Wage Disparity and Human Capital Accumulation

Errol D'Souza♣

Abstract: When the acquisition of skills and technological change have mutually reinforcing effects the wage gap between skilled and unskilled workers increases. The cost of education is a deterrent to investment in skills that can be overcome if there is strong complementarity between skills and technology.

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Human Capital, Technology, and Development

Increasingly there is recognition that the acquisition of human capital is central to development and growth. The acquisition of skills not only makes people more productive, but in an era of rapidly changing technology it also makes them more adaptable to technological progress. A lot of attention in the literature has thus been devoted to whether markets provide sufficient incentives for investments in skills. It is often argued that when people face credit constraints they cannot finance education by borrowing and governments should intervene to relax credit controls, or provide educational vouchers or loan guarantees. Similarly, the signaling literature emphasizes market failure in that even if education is acquired, it cannot be perfectly signaled to potential employers. Related to this is the issue of the acquisition of training which is linked with occupational qualifications in Germany and to life-long employment in Japan, but in most other nations it is left to the individual to acquire the skills associated with training and education. Indeed, by and large, skill formation is viewed as a supply-side policy that sometimes makes the state responsible for giving people the opportunity to get educated or trained, and a policy that leaves the individual and firms as responsible for the employability of that human capital.

This paper explores the consequences of the view that increases in human capital enables more technological change because more skilled workers enable the introduction of more sophisticated and productive machines. The technological change in turn influences the demand for skilled workers and affects the return on the acquisition of human capital. With technological change and the acquisition of skills having mutually reinforcing effects that enhance the returns to skilled labour and to investments in technology the gap between skilled and unskilled

workers can increase which results in disparities that have political and social consequences. In India part of the inequality that is being witnessed over the last decade may be attributable to this factor. Deaton and Dreze (2002) for instance point out that whilst poverty declined in the 1990s in India, inequality has increased between rural and urban areas, and per capita expenditures of the high-income groups have increased faster than for other groups. They conclude that "the rate of increase of economic inequality in the nineties is far from negligible" (p. 3740).

The poor human capital base which is labeled as the Achilles heel of the Indian economy by Chadha (2004) shows a gradual decline in the proportion of illiterate workers and a corresponding increase in the proportion of educated ones over the last two decades (Table I). A summary statistic that we employ to capture the stock of education or human capital (L) in the economy is given in the last row of the table and is computed as $L = \sum l_i s_i$, where, l_i is the share of persons in the labour force with i^{th} level of schooling, and s_i is the average years of education received in the ith level of schooling. The growth rate of the education stock in the decade between 1983-84 and 1993-94 is 2.7% which reduced to a growth rate of 2.2% between 1993-94 and 1999-00. This is barely above the labour force growth rate, and as Chadha points out the still high proportion of illiterate workers is a cause for concern. In addition to the usual reasons advocated for this low attainment such as political economy and credit constraints, we propose that the complementarity between technology and skilled labour and the interaction of this with the externalities associated with education can provide an additional insight into the nature of the accumulation of human capital.

<u>Table I</u>

Distribution of Workers by Level of Education

	1983-84	1993-94	1999-00
Illiterate	57.5	48.5	44.1
Primary	24.3	24.9	23.5
Middle	8.9	11.4	13.8
Secondary & above	9.3	15.1	18.6
Education Stock	304.3	396.9	451.1

Source: Chadha (2004)

N.B.: Years of education for primary level is taken as 5, for middle 8, and for secondary & above, 12, whilst calculating education stock.

The Process of Accumulation:-

Strictly speaking to understand the problem we need to consider at least two time periods. In the first period people invest in human capital, and in the second they work and spend. Many would even insist that other assets are included in the set up so that agents can have claims on physical capital in addition to human capital. Introducing time periods and different assets makes the problem more dynamic and results such as multiple equilibria may be derived. We opt to forgo this and instead take human capital to be a discrete variable – people are either skilled or unskilled. An unskilled worker is taken to own 1 efficiency unit of labour and a skilled worker owns ρ $(\rho > 1)$ efficiency units of labour. Total labour input in efficiency units is given by $L = \rho L_S + L_u$, where, L_S is the number of skilled individuals in the labour force, and L_u is the number of unskilled individuals in the labour force. More realistically, skilled and unskilled labour are imperfect substitutes but we bypass this generality which does no damage to our results. Given that some

individuals may not be employed the total labour force, $\overline{L}$, can be divided according to whether an individual is skilled or unskilled. Thus,

$$L_S + L_u = \overline{L} \qquad\qquad \text{............(1)}$$

Let $x = L_S/\overline{L}$ be the proportion of skilled workers in the labour force and $(1-x) = L_u/\overline{L}$ be the proportion of unskilled workers. Production is assumed to be given by

$$Y = AL^\alpha = A\{\rho L_S + L_u\}^\alpha$$

or, $\qquad Y = A\big[\{\rho x + (1-x)\}\overline{L}\big]^\alpha \qquad\qquad \text{............(2)}$

We can then derive the demand for unskilled labour as

$$w_u = \alpha A\left[\{\rho x + (1-x)\}\overline{L}\right]^{\alpha-1} \qquad\qquad \text{............(3)}$$

Given perfect substitution between the types of labour we must have

$$\frac{w_S}{w_u} = \rho \qquad\qquad \text{............(4)}$$

This is the condition for employment under profit maximization which states that the relative wage depends on the relative productivity of the two factors. The productivity of skilled workers, however, is determined by the technology in the economy. Reciprocally, technological change is influenced by the proportion of skilled workers in the economy as the accumulation of human capital is favourable to innovation. Hence,

$$\rho = \rho(A), \quad \rho' > O$$

and, $\qquad A = A(x), \; A' > O$

We could postulate simple functional forms for the above –

$$\rho = \bar{\rho} + \theta A, \quad \bar{\rho} > 1.$$

and, $\quad A = 1 + \gamma x$ ....(5)

Profit maximization then yields

$$w_S - w_u = \left[\{\rho x + (1-x)\}\bar{L} \right]^{\alpha-1} \left[A'(x)\{\rho x + (1-x)\} + A(x)\{\rho' A' x + \rho - 1\} \right] \quad ....(6)$$

On the demand side firms are willing to pay higher wages to skilled workers as the stock of human capital increases because this increases the adoption of new technology which makes skilled workers more productive. The graph of equation (6) is depicted in Figure I as the solid upward sloping line. An increase in the sensitivity of the productivity parameter for skilled workers, $\rho' = \theta$, shifts the graph to the dashed line and the gap in wages between skilled and unskilled workers is widened for any stock of human capital. Also, an increase in the sensitivity of the technology parameter, $A' = \gamma$, shifts the graph up even more to the dotted line and widens the gap between skilled and unskilled wages further.
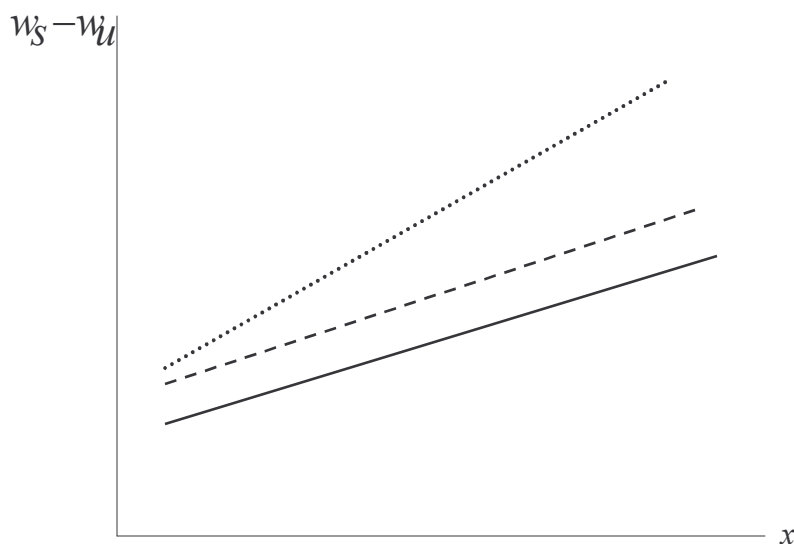
Figure I: Wage Disparity and Labour Demand

We now turn to the supply side. The dividend to investing in an education is the wage differential between skilled and unskilled workers. Again, we are ignoring the presence of unemployment which could be factored in – the *expected* wage differential would then represent the return to education – but again to extract the essence of the problem we ignore this factor. Also for simplicity the acquisition of education is treated as being instantaneous. There are two costs associated with acquiring an education. There are direct costs that depend on how many individuals are being educated. As efficient class size is more than one student in a class, education is a public good with the characteristics of collective benefit and shared costs. Increases in class size may affect educational effectiveness in which case education becomes a congestible public good. Education also results in externalities as social benefits arise from more educated fellow citizens. The direct costs thus decline with the proportion of individuals who are skilled, i.e., $c = c(x)$ and $c'(x) < 0$. We specify $c(x) = \psi + x^{-\beta}$ where β is a measure of the public- ness or externality generation associated with education and ψ is

a direct flat cost. Additionally, individuals differ in their cost of acquiring education as more able individuals or better endowed individuals with lower credit constraints incur a lower cost associated with their endowment e which is uniformly distributed and $e \in (0,1)$. Equating costs and benefits,

$$w_S - w_u = \frac{\psi + x^{-\beta}}{e}$$

The individual who is indifferent between becoming skilled and remaining unskilled would be that individual whose endowment is $e* = \left(\psi + x^{-\beta}\right)\Big/\left(w_S - w_u\right)..$ Given that e is uniformly distributed we must have $x = (1 - e*)$ and so we may write

$$w_S - w_u = \frac{\psi + x^{-\beta}}{1 - x} \qquad\qquad ....(7)$$

This is graphed in Figure II where we witness that the disparity in wages initially declines due to the decrease in educational costs as more individuals benefit from fixed facilities or due to externalities. As more individuals acquire an education the opportunity costs of doing so begin to kick in and this requires an increase in the wage differential between skilled and unskilled workers so that a greater supply of skilled labour may be forthcoming. Any increase in the externalities or capacity of facilities for education β shifts the curve up to the dashed curve. An increase in the direct flat cost ψ also shifts the curve up to the dotted curve. The increase in the externality prolongs the decline in wage disparity whereas the increased direct cost shortens the decline in wage disparity.
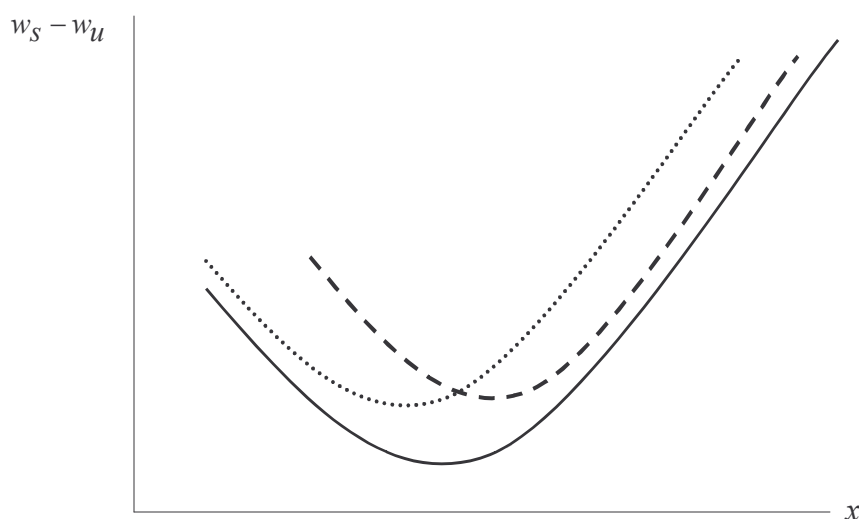
Figure II: Wage Disparity and Labour Supply

Putting together demand and supply we get the situation depicted in Figure 3. As can be seen there are two equilibria denoted by points A and B with the former being a case where the proportion of skilled workers in the labour force is low and the latter represents an economy with a highly skilled labour force. Some outcomes caused by parametric changes can now be depicted in this framework. An increase in the relative productivity of skilled workers due to technological change (an increase in $\rho' = \theta$), or, an increase in technological change due to an increase in the availability of skilled labour (an increase in $A' = \gamma$), shifts the demand curve up to intersect the supply curve at points C and D. As C is to the north-west of A, for an economy that is poorly endowed with skilled labour to begin with, any increase in the productivity of skilled labour due to technological change or in the impact of skilled labour on the introduction of new technology results in a reduction in the acquisition of human capital and an increase in the disparity between skilled and unskilled workers. In this situation the unskilled workers are relatively productive in the production of goods and services and the

feeble technology driven demand for skilled labour raises the return to skilled labour relative to unskilled labour and simultaneously causes a substitution for skilled with unskilled labour that is abundantly available.
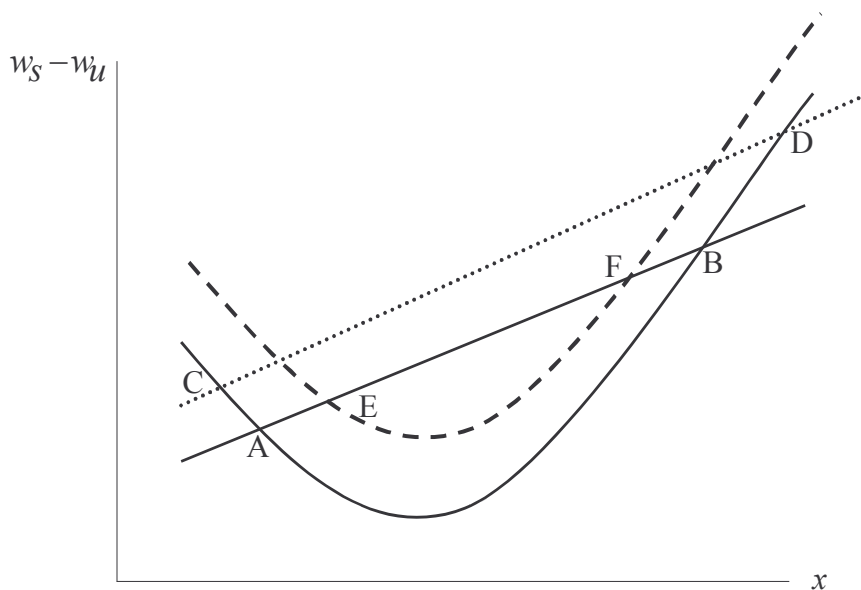

Figure III: Parametric Shifts in Demand & Supply

If there is an increase in the direct cost of education or in the externalities or public good properties associated with education, as we saw there occurs a shift in the supply curve upwards to intersect the demand curve at points E and F. For the case where the initial proportion of skilled workers is low, as point E is to the north-east of A, there results an increase in the acquisition of human capital. The increase in the direct cost requires higher wage disparities for each level of skilled labour supply and that raises the return to investing in education which causes a rise in the supply of skilled labour. As unskilled labour is abundant this keeps the unskilled wage low and the higher wage required to be paid for eliciting larger investments in skills is made available by the productivity and technology driven demand for skilled labour. An increase in the cost of education paradoxically raises

the investment in education but this occurs due to the complementarity between investment in education and technological change which causes the wage disparity to rise along with the stock of skilled labour in the economy.

CONCLUDING REMARKS:-

Rising wage disparity and inequality is inevitable in the early stages of development when the proportion of skilled labour in the labour force is low. However, if at this juncture in the development trajectory technological change is not sufficiently strong to raise the productivity of skilled labour relative to unskilled labour, then, the rising wage disparity is accompanied by a reduction in the incentive to invest in education and the economy does not witness an increase in the proportion of skilled labour. On the other hand, rising wage disparity is associated with an increase in investment in education when the increased cost of eliciting that investment is paid for through the productivity enhancement that occurs. The lesson that emerges is that the cost of education is not a deterrent to investment in education in the early stages of development if the skills produced in the education sector can trigger off changes in technology that raise the returns to education strongly enough so as to pay for the cost. This points to the need to ensure that the quality of skills imparted in education is of a standard that it provides an impetus for initiating technological change. Enhancing the complementarity between skills and technology is the key to the motor of development.

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Paper written for the 46th annual conference of the Indian Society of Labour Economics to be held at Institute of Development Studies, Jaipur, during December 16-18, 2004.

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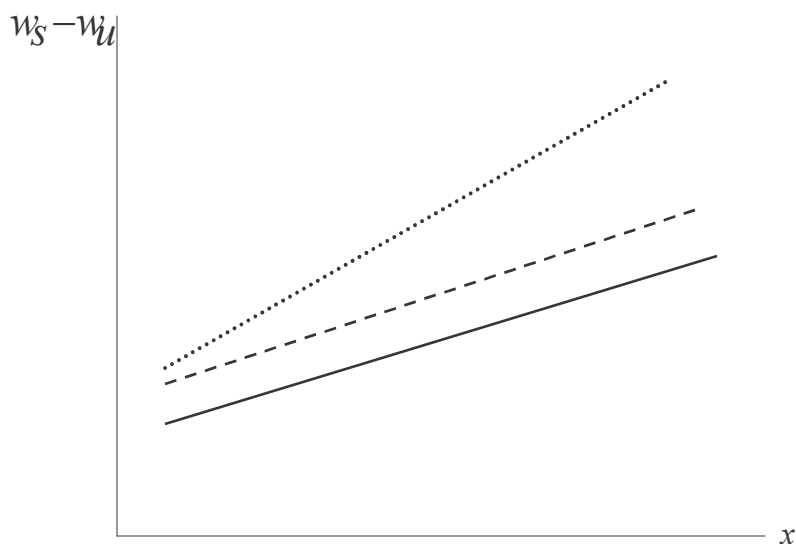
$w_S - w_u$

x

Figure I: Wage Disparity and Labour Demand

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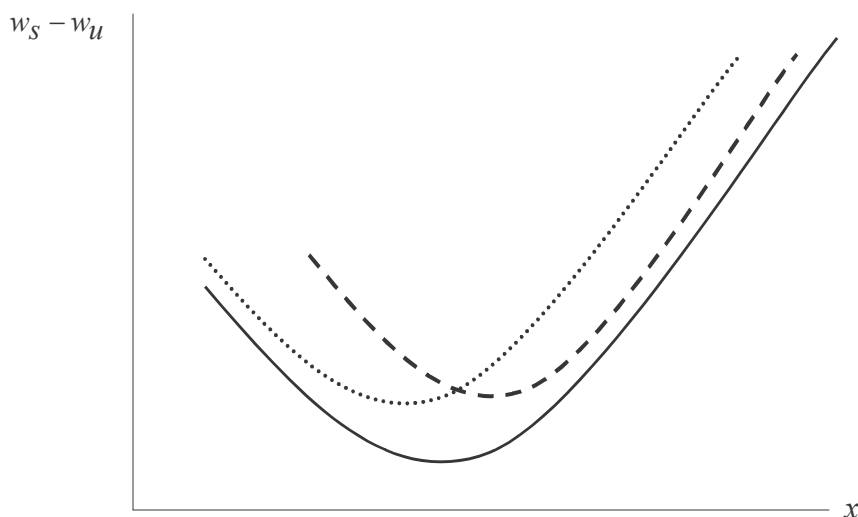
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Figure II: Wage Disparity and Labour Supply

Putting together demand and supply we get the situation depicted in Figure 3. As can be seen there are two equilibria denoted by points A and B with the former being a case where the proportion of skilled workers in the labour force is low and the latter represents an economy with a highly skilled labour force. Some outcomes caused by parametric changes can now be depicted in this framework. An increase in the relative productivity of skilled workers due to technological change (an increase in $\rho' = \theta$), or, an increase in technological change due to an increase in the availability of skilled labour (an increase in $A' = \gamma$), shifts the demand curve up to intersect the supply curve at points C and D. As C is to the north-west of A, for an economy that is poorly endowed with skilled labour to begin with, any increase in the productivity of skilled labour due to technological change or in the impact of skilled labour on the introduction of new technology results in a reduction in the acquisition of human capital and an increase in the disparity between skilled and unskilled workers. In this situation the unskilled workers are relatively productive in the production of goods and services and the

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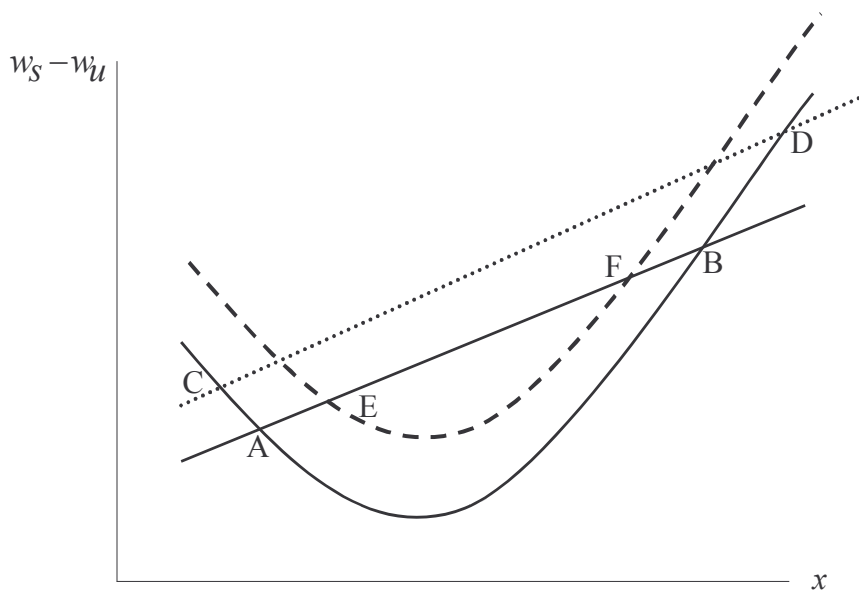

Figure III: Parametric Shifts in Demand & Supply

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CONCLUDING REMARKS:-

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Increasingly there is recognition that the acquisition of human capital is central to development and growth. The acquisition of skills not only makes people more productive, but in an era of rapidly changing technology it also makes them more adaptable to technological progress. A lot of attention in the literature has thus been devoted to whether markets provide sufficient incentives for investments in skills. It is often argued that when people face credit constraints they cannot finance education by borrowing and governments should intervene to relax credit controls, or provide educational vouchers or loan guarantees. Similarly, the signaling literature emphasizes market failure in that even if education is acquired, it cannot be perfectly signaled to potential employers. Related to this is the issue of the acquisition of training which is linked with occupational qualifications in Germany and to life-long employment in Japan, but in most other nations it is left to the individual to acquire the skills associated with training and education. Indeed, by and large, skill formation is viewed as a supply-side policy that sometimes makes the state responsible for giving people the opportunity to get educated or trained, and a policy that leaves the individual and firms as responsible for the employability of that human capital.

This paper explores the consequences of the view that increases in human capital enables more technological change because more skilled workers enable the introduction of more sophisticated and productive machines. The technological change in turn influences the demand for skilled workers and affects the return on the acquisition of human capital. With technological change and the acquisition of skills having mutually reinforcing effects that enhance the returns to skilled labour and to investments in technology the gap between skilled and unskilled

workers can increase which results in disparities that have political and social consequences. In India part of the inequality that is being witnessed over the last decade may be attributable to this factor. Deaton and Dreze (2002) for instance point out that whilst poverty declined in the 1990s in India, inequality has increased between rural and urban areas, and per capita expenditures of the high-income groups have increased faster than for other groups. They conclude that "the rate of increase of economic inequality in the nineties is far from negligible" (p. 3740).

The poor human capital base which is labeled as the Achilles heel of the Indian economy by Chadha (2004) shows a gradual decline in the proportion of illiterate workers and a corresponding increase in the proportion of educated ones over the last two decades (Table I). A summary statistic that we employ to capture the stock of education or human capital (L) in the economy is given in the last row of the table and is computed as $L = \sum l_i s_i$, where, l_i is the share of persons in the labour force with i^{th} level of schooling, and s_i is the average years of education received in the ith level of schooling. The growth rate of the education stock in the decade between 1983-84 and 1993-94 is 2.7% which reduced to a growth rate of 2.2% between 1993-94 and 1999-00. This is barely above the labour force growth rate, and as Chadha points out the still high proportion of illiterate workers is a cause for concern. In addition to the usual reasons advocated for this low attainment such as political economy and credit constraints, we propose that the complementarity between technology and skilled labour and the interaction of this with the externalities associated with education can provide an additional insight into the nature of the accumulation of human capital.

<div align="center">

<u>Table I</u>

Distribution of Workers by Level of Education

</div>

	1983-84	1993-94	1999-00
Illiterate	57.5	48.5	44.1
Primary	24.3	24.9	23.5
Middle	8.9	11.4	13.8
Secondary & above	9.3	15.1	18.6
Education Stock	304.3	396.9	451.1

Source: Chadha (2004)

N.B.: Years of education for primary level is taken as 5, for middle 8, and for secondary & above, 12, whilst calculating education stock.

The Process of Accumulation:-

Strictly speaking to understand the problem we need to consider at least two time periods. In the first period people invest in human capital, and in the second they work and spend. Many would even insist that other assets are included in the set up so that agents can have claims on physical capital in addition to human capital. Introducing time periods and different assets makes the problem more dynamic and results such as multiple equilibria may be derived. We opt to forgo this and instead take human capital to be a discrete variable – people are either skilled or unskilled. An unskilled worker is taken to own 1 efficiency unit of labour and a skilled worker owns ρ $(\rho > 1)$ efficiency units of labour. Total labour input in efficiency units is given by $L = \rho L_S + L_u$, where, L_S is the number of skilled individuals in the labour force, and L_u is the number of unskilled individuals in the labour force. More realistically, skilled and unskilled labour are imperfect substitutes but we bypass this generality which does no damage to our results. Given that some

individuals may not be employed the total labour force, $\overline{L}$, can be divided according to whether an individual is skilled or unskilled. Thus,

$$L_S + L_u = \overline{L} \qquad\qquad \ldots\ldots\ldots\ldots(1)$$

Let $x = L_S/\overline{L}$ be the proportion of skilled workers in the labour force and $(1-x) = L_u/\overline{L}$ be the proportion of unskilled workers. Production is assumed to be given by

$$Y = AL^\alpha = A\{\rho L_S + L_u\}^\alpha$$

or, $\qquad Y = A\left[\{\rho x + (1-x)\}\overline{L}\right]^\alpha \qquad\qquad \ldots\ldots\ldots\ldots(2)$

We can then derive the demand for unskilled labour as

$$w_u = \alpha A\left[\{\rho x + (1-x)\}\overline{L}\right]^{\alpha-1} \qquad\qquad \ldots\ldots\ldots\ldots(3)$$

Given perfect substitution between the types of labour we must have

$$\frac{w_S}{w_u} = \rho \qquad\qquad \ldots\ldots\ldots\ldots(4)$$

This is the condition for employment under profit maximization which states that the relative wage depends on the relative productivity of the two factors. The productivity of skilled workers, however, is determined by the technology in the economy. Reciprocally, technological change is influenced by the proportion of skilled workers in the economy as the accumulation of human capital is favourable to innovation. Hence,

$$\rho = \rho(A), \quad \rho' > O$$

and, $\qquad A = A(x), \; A' > O$

We could postulate simple functional forms for the above –

$$\rho = \bar{\rho} + \theta A, \quad \bar{\rho} > 1.$$

and, $\quad A = 1 + \gamma x$ ....(5)

Profit maximization then yields

$$w_S - w_u = \left[\{\rho x + (1-x)\}\bar{L} \right]^{\alpha-1} \left[A'(x)\{\rho x + (1-x)\} + A(x)\{\rho' A' x + \rho - 1\} \right] \quad ....(6)$$

On the demand side firms are willing to pay higher wages to skilled workers as the stock of human capital increases because this increases the adoption of new technology which makes skilled workers more productive. The graph of equation (6) is depicted in Figure I as the solid upward sloping line. An increase in the sensitivity of the productivity parameter for skilled workers, $\rho' = \theta$, shifts the graph to the dashed line and the gap in wages between skilled and unskilled workers is widened for any stock of human capital. Also, an increase in the sensitivity of the technology parameter, $A' = \gamma$, shifts the graph up even more to the dotted line and widens the gap between skilled and unskilled wages further.
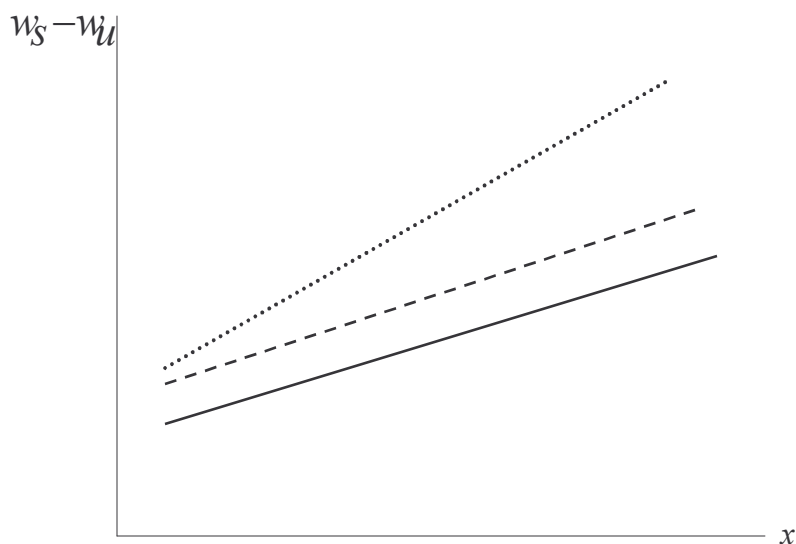
$w_s - w_u$

Figure I: Wage Disparity and Labour Demand

We now turn to the supply side. The dividend to investing in an education is the wage differential between skilled and unskilled workers. Again, we are ignoring the presence of unemployment which could be factored in – the *expected* wage differential would then represent the return to education – but again to extract the essence of the problem we ignore this factor. Also for simplicity the acquisition of education is treated as being instantaneous. There are two costs associated with acquiring an education. There are direct costs that depend on how many individuals are being educated. As efficient class size is more than one student in a class, education is a public good with the characteristics of collective benefit and shared costs. Increases in class size may affect educational effectiveness in which case education becomes a congestible public good. Education also results in externalities as social benefits arise from more educated fellow citizens. The direct costs thus decline with the proportion of individuals who are skilled, i.e., $c = c(x)$ and $c'(x) < 0$. We specify $c(x) = \psi + x^{-\beta}$ where β is a measure of the public- ness or externality generation associated with education and ψ is

a direct flat cost. Additionally, individuals differ in their cost of acquiring education as more able individuals or better endowed individuals with lower credit constraints incur a lower cost associated with their endowment e which is uniformly distributed and $e \in (0,1)$. Equating costs and benefits,

$$w_s - w_u = \frac{\psi + x^{-\beta}}{e}$$

The individual who is indifferent between becoming skilled and remaining unskilled would be that individual whose endowment is $e* = \left(\psi + x^{-\beta}\right)/\left(w_s - w_u\right)$.. Given that e is uniformly distributed we must have $x = (1 - e*)$ and so we may write

$$w_s - w_u = \frac{\psi + x^{-\beta}}{1 - x} \qquad\qquad \text{..............(7)}$$

This is graphed in Figure II where we witness that the disparity in wages initially declines due to the decrease in educational costs as more individuals benefit from fixed facilities or due to externalities. As more individuals acquire an education the opportunity costs of doing so begin to kick in and this requires an increase in the wage differential between skilled and unskilled workers so that a greater supply of skilled labour may be forthcoming. Any increase in the externalities or capacity of facilities for education β shifts the curve up to the dashed curve. An increase in the direct flat cost ψ also shifts the curve up to the dotted curve. The increase in the externality prolongs the decline in wage disparity whereas the increased direct cost shortens the decline in wage disparity.
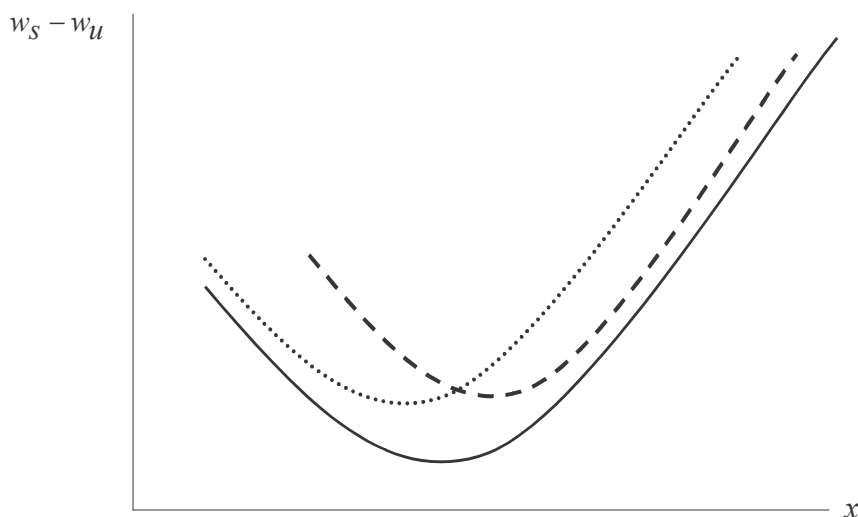
$w_s - w_u$

x

Figure II: Wage Disparity and Labour Supply

Putting together demand and supply we get the situation depicted in Figure 3. As can be seen there are two equilibria denoted by points A and B with the former being a case where the proportion of skilled workers in the labour force is low and the latter represents an economy with a highly skilled labour force. Some outcomes caused by parametric changes can now be depicted in this framework. An increase in the relative productivity of skilled workers due to technological change (an increase in $\rho' = \theta$), or, an increase in technological change due to an increase in the availability of skilled labour (an increase in $A' = \gamma$), shifts the demand curve up to intersect the supply curve at points C and D. As C is to the north-west of A, for an economy that is poorly endowed with skilled labour to begin with, any increase in the productivity of skilled labour due to technological change or in the impact of skilled labour on the introduction of new technology results in a reduction in the acquisition of human capital and an increase in the disparity between skilled and unskilled workers. In this situation the unskilled workers are relatively productive in the production of goods and services and the

feeble technology driven demand for skilled labour raises the return to skilled labour relative to unskilled labour and simultaneously causes a substitution for skilled with unskilled labour that is abundantly available.
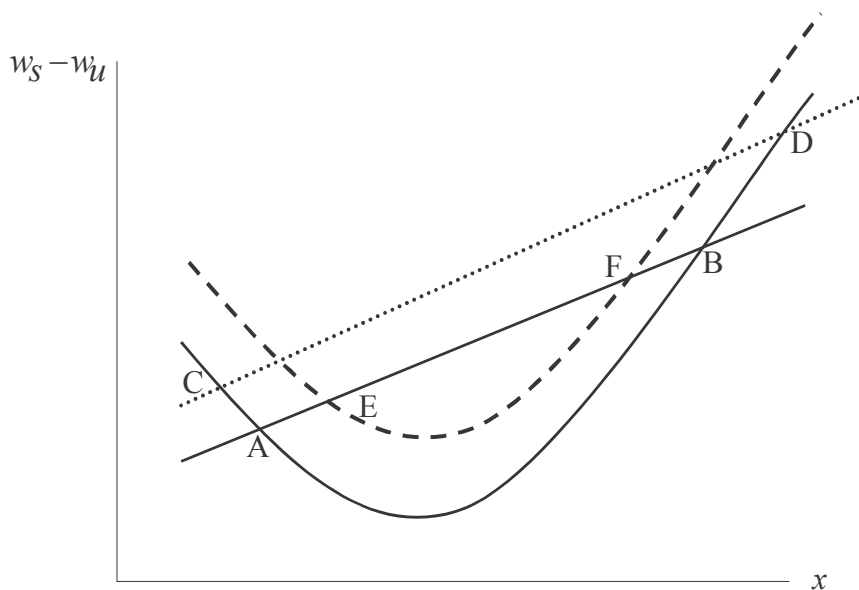

Figure III: Parametric Shifts in Demand & Supply

If there is an increase in the direct cost of education or in the externalities or public good properties associated with education, as we saw there occurs a shift in the supply curve upwards to intersect the demand curve at points E and F. For the case where the initial proportion of skilled workers is low, as point E is to the north-east of A, there results an increase in the acquisition of human capital. The increase in the direct cost requires higher wage disparities for each level of skilled labour supply and that raises the return to investing in education which causes a rise in the supply of skilled labour. As unskilled labour is abundant this keeps the unskilled wage low and the higher wage required to be paid for eliciting larger investments in skills is made available by the productivity and technology driven demand for skilled labour. An increase in the cost of education paradoxically raises

the investment in education but this occurs due to the complementarity between investment in education and technological change which causes the wage disparity to rise along with the stock of skilled labour in the economy.

CONCLUDING REMARKS:-

Rising wage disparity and inequality is inevitable in the early stages of development when the proportion of skilled labour in the labour force is low. However, if at this juncture in the development trajectory technological change is not sufficiently strong to raise the productivity of skilled labour relative to unskilled labour, then, the rising wage disparity is accompanied by a reduction in the incentive to invest in education and the economy does not witness an increase in the proportion of skilled labour. On the other hand, rising wage disparity is associated with an increase in investment in education when the increased cost of eliciting that investment is paid for through the productivity enhancement that occurs. The lesson that emerges is that the cost of education is not a deterrent to investment in education in the early stages of development if the skills produced in the education sector can trigger off changes in technology that raise the returns to education strongly enough so as to pay for the cost. This points to the need to ensure that the quality of skills imparted in education is of a standard that it provides an impetus for initiating technological change. Enhancing the complementarity between skills and technology is the key to the motor of development.

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