2_U \qquad (14)$$

Where

$$\lambda = \frac{PX^2_{UL} - PX^2_{LL}}{X^1_{LL}+PX^2_{LL}} < 0 \qquad (15)$$

It is clear from equation (14) that the sign of $\frac{dW}{dP}$ depends on the value of λ

$$\left.\begin{aligned} &\frac{dW}{dP} < 0 \ for\ |\lambda| > 1 \\ &\text{And} \\ &\frac{dW}{dP} > 0 \ for\ |\lambda| < 1 \ only\ if\ X^2_L \gg X^2_U \end{aligned}\right\} \quad (16)$$

Thus, equation (16) states that *relative wage rate* may fall unambiguously if the absolute value of λ is greater than unity. However, if the absolute value of λ is less than unity then the *relative wage rate* may rise provided the marginal productivity of skilled labour is sufficiently higher than the unskilled labour. This gives rise to the second empirical analysis of this paper that if the *relative wage rate* is observed to be increasing then it must be because

of 1) λ taking an absolute value of less than unity and 2) differential growth in the marginal productivities of skilled and unskilled labour.

However, the Barua and Pant (2014) result needs further justification. That is, why marginal productivities of the skilled and unskilled labour grow differentially? Our endeavour in this paper is to empirically analyze the movements of wages of skilled and unskilled labour in Indian manufacturing and to verify whether our empirical findings conform to the Barua and Pant (2014) results as described above. After confirming this we try to move one step further to find the underlying causes of differential movements of marginal productivities of skilled and unskilled labour in terms of a plausible econometric model.

4. Hypotheses and Data

4.1 Hypotheses

We propose to test the following two hypotheses based on the Barua – Pant (2014) model in the context of the Indian manufacturing.

Hypothesis 1: *As a small country is opening up to trade where unskilled labour is specific to the export sector and the skilled labour is specific to the import competing sector, then we shall expect that the absolute wage rates of both skilled and unskilled labour would increase simultaneously.*

Hypothesis 2: For small open economy with a large body of unskilled labour force specific to the export sector and skilled labour specific to the import competing sector, trade liberalization may lead to an increase in the *relative wage rate* of the skilled labour or rise in *wage inequality* between skilled and unskilled labour if the skilled labour is sufficiently more productive than the unskilled labour.

4.2. Data

The basic source of data used in this study is Annual Survey of Industries (ASI)[6], Central Statistical Organisation (CSO). In ASI industries have NIC (National Industrial

[6] Annual survey of Industries covers all those industries registered under the factories act of 1948. They are the industries use power and employ at least 10 workers or do not use power but employ 20 or more workers.

Classification) coding those has changed couple of time in the past[7]. To get a comparable data across year concordance has been worked out between NIC-1987, NIC-1998 and NIC-2004 keeping NIC-1998 as the base classification of industries. Economic and Political Weekly has created a systematic electronic data base on ASI results, help of which has been taken in making the concordance. The unit of observation is the organized manufacturing industries at 3-digits NIC 1998 classification. Data for 35 three digits industries have been taken for the analysis[8]. The period of analysis is 1980-2007 that covers both pre and the post liberalization period. The data from ASI have been drawn on the following variables: number of workers, number of employees, wages to workers, total emoluments, gross value added, fixed capital and depreciation. Note that, fixed capital as defined in ASI is not same as the stock of capital. To obtain the data series on stock of capital perpetual inventory method has been used. The measurements of the variables including capital stock are in detail explained in appendix. ASI does not provide data on R&D expenditure. However, PROWESS reports company level data on this variable, from where the compilation has been done at three digit industry level[9]. To obtain the data on foreign transactions (export and import) ASI cannot be relied on, thus is taken from UN's COMTRADE online database. This database provides data in Standard International Trade (SIT) classification. To match this data with the data series given in ASI a concordance has been made between NIC and SIT classification. This was done based on concordance series between ISIC revision 3 and SITC revision 3 provided by United Nations Statistics division. Since industry coding given by ISIC rev 3 is exactly similar with NIC-1998 up to 4 digit level of classification, purpose of the study was served with the use of the concordance series provided by United Nations.

5. Structure of Industries and Factor Specificity

5.1. **Distribution of workers across industries**

The industries have been classified based on the nature of foreign market participation (such as exportable sector and importable sector) and skilled intensity (high and the low skilled intensive industry). Exportable (importable) sector/industry is defined as a sector

[7] NIC-1970 was followed to classify economic activities of factories from ASI 1973-74 to ASI 1988-89.Then NIC-1987 was introduced and followed till ASI 1997-98. NIC-1998 was followed between ASI 1998-99 to ASI 2003-04.In 2004 NIC 2004 developed and continued till ASI 2007-08. NIC 2008 is the latest development.

[8] There are 61 three digit level industries in NIC 1998 classification.

[9] We are thankful to Rijesh R. (Research Associate, IIFT, New Delhi) for providing the data on R&D expenditure.

having positive (negative) net export[10]. To divide industries into the categories of low and high skill intensive industries, skilled intensities (ratio of skilled to unskilled workers) have been calculated for every industry in every year. Then the industry having skilled intensity lesser (higher) than the "mean skilled intensity"[11] was categorised as low (high) skilled intensive industry. The Table 1 below shows the distribution of skilled and unskilled labour intensive industries across exportable and importable sectors. It also shows how this distribution has changed over time.

Table 1:

Proportion of low skilled intensive and high skilled intensive industries among exportable and importable industries during different periods (in percentage term)

Period	Industry type	Low skilled intensive	High skilled intensive
1988-2007	Exportable Sector	80.77%	19.23%
	Importable Sector	34.62%	65.39%
1988-1997	Exportable Sector	80.77%	19.23%
	Importable Sector	30.77%	69.23%
1998-2007	Exportable Sector	78.57%	21.43%
	Importable Sector	42.31%	57.69%
2004-2007	Exportable Sector	79.17%	20.83%
	Importable Sector	48.15%	51.85%

Source: Own calculation based on ASI reports and UN COMTRADE database.

The above table indicates that in an average year for the period 1988 to 2007, low skilled intensive industries constitute 81% of the exportable sector and 35% of the importable sector. On the other hand, high skilled intensive industries constitute only 19% of the

[10] Net export is the difference between exports and imports
[11] Average across the skilled intensities of all the industries was termed as mean skilled intensity.

exportable sector but 65% of importable sector. It also shows that the distribution remained more or less unchanged across the period of study. In Table 2 we show the proportion of unskilled workers in exportable and importable sectors.

Table 2:

Proportion of low skilled unskilled workers in exportable and importable industries (in percentage terms)

Year	Exportable Industries	Importable Industries
1990	85.15%	14.85%
1995	84.20%	15.80%
2000	85.54%	14.46%
2005	86.61%	13.39%
2007	85.73%	14.27%

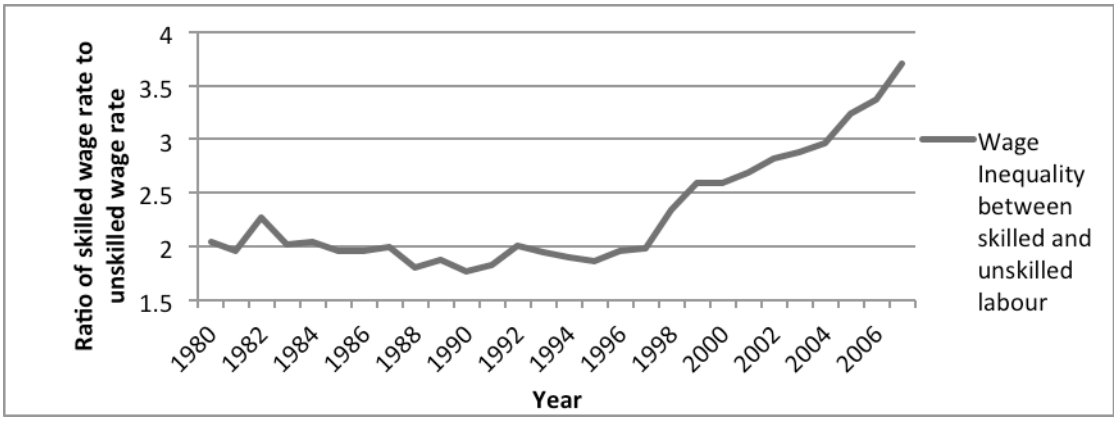
Source: Own calculation based on ASI reports and UN COMTRADE database.

It can be observed from the Table 2 that more than 85% of the unskilled workers are employed in the exportable industries in almost every five years of the period 1990 to 2005. On the other hand little less than 15% unskilled workers are employed in importable industries. Given such characteristics of employment of skilled and unskilled labour in Indian manufacturing industries we can draw the conclusion that while unskilled labour are specific to the export industries, skilled labour are specific to the import competing industries.

5.2. Trends in relative and absolute wages of skilled and unskilled labour in Indian manufacturing sector

This section discusses the behaviour of wage inequality between skilled and unskilled labour in Indian manufacturing sector since 1980 and explains how it changed with the liberalization of trade.

Figure 1: Trend in the ratio of skilled and unskilled wage rates in India

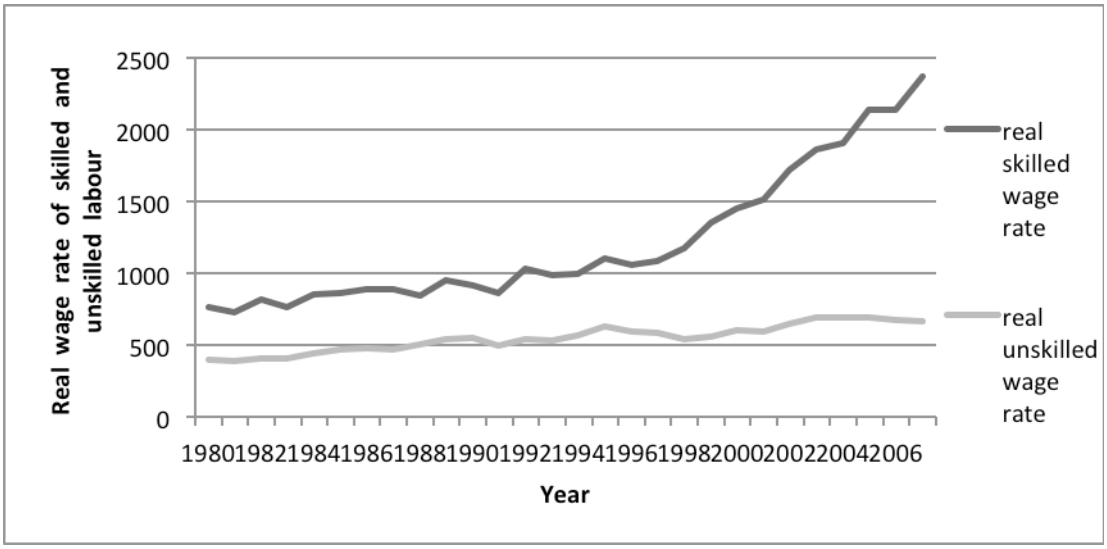


Source: Own calculation from Annual Survey of Industries report

The Figure 1 above clearly indicates that after a falling trend in the 1980s wage inequality between skilled and unskilled labour has increased continuously since the 1990s. Although the rate of rise is small during early 1990s there has been a steady and large increase in the wage inequality since 2000 (Figure 1). Therefore after the liberalization of the economy inequality in income between skilled and unskilled labour has gone up.

There are several reasons for wage inequality between skilled and unskilled to go up and each of them has different implication. Rise in the wage inequality may resulted with a fall in the real wage rate of unskilled labour, rise in the real wage rate of skilled labour or with a simultaneous rise (fall) in both the skilled and unskilled wage rate with a greater rise (fall) in the former. If unskilled wage rate fall it implies that the poverty situation of the economy is worsening. Contrary to this if both the wage rates increase then it imply that although the inequality in income may increase there is stability in the poverty situation of the country. Since differential movements in the real wage rate of skilled and unskilled labour leads to different economic situation it is worthwhile to analyze the movements of the skilled and unskilled real wage rates. The following figure shows the trends in the real wage rate of skilled and unskilled labour during the period 1980-2007.

Figure 2: Trends in the real wage rate of skilled labour and unskilled labour in India (amount in hundred rupees)



Source: Own calculation from Annual Survey of Industries report

The above Figure 2 shows that real wage rate of both the skilled and unskilled labour has been steadily increasing in India during the period under study. This result vindicates our first hypothesis that as a small economy is opened up to trade, the wage rates of both skilled and unskilled labour must rise provided both factors were specific to each of the two industries. Thus, our empirical finding supports the conclusion of Barua and Pant (2014).

Interestingly, a closer look at the data suggests that wage rate of unskilled labour has been increasing almost at the same rate throughout the period of 1980-2007. On the other hand, the skilled wage rate has been increasing initially at a moderate rate during the early post- liberalization period (1991-1998) and then after it has started increasing at a rather faster rate in the decade of 2000s. This has resulted in a small rise in the wage gap between skilled and unskilled labour in the beginning of the post-liberalization period followed by a larger increase in the wage gap in the later part of the post liberalization period. The above results confirm *hypothesis 1* holds true for Indian Manufacturing sector.

5.3 Absolute value of Lemda (λ)

The first step towards the empirical validation of Hypothesis 2 is to calculate the absolute value of Lemda (λ). Following equation 15 in the model

$$\lambda = \frac{PX^2_{GL} - PX^2_{LL}}{X^2_{LL} + PX^2_{LL}} < 0 \qquad (15)$$

Taking P common in both the numerator and denominator the expression becomes

$$\lambda = \frac{X^2_{UL} - X^2_{LL}}{\frac{1}{P}X^1_{LL} + X^2_{LL}} < 0 \qquad (17)$$

Since 1/P is less than one, we write 1/P = ε < 1.

Then, (17) can be written as

$$\lambda = \frac{X^2_{UL} - X^2_{LL}}{\varepsilon X^1_{LL} + X^2_{LL}} < 0 \qquad (18)$$

In expression (18), it is possible to find the values of X^2_{UL}, X^2_{LL} and X^1_{LL}. The value of X^2_{LL} (X^2_{UL}) is obtained by regressing marginal productivity of skilled (unskilled) labour in exportable sector[12] on both the skilled labour and unskilled labour. Taking the marginal productivity of skilled labour in importable sector and regressing it on skilled labour and capital gives us X^1_{LL}. Then the values λ can be calculated by calibrating for different values of ε.

The above regressions provide us the following figures

X^1_{LL} = -0.00052, X^2_{LL} = -0.00026, X^2_{UL} = 0.00002

Therefore $\lambda = \frac{X^2_{UL} - X^2_{LL}}{\varepsilon X^1_{LL} + X^2_{LL}} = -\frac{2\varepsilon}{26(2\varepsilon+1)}$ <0 for all ε>0

Here $|\lambda| < 1$ if $\varepsilon > 1/26$ and $|\lambda| > 1$ if $\varepsilon < 1/26$

Therefore a number of possibilities open up. From equation (16), wage inequality increase when $1/26 < \varepsilon < 1$ as long as the productivity of skilled labour exceed productivity of unskilled labour. Wage inequality decrease if $\varepsilon < 1/26$. From equation (14) when ε is closer to 1/26, λ is closer to unity, then the difference between the marginal productivities has to be very significant for wage inequality to go up. And if ε is closer to 1, λ would be very low then the difference need not be too significant.

5.4. Trends in the skilled and unskilled labour productivities

Productivity can be of two types: average productivity and the marginal productivity. Average productivity is the productive capacity of the factor while the marginal productivity is the marginal contribution of a factor. Factors are paid according to their marginal

[12] Sector 2 is an export sector and sector 1 an importable sector.

contribution. Therefore an analysis of skilled and unskilled wage rate requires a corresponding analysis of their marginal productivities.

In our attempt to measure the marginal productivities of skilled and unskilled labour, we estimate a Cobb-Douglas production function as defined below:

$$Y_{it} = AK^{\alpha}_{it} L^{\beta}_{it} S^{\gamma}_{it} \qquad (17)$$

In the Cobb-Douglas production (17) above Y_{it} is defined as the output produced by the industry i at time t, K_{it}, L_{it} and S_{it} are the capital, unskilled labour and skilled labour respectively employed by the industry i at time t. The parameters α, β and γ are the shares of capital, unskilled labour and skilled labour in the produced output. In order to estimate (17) we make a logarithmic transformation of the Cobb-Douglas production (17) as given below:

$$log\, Y_{it} = c + \alpha\, log\, K_{it} + \beta \log L_{it} + \gamma \log S_{it} + u_{it} \qquad (18)$$

The OLS estimation of (18) gives us elasticities of different factors of production. For example, β is the elasticity of unskilled labour and γ is the elasticity of the skilled labour. Now we define the marginal productivity of a factor, say the skilled labour, as the product of the elasticity of the skilled labour (γ) and the average productivity of skilled labour as shown below:

$$\frac{\partial Y}{\partial S} = \left(\frac{\partial Y}{\partial S}\frac{S}{Y}\right)\left(\frac{Y}{S}\right) \qquad (19)$$

Where $\frac{\partial Y}{\partial S}$ is defined as the marginal productivity of the skilled labour, $\left(\frac{\partial Y}{\partial S}\frac{S}{Y}\right)$ is the elasticity of the skilled labour (our estimated γ) and $\left(\frac{Y}{S}\right)$ is the average productivity of the skilled labour.

Similarly, we define the marginal productivity of unskilled labour as

$$\frac{\partial Y}{\partial L} = \left(\frac{\partial Y}{\partial L}\frac{L}{Y}\right)\left(\frac{Y}{L}\right) \qquad (20)$$

Where $\left(\frac{\partial Y}{\partial L}\frac{L}{Y}\right)$ is the elasticity of the unskilled labour (β).

Table 3: Panel Data estimation of C – D production function at 3-digit manufacturing industries for India

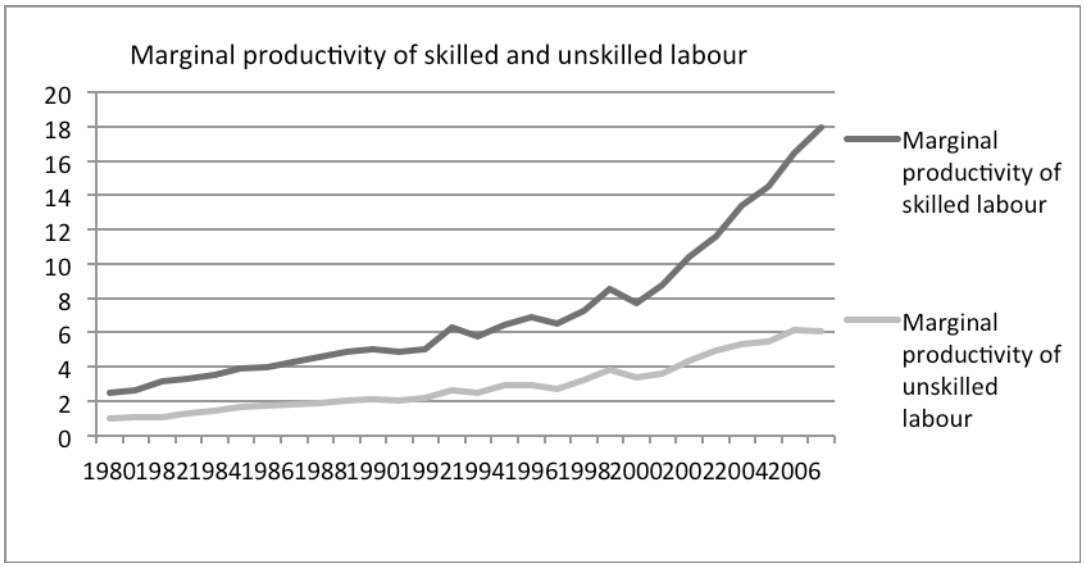
	Dependent Variable: log (Value added)	
Independent Variable	**1980-2007**	**1988-2007**
Capital	0.281***	2.423***
	(26.79)	(19.33)
Skilled employment	0.294***	0.177***
	(5.32)	(2.83)
Unskilled employment	0.324***	0.435***
	(5.48)	(6.48)
Constant	-13.1***	-9.776***
	(-33.59)	(-23.67)
R^2	Within=0.6524	Within=0.5806
	Between=0.8485	Between=0.8136
	Overall=0.7289	Overall=0.7501
Test Statistics for Joint Significance Slope Coefficient	F(3,1401) = 877.28	F(2,985)=454.60
	Prob>F(3,1401)=0.000	Prob>F(2,985) =0.000
Hausman Test Statistics	Chi2(3)= 624.61	Chi2(3)= 147.61
	Prob>Chi2 =0.000***	Prob>Chi2 =0.000***
Number of Observations	1456	1040
Number of Industries	52	52
Model Specification	Fixed Effect	Fixed Effect

Values in the parentheses are the t-values and '***' indicates significant at 1% level.

The above Table 3 reports the estimates of equation (18) for two samples. The first sample covers the period 1980-2007 that include both pre and post liberalization years while the second sample covering the period 1988 - 2007 stands for post liberalization period. The

coefficients of all the three factors (capital, skilled labour and unskilled labour) are positive as expected and significant. In order to obtain the partial marginal productivity of skilled (unskilled) labour we have to multiply elasticity of skilled (unskilled) labour with the average productivity of skilled (unskilled labour) as defined in equation (19) and (20). Accordingly, the partial marginal productivity of both skilled and unskilled labour have been computed for every year for the period 1980-2007. The trends in the partial marginal productivity of both the skilled and unskilled labour have been shown in the following Figure 3.

Figure 3: Trends in marginal productivity of skilled and unskilled labour



Source: Own calculation from Annual Survey of Industries report

The above Figure 3 shows that the marginal productivity of skilled labour is higher than the marginal productivity of unskilled labour. Although the productivity of both the skilled and unskilled labour had been increasing consistently since the 1980s, the marginal productivity of the skilled labour has been rising at a higher rate than the marginal productivity of the unskilled labour. As a result, the gap between the productivity levels has got widened up and the gap has increased sharply since the year 2000. This result confirms our second hypothesis.

Comparing Figure 2 and Figure 3 we may conclude that the differences in the marginal productivities of skilled and unskilled labour is the reason for the differences in the rate of growth in the wage rate resulting in rising the relative wage of the skilled labour. In other words, a rise in the relative wage of the skilled labour implies an increase in wage inequality.

Thus, we draw the following three conclusions from the above analyses:

1. The absolute wage rate of both skilled and unskilled labour has increased;
2. The relative wage rate of skilled labour as compared to the unskilled labour has also increased. The rise in the relative wage rate implies rising wage inequality.
3. Marginal productivities of both skilled and unskilled labour have gone up. However, the marginal productivity of the skilled labour has increased at a faster rate than the marginal productivity of unskilled labour.

Now we turn to the issue of the determinants of marginal productivities so as explain what has caused the marginal productivity of skilled labour to rise at a faster rate.

6. Determinants of Marginal Productivities:

In our attempt to determine the factors affecting the marginal productivities of skilled and unskilled labour we set up a simple regression equation where the marginal productivities of the skilled and unskilled labour are the dependent variable and we shall use several explanatory variables such as trade, R & D investment and capital labour ratios. To find the effects of trade we define a variable named net export to total value added. Research and development expenditure is taken as a proxy for technology. While R&D expenditure captures the disembodied form of technology, for considering the effects of embodied technical change we shall use capital labour ratio as a proxy variable. Since the objective is to find the determinants of the marginal productivity of skilled and unskilled labour, capital usage per unit of skilled labour and capital usage per unit of unskilled labour are taken separately.

6.1. **Regression Model 1**

The regression equation that we are going to estimate is as follows.

$$\log MP_{it}^{J} = \beta_i + \beta_1 \log R\&D_{it} + \beta_2 \log(K/J)_{it} + \beta_3 \log(NX/VA)_{it} + U_{it}$$

Here J = S, L i.e. J stands for either skilled labour (S) or unskilled labour (L) and i denote industry, t denotes time. MP_{it}^{J} is the marginal productivity of J^{th} type of labour in i^{th} industry in t^{th} year. $R\&D_{it}$ is the research and development expenditure incurred by i^{th} industry in t^{th} year. $(K/J)_{it}$ is the capital intensity of i^{th} industry in t^{th} year, measured by capital to skilled (unskilled) labour when dependent variable is marginal productivity of skilled (unskilled) labour. $(NX/VA)_{it}$ denotes net export to total value added in industry i in t^{th} year.

In confronting with the basic Barua-Pant model separate analysis has been made for exportable and importable industries. While exportable sectors are unskilled labour intensive sectors import competing sectors have certain tangible factors specific to itself we may call it technology or a specific type of capital[13]. The Table 4 below reports the results of the regression model 1

[13] The detail description of the method followed in division of industries is provided in appendix 3

Table 4: Determinants of marginal productivities for two industry groups (skilled intensive and unskilled intensive)

'***', '**' and '*' indicate significant at 1%, 5% and 10% level respectively.
Values in the parentheses of column 2 and 4 are t values and in column 3 and 5 are Z values.

Period of Analysis = 1990-2007				
	Unskilled Labour Intensive Exportable Industries		**Capital Intensive Importable Industries**	
Independent Variable	**Dependent Variable:** log(Marginal productivity of skilled labour)	**Dependent Variable:** log(Marginal productivity of unskilled labour)	**Dependent Variable:** log(Marginal productivity of skilled labour)	**Dependent Variable:** log(Marginal productivity of unskilled labour)
R&D	0.153*** (12.02)	0.130*** (11.09)	0.118*** (5.70)	0.111*** (5.69)
Capital to Skilled Employment	0.726*** (5.65)		0.641*** (4.91)	
Capital to Unskilled Employment		0.287*** (3.19)		0.270** (2.41)
Net Export to Total Value Added	-0.001 (-0.06)	0.002 (0.12)	- 0.065* (-1.81)	- 0.057* (-1.92)
Constant	-1.890*** (-5.54)	-1.062*** (-5.28)	-1.711*** (-4.62)	-0.789*** (-2.62)
R^2	Within=0.4887 Between=0.0869 Overall=0.1230	Within=0.4076 Between=0.3692 Overall=0.3888	Within=0.4464 Between=0.5535 Overall=0.4190	Within=0.3123 Between=0.3580 Overall=0.2837
Test Statistics for Joint Significance Slope Coefficient	F(3,180) = 57.35 Prob>(3,180)= 0.000	Wald Chi2(3)=129.62 Prob>Chi2(3)=0.00	F(3,131) = 35.21 Prob>(3,131)=0.00	Wald Chi2(3)=62.58 Prob>Chi2(3)=0.000
Hausman Test Statistics	Chi2(3)= 24.02 Prob>Chi2= 0.000***	Chi2(3)= 2.03 Prob>Chi2 =0.567	Chi2(3)= 12.90 Prob>Chi2= 0.005***	Chi2(3)= 1.43 Prob>Chi2 =0.698
Number of Observations	195	195	143	143
Number of Industries	12	12	9	9
Model Specification	Fixed Effect	Random Effect	Fixed Effect	Random Effect

It can be seen that R&D expenditure has a positive and significant effect on marginal productivity of skilled and unskilled labour for both the industry groups. It implies that irrespective of the industry group technological innovation by industries improves the productive capacity of both skilled and unskilled labour. Similar can be argued for embodied

technological change. Positive and significant coefficients of the variables capital to skilled labour and capital to unskilled labour indicates that increasing usage of machine and other forms of embodied technologies raises the productivity of both types of labour. The most interesting result is concerning the trade variable. In unskilled labour exportable intensive industries the variable net export to value added did not show any significant impact on the marginal productivities suggesting trade has no influence on marginal productivities in these industries. However for import competing industries it indicates trade has a significant negative effect on both the marginal productivities. Apparently the result seems to be misleading as expansion of trade supposes to improve productivities. However note that for importable industries liberalization of trade is associated with a fall in the net export (or in other words a rise in net imports) which along with the negative coefficient implies an upward surge in the productivities. Since productivities improve with the rise in imports (rather than rise in export) it is essentially the import of new modern technologies that raises productivities and the role that trade plays is only the role of an intermediary.

Since trade merely plays any role in raising labour productivities it cannot be make responsible for rising wage inequality. The productivity enhancements are entirely due to the technological advancement and since the benefit of technology can be accrued more by employing more skilled labour, productivity of skilled labour increased more than the productivity of unskilled labour which ultimately resulted in rising wage inequality.

The numerical values of R&D and capital intensity coefficients are reported to be higher for marginal productivity of skilled labour than that of unskilled labour. However it is not sufficient to argue that the actual effects of these variables are higher on skilled labour productivity than unskilled labour productivity since the differences in the numerical values might be simply due to the comparatively lesser variation in R&D and capital intensity in relation to the marginal productivity of skilled labour than marginal productivity of unskilled labour. Therefore the above table cannot explain the rising divergence between skilled and unskilled labour productivity. An attempt in such direction has been made with the following regression model.

6.2. **Regression Model 2**

To identify the factors responsible for growing divergence between marginal productivity of skilled and unskilled labour we estimate the following regression equation.

$$\log(MP_{it}^{S} / MP_{it}^{L}) = \beta_i + \beta_1 \log R\&D_{it} + \beta_2 \log(K/J)_{it} + \beta_3 \log(NX/VA)_{it} + U_{it}$$

The dependent variable is the difference between the log values of the productivity of skilled and unskilled labour ($\log(MP_{it}^{S} / MP_{it}^{L})$). The independent variables are same as the previous regression model. For capital (unskilled labour) intensive importable (exportable) industries j stands for skilled (unskilled) labour and correspondingly capital intensity is measured by taking the ration of capital to skilled (unskilled) labour.

Table 6: *Determinants of marginal productivities of skilled labour relative to the marginal productivity of unskilled labour in two industry groups (capital intensive and unskilled intensive)*

'***', and '*' indicate significant at 1% and 10% level respectively.
Values in the parentheses of column 2 are Z values and in column 3 t values.

Period of Analysis = 1990-2007		
	Unskilled Labour Intensive Exportable	**Capital Intensive Importable Industries**
Independent Variable	**Dependent Variable:** log(Ratio of Marginal Productivity of Skilled and	**Dependent Variable:** log(Ratio of Marginal Productivity of Skilled and Unskilled Labour)
R&D	0.010* (1.85)	0.003 (0.35)
Capital to Skilled Employment		0.482*** (9.39)
Capital to Unskilled Employment	-0.348*** (-7.14)	
Net Export to Value Added	0.005 (0.580)	-0.017 (-1.18)
Constant	1.194*** (10.50)	-1.134*** (-7.79)
R^2	Within=0.2500 Between=0.4458 Overall=0.4681	Within=0.5008 Between=0.2503 Overall=0.2513
Test Statistics for Joint Significance Slope Coefficient	Wald Chi2(3) = 68.78 Prob>Chi2=0.000	F(3,131) = 43.82 Prob>(3,131)=0.000
Hausman Test Statistics	Chi2(3)= 2.57 Prob>Chi2=0.4634	Chi2(3)= 18.51*** Prob>Chi2=0.0003
Number of Observations	195	143
Number of Industries	12	9
Model Specification	Random Effect	Within Effect

The column 1 of the above table suggests that for unskilled labour intensive industries the variable R&D activities has a positive and significant effect on the relative productivity of

skilled labour[14]. Therefore more an unskilled labour intensive industry spends on R&D more it favours skilled labour by increasing the productivity gap between skilled and unskilled labour. However for import competing industries neither of skilled or unskilled labour is favoured by R&D investment (column 2). For capital intensive importable industries capital intensity (capital to skilled labour)[15] has a positive significant effect on the productivity differential. This suggests that the larger use of capital goods increased the productivity gap between skilled and unskilled labour in these industries. On the other hand for unskilled labour intensive industries the coefficient of the capital intensity (capital to unskilled labour) variable is negative. In unskilled labour intensive exportable industries, unskilled labour grows at a faster rate than capital leading to a fall in the capital intensity and as the capital intensity falls the negative coefficient suggests an increase in the productivity gap. Trade does not found to have any effect on the productivity gap between skilled and unskilled labour in either of the industry group.

From the above result it can be concluded that while the disembodied (R&D) technological improvement is the reason for growing divergence between skilled and unskilled labour productivity in unskilled labour intensive industries, embodied (capital intensity) technological progress increases the skilled-unskilled productivity gap in capital intensive industries. However expansion of trade does not have any direct influence on the relative productivity of skilled labour, if it has any influence they are indirect and realized though its effect on research and development expenditure and capital intensity.

5. Conclusion

Our empirical analysis has demonstrated that the trend in the income gap between skilled and unskilled labour has moved against the prediction of the Stolper Samuelson theory since the theory predicts, given that India is presumably an unskilled labour abundant country, a rise in the real wage rate of the skilled labour and a fall in the real wage rate of unskilled labour and thereby causing a decrease in wage inequality. However, our analysis based on the Indian manufacturing sector shows a rising wage inequality along with rise in the wage rate of both skilled and unskilled labour. Unlike the other existing theoretical studies, the model referred

[14] Relative productivity of skilled labour is same as productivity differential i.e. the ration of skilled and unskilled labour.

[15] Since skilled labour intensive industries are majorly the employer of skilled labour instead of the ratio of capital and labour we have taken the ratio of capital and skilled labour to measure capital intensity. Similarly for unskilled labour intensive industries the ratio of capital to unskilled labour has been taken as a measure of capital intensity.

here predicts absolute wage rates of both skilled and unskilled labour increases with free trade. Factor specificity is a crucial assumption of the model where unskilled labour is specific to export sector. This is reflective of Indian manufacturing sector since the empirical verification supports it. The model suggests that the income gap between skilled and unskilled labour goes up if the skilled labour are more productive than the unskilled labour. An average industry in Indian manufacturing sector has been found to observe a higher productivity for skilled labour as compared to the unskilled labour, which possibly is the cause of rising wage inequality in India.

In our attempt to find the reasons for differential productivities of skilled and unskilled labour, we have formulated a simple regression model where factors like the R & D expenditure (disembodied technology), Capital intensity (embodied technology) and trade were taken as possible determinants of productivity differentials. When the analysis is carried out for all the industries each of the above three determinants found to have significant positive effect on the productivities of skilled and unskilled labour. The analysis shows that for unskilled labour intensive exportable industries, the technology variables (R&D expenditure and capital intensity) were found to explain the movement of skilled and unskilled labour productivities. Nevertheless, trade is still an important determinant of productivity in the capital intensive importing - competing industries along with the technology variables. The impacts of trade is however indirect and realized through the trade induced imports of technologically advanced foreign goods. Therefore, it is the technology (be it embodied or disembodied) not the trade that determined the productivities and explain their movements. Investment in technology is also responsible for the rise in the productivity gap between skilled and unskilled labour. For unskilled labour intensive exportable industries investment in R&D expenditures has been found to increase the productivity gap while it is the investment in capital goods that causes the gap in the productivity levels to shoot up in capital intensive importable industries.

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Appendix

A1: *Measurements of variables*

Skilled (non-production workers) and unskilled (production workers) differentiation have been made based on ASI's definition of workers and total employees. According to ASI, workers are the people directly related to the production process (production workers) and employees are the people directly and indirectly (non-production workers such as workers, supervisors, administrative officers etc.) related to the production process. Number of unskilled labour has been taken to be same as the number of workers and the number of skilled labour has been computed by subtracting number of workers from number of employees.

The ratio of wages to workers and number of workers has been taken to compute unskilled wage rate. Total emolument reported in ASI is the sum of wages of workers and salaries of skilled labour. Therefore skilled wage rate was obtained by subtracting wages to workers from total emoluments and then dividing it by number of skilled workers. Real wage rate of unskilled and skilled workers have been computed by deflating the nominal figures by the consumer price index (1980-81 base). Data for consumer price index has been collected from Labour Bureau of Government of India.

Then finally the wage inequality has been measured by taking the ratio of skilled to unskilled wage rate.

To obtain the gross value added in constant price (or real gross value added), gross value added at current price as provided in ASI has been deflated by whole sale price index (WPI) for manufactured products in 1980-81 base. Separate WPI index for separate commodity group has been used while deflating. Data for wholesale price index (sector wise and commodity group wise) has been collected from Office of Economic Advisor of Ministry of Commerce and Industry.

A2: *Calculation of capital stock*

Net fixed capital stock at constant price (or real net fixed capital stock) has been taken as a measure of capital input. Perpetual inventory method has been employed to construct the series on net fixed capital stock at constant price. Firstly, the book value of fixed capital in previous year has been subtracted from the current year, and then the figure has been added

with depreciation in the current year to obtain the gross investment in the current year. Real gross investment is computed next by deflating obtained gross investment figure by price index for machines and machinery products. Secondly, base year (1980-81) capital stock is computed by doubling the book value of fixed capital in the year 1980-81. This is a rule of thumb applied in Golder (1986), Sarma and Rao (1990) etc. Base year capital stock thus obtained is then converted to of real capital stock in the base year. Thirdly, the real gross fixed capital stock in 1981-1982 is computed by adding base year (1980-81) capital stock with real the gross investment in 1981-1982. To construct real gross fixed capital stock in a year following 1981-1982, real gross fixed capital stock in the previous year has been added with the real gross investment in the current year. Finally, the real net fixed capital stock in the current year is constructed by subtracting depreciation in the current year from real gross fixed capital stock in the current year.

A3: *Division of industries*

All the industries were divided in two groups, skilled labour intensive industries and unskilled labour intensive industries. The method used is explained below.

In the first step, skilled intensities were calculated for all the industries in five selected years: 1990, 1995, 2000, 2005 and 2007. Skilled intensity was calculated by taking the ratio of number of skilled labour and number of unskilled labour. Note that, the years were selected keeping a gap of five years in between any two consecutive years.

In the second step, the industries were ranked in ascending order (low skilled intensive to high skilled intensive) in the five selected years based on the value of their skilled intensity. Then it was identified that the industries those were at the top (bottom) of the ranking in any one of the five selected years were also at the top (bottom) in the remaining four years.

In the third step, among the top ranking industries 12 were selected those were net exporter in all the sample years (1990 to 2007) except for one or two years. They were termed as unskilled labour intensive industries. Similarly 9 industries from the bottom of the ranking were selected those were net importer in all the sample years except for one or two years. They were termed as skilled labour intensive industries.

So it can be seen that the division was made not only based on skilled intensity but also based on export status. Here unskilled labour intensive industries are also net exporter and skilled intensive industries are also net importer.

A4: *List of Industries*

Table A1: List of Net Importable Industries

Net Importable Industries (Capital Intensive Industries)	
Industry code	**Industry Name**
241	Manufacture of basic chemicals
272	Manufacture of basic precious and non-ferrous metals
291	Manufacture of general purpose machinery
292	Manufacture of special purpose machinery
300	Manufacture of office, accounting and computing machinery
313	Manufacture of insulated wire and cable
321	Manufacture of electronic valves and tubes and other electronic components
323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
353	Manufacture of aircraft and spacecraft

Table A2: List Net Exportable Industries.

	Net Exportable Industries (Unskilled labour Industries)
Industry Code	**Industry Name**
151	Production, processing and preservation of meat, fish, fruit vegetables, oils and fats
153	Manufacture of grain mill products, starches and starch products, and prepared animal feeds
154	Manufacture of other food products
160	Manufacture of tobacco products
171	Spinning, weaving and finishing of textiles
181	Manufacture of wearing apparel, except fur apparel
192	Manufacture of footwear
251	Manufacture of rubber products
252	Manufacture of plastic products
269	Manufacture of non-metallic mineral products n.e.c.
289	Manufacture of other fabricated metal products; metal working service activities
359	Manufacture of transport equipment n.e.c.