Technology-Driven Growth and its Welfare Implications: Evidence from Indian Industry

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Abstract

The significance of productivity and efficiency can be understood in several perspectives. The theory of distribution states that, at equilibrium, each factor of production is remunerated in proportion to its marginal product. From an industrial perspective, higher productivity leads greater production efficiency, thereby enhancing firms and industries. From the viewpoint of welfare: productivity shows how well an economy can make greater goods with fewer factors of production, like people or money, while decreasing the costs of making and using products. From the 1980s onwards, as technology develops, almost all economies have experienced a persistent fall in labour's share in national income compared to Capital's Share. A shrinking proportion of income going to workers in the form of wages and benefits tends to widen income inequality, thereby reduces economic growth. In India, too, has a similar trend since the 1980s, with the share of wages and salaries in gross value added showing a declining trend (ILO 2017). Rising capital intensity has led to a contraction in labour demand, while shifts in the composition of capital have introduced biases in labour demand. As these developments occurred, the share of wages relative to gross value added has decreased (Thomas Piketty, 2014). Labour is receiving a lower proportion and decrease in labour's bargaining power has declined the union membership and rise in unemployment. Thus, this view is gaining increasing significance within the current discourse of development policy. This study identifies the persistent and significant decline in welfare effects of Automaton on Indian industrial sector.

Key words: Technology; Productivity; Automation; Economic Growth; India KLEMS; Social welfare

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Introduction

Productivity emerges as the primary driver accelerating the developmental progress of India.The significance of productivity and efficiency enhancement can be understood from several perspectives. From an industrial standpoint, higher productivity is generally linked to improved production efficiency, which strengthens the competitiveness of firms and industries. In contrast, from a welfare-oriented viewpoint, productivity reflects an economy's capacity to generate greater output from a given set of inputs, such as output per worker or per unit of capital, while reducing the cost of production and consumption. This, in turn, contributes to greater consumer purchasing power and leads to sustained improvements in living

standards. It is this broader welfare implication of productivity growth that underpins Krugman's (1994) well-known assertion: “although productivity is not the sole determinant of economic progress, it is the principal driver of a nation's ability to enhance its standard of living”. So it is very important to investigate, whether productivity gains via technology reaches equally between every factors of production.

The integration of foreign technological advancements has instigated extensive discourse concerning the indigenous capacity to adeptly assimilate such innovations (Subhash. P. P and Karunakaran N, 2025). Typically, labour markets in economically disadvantaged countries predominantly feature unskilled and minimally educated workforce (Singh S.P., Singh M., Khadse A., 2025). The infusion of novel technologies into the production paradigm, demanding heightened technical specialization and skill sets, may engender a disjunction between the labor supply and demand dynamics, consequently inducing short-term imbalances. Hence, the requisite technology is more aptly characterized as labor-intensive, encompassing methodologies and products tailored for rural production contexts. Stewart and Rannis (1990) posit that nations should embrace technologies aligning with their inherent attributes, considering factors, skills, and contextual nuances. This perspective has progressively ascended in prominence within policy research pertinent to the developmental agenda (Singh Jyoti., Verma Kumar Krishna ,2024).

Piketty (2014) argued that rising inequality receiving a smaller proportion of national income due to the weakening of its bargaining power, declining trade union membership, and higher unemployment. He also mentions that the labour share of national income tends to decline when labour's bargaining power weakens (e.g., via declining union density, increased unemployment, globalised competition). However, there is some dispute regarding the contribution of declining minimum wages and union membership (Benaboun, 2005). In the early stages of development, a technological gap has the potential to bring about rapid structural change through global technological knowledge (Subhash. P. P and Karunakaran N, 2025). However, the extent to which such changes can be realized is dependent on the absorptive capacity of a country's sectors and firms. The utilization of new technologies requires basic education and new skills, and a more educated population is more likely to adopt new technologies at a faster rate.

Literature Review

The term productivity usually denotes improving production efficiency, which in turn will improve the competitiveness of businesses and industries. However, from a welfare standpoint, productivity reflects the economy's capacity, thereby leading to lower costs of consumption and higher standards of living. In his 1994 statement (Krugman), "productivity isn't everything, but in the long run, it is nearly everything", he strongly indicates that a nation's ability to grow over time is the most critical factor affecting the improvement of living standards. Therefore, despite the potentially irrational assumptions that may be underlying the many separate aggregate productivity measurements, they can provide significant recommendations concerning the welfare impact of an economy (Basu and Fernald, 2002; Basu et al., 2014; Erumban and Van Ark, 2017). Furthermore, Basu and Fernald (2002) state that TFP is a reasonable measure of welfare change because of the comprehensive nature of TFP in measuring the collective production increase that occurred after adjusting for the opportunity cost of factor inputs (Subhash. PP and Karunakaran N, 2025). Productivity has multiple influences on reducing poverty (Christiaensen et al., 2011; Ravallion and Datt, 1996; Datt and Ravallion, 1992). Labour and capital will play a key role in determining how poverty can be reduced through increased productivity. Subsequent research endeavours, employing

suitable methodologies and complementary datasets, may be imperative to gain a comprehensive understanding of this distribution (Subhash. P. P and Karunakaran N, 2025). The employment and productivity effects of innovation within economic theory lack a definitive resolution, necessitating comprehensive empirical analyses at aggregate, sectoral, and microeconomic levels.

It's possible that while technology advancements or increased capital intensity have increased labour productivity. The reduction in labour share is also observed as trade-off between technology and labour productivity (Goldar, 2017). Recent scholarly articles suggests that although the diffusion of AI-enabled automation and other capital-intensive technologies has reduced labour demand in certain sectors, a range of adjustment and compensation mechanisms may emerge that partially or, in some cases, fully counterbalance these displacement effects (Jain, Reddy, Saini & Dahiya, 2025). In a same way, the technological choices made by companies, according to Del Rio-Chanona et al. (2025) based on both theory and empirical research, are influenced by differences in the prices that companies face for their different inputs of production, resulting in endogenous adjustment processes that may serve as a stabilising force for companies in the long-term.

Objectives

- To analyse the trends in output growth and input contribution in Indian Industrial sector.
- To evaluate how productivity improvements are shared between labour and capital and their consequent impact on social welfare.
- To find out, 'Does automation affects the share of income accruing to the labour.

Materials and methods

The December 2019 update of the India KLEMS Data Base from the Reserve Bank of India (RBI), providing time-series data for 27 industries and for the economy as a whole, consistent with the Central Statistical Organisation (CSO)'s annual publication of National Account Statistics (NAS) is the primary source of data for this study. Supplementing National Account Statistics with Input-Output tables from the Annual Survey of Industries (ASI), this data source allows for a detailed breakdown of industry data by consistent series of labour input and other employment, as well as for the economy as a whole. The data source also provides both Gross Value of Output (GVO) and Gross Value Added (GVA) estimates for both current price and constant price estimates at the level of the three-digit economic sector or industry, with current price and constant price GVA estimates for individual economic sectors and industries directly obtained from NAS. The total contribution of labour input to production is estimated from the quantitative measure of labour using both an employee count method and a total hour worked method. Capital and non-labour inputs (i.e. intermediate inputs) are also considered as significant inputs to production in estimating productivity and total input to production, consistent with the methodology detailed in the process established by Jorgenson and Griliches (1967) in the India KLEMS framework.

Results, analysis and discussion

Understanding the Sources of Output Growth; the Role of Inputs and Technology: As per the inclusive growth accounting method created by Jorgenson et al. (2005), the gross output of an industry is the primary

input factors of labour, capital and intermediate goods, along with advancements in technology. An inclusive growth accounting approach presents a more complete description of the production process by treating all of the production inputs equally with respect to analysis. In contrast, value added does not include any intermediate goods, although they provide a significant contribution to many industries' total production. Thus, a levied approach gives a more restricted view on the performance of an entire industry.

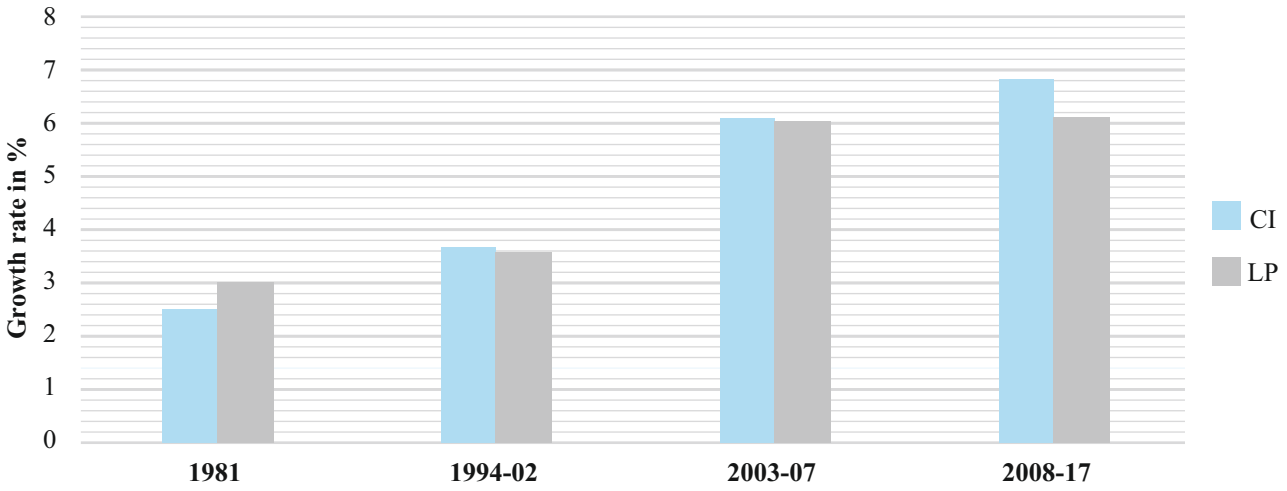
Table 1: Industry Contribution to Output Growth in Major Industries

KLEMS Industry	Output Growth	Capital Input contribution	Labour Input Contribution	Intermediate Input contribution	TFP contribution
Agriculture & allied	2.31	2.31	0.72	0.54	0.85
Mining & quarrying	4.5	3.57	0.46	3.01	-1.45
Food products, beverages & tobacco	6.59	0.91	0.72	5.76	0.7
Textiles & leather	6.33	1.48	0.21	5	0.64
Wood & wood products	1.16	1.85	0.03	1.41	-2.13
Pulp & paper products	5.42	1.52	0.84	4.66	0.22
Coke & petroleum products	6.09	1.47	0.03	5.25	-0.67
Chemicals & chemical products	7.05	1.3	0.31	5.78	0.25
Rubber & plastic products	11.7	2.68	0.83	6.39	0.9
Non-metallic mineral products	7.21	3.21	0.25	0.25	-0.02
Basic metals & metal products	8.21	1.6	0.25	5.03	0.33
Machinery, nec.	6.71	2.27	0.55	4.21	0.67
Electrical, optical equipment	11.7	1.28	0.68	6.64	2.47
Transport equipment	9.01	1.74	0.35	6.31	0.6
Other manufacturing	10.5	1.44	0.69	7.13	1.79
Utilities	6.33	1.58	0.89	4.29	1.06
Construction	6.03	1.08	2.41	4.79	-1.37
Trade	6.97	4.07	1.83	1.48	0.09
Hotels & restaurants	6.08	1.03	0.61	4.43	0.43
Transport & Storage	6.08	1.89	1.13	4.43	0.66
Post & telecom	8.97	2.47	0.91	6.34	0.45
Financial services	8.72	3.36	2.63	2.29	1.44
Business services	11.4	5.45	2.34	5.38	-0.47
Public administration	5.16	0.87	0.33	1.67	3.07
Education	5.16	2.48	2.56	1.33	1.49
Health & social work	5.16	2.16	1.75	2.39	0.57
Other services	5.16	2.07	1.63	1.25	0.61
Industry Median	6.87	1.85	0.72	4.66	0.6
Industry Average	6.46	2.07	0.97	4.16	0.47

Source: INDIA KLEMS data base, Version-2019.

The average for all industries over this period was 6.85% (7%) with a 6.40% median. The average growth rate was close to the mean (7%), and only a few industries had higher growth rates: Business Services (11.4%), Electrical and Optical Goods (11.7%), Other Manufacturing (10.0%), Rubber and Plastics (11.0%), and Post & Telecommunications (8.7%). In contrast, the average growth rate for Agriculture and Related Industries was only 2.31% during this time (Table 1). The contribution of labour input to overall output growth averages only 0.97%, less than half of the contribution made by capital. However some individual industries differ (service sectors like education, business, financial, health and social work).

Figure 1: Growth of Labour Productivity and Capital Intensity



Source: INDIA KLEMS data base, Version-2019.

Decomposition of Aggregate Primary Input Growth across Industries:

To neoclassical production function, increased capital per worker leads to increased potential output of worker; this results in increased output capacity, which increases labour productivity at all levels (Solow, 1960). Figure 1 depicts the growth of labour productivity and capital intensity.

Changes in input contributions to output Growth in Industries:

Table 2 shows the relative changes in contributions of labour and capital inputs towards total output growth.

Table 2: Changes in Input contributions (Labour and Capital) to output Growth in Industries

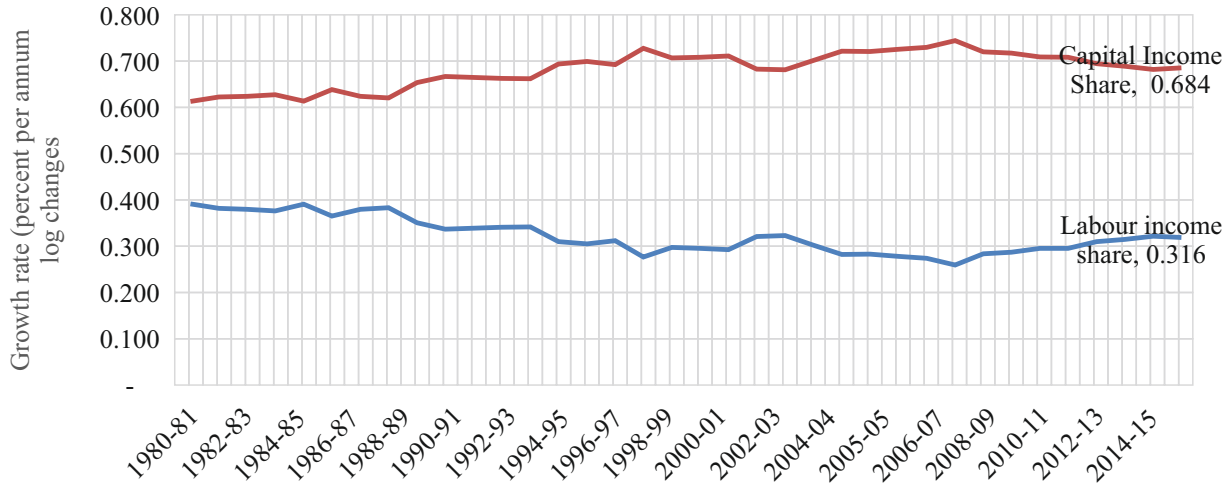
KLEMS Industry	Capital input growth	Labour input growth
Agriculture & allied	0.04	0.02
Mining & Quarrying	0.1	0.02
Food ,beverages & Tobacco	0.02	0.01
Textiles & leather	0.12	0.03
Wood & wood	0.17	0.36
Pulp &Paper.	0.49	0.14
Coke & petroleum.	0.04	0.02
Chemicals & Chemical.	0.09	0.11
Rubber & plastic.	0.11	0.03
Non-metallic Mineral.	0.2	0.09
Basic metals & Metal.	0.32	0.14
Machinery, nec.	0.07	0.03
Electrical & optical eqpt	0.09	0.08
Transport eqpt	0.05	0.03
Other manufacturing	0.02	0.01
Utilities	0.12	0.03
Construction	0.17	0.36
Trade	0.49	0.14
Hotels & restaurants	0.04	0.02
Transport & Storage	0.09	0.11
Post & telecom	0.11	0.03
Financial services	0.2	0.09
Business services	0.32	0.14
Public administration	0.07	0.03
Education	0.09	0.08
Health & social work	0.05	0.03
Other services	0.25	0.22
Total	3.61	1.55

Source: India KLEMS data Version 2019

At the sectoral level, the highest capital input contributions are observed in Trade (0.49) and Pulp & Paper Products (0.49) followed by Basic Metals & Metal Products (0.32) and Business Services (0.32). These sectors demonstrate significant capital deepening, possibly due to increased investment in machinery, infrastructure, and technological assets. In contrast, labour input growth is relatively modest across most industries, with notable exceptions like wood and wood products (0.36) and construction (0.36), where, that of labour equals or exceeds compared to capital. These industries are typically labour-intensive, relying heavily on manual skills and less mechanized production processes. Similarly, sectors like other services (0.22), pulp and paper products (0.14), and business services (0.14) also exhibit relatively higher labour

input contributions, reflecting their employment-generating potential. In manufacturing industries such as chemicals and chemical products (0.11 labours; 0.09 capitals) and transport and storage (0.11 labours, 0.09 capitals), indicating complementary growth between capital accumulation and labour expansion.

Figure 2: Labour and Capital Income Contribution to Output



Source: India KLEMS Data base, Version 2019.

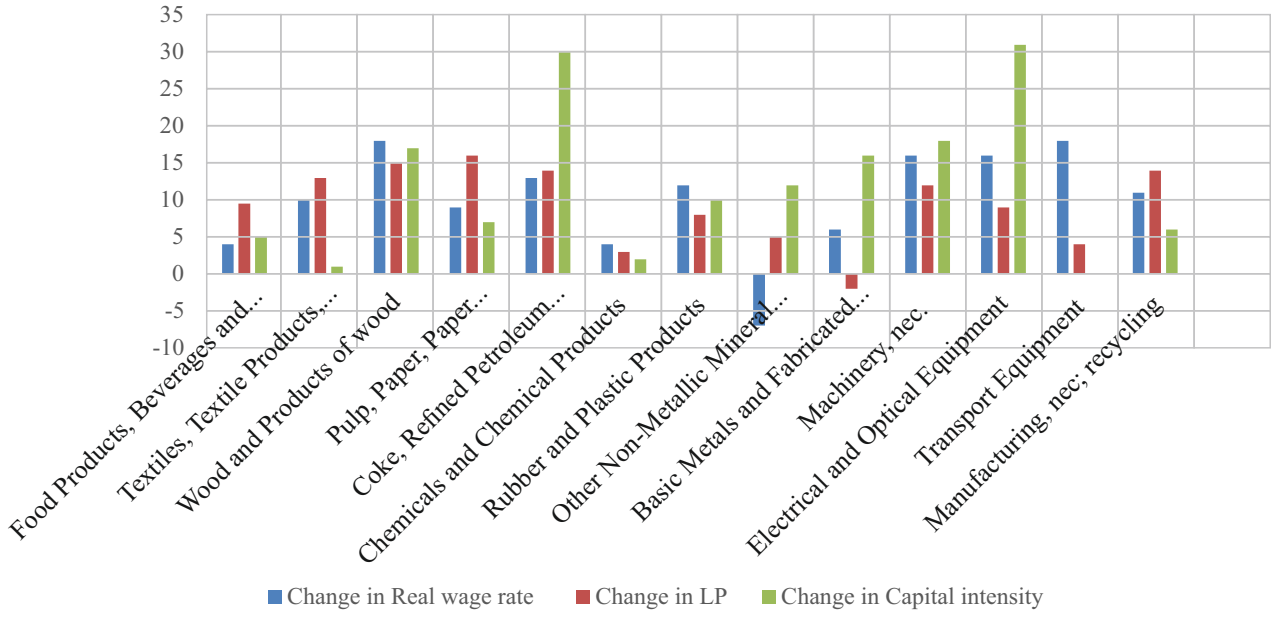
Labour and capital income share in gross output: Figure 2 visualized the distribution of labour and capital income to total output. Since 1990, the trend has been for labour income share to decline relative to capital income. However, the changing relative proportions of labour and capital can also reflect changing structural conditions, technological advancements, government intervention, or macroeconomic factors. This provides support for understanding the reasons influenced the distribution of income and economic growth. Rising capital intensity has reduced the demand for labour, while shifts in the composition of capital have introduced more skill biased and task-based patterns in labour demand. The contraction in the wages and emoluments may thus be interpreted as reflecting increasing labour market flexibility, which has heightened workers' vulnerability and strengthened mechanisms of capital control.

Figure 3: Trends in wage growth by technology intensity

Source: INDIA KLEMS data base, Version-2019.

Trends in Wage Growth by Technology Intensity: In Figure 3 the wage growth in different technology intensity manufacturing sectors over time is depicted. It was not growing at a negative rate prior to the reforms; however, the Low Technology Intensity (LTI) industries have experienced decreased wage growth of -1.43 percent from 2004-05 to 2015-16. At an aggregate level, the wage share has fallen consistently and the trend for increasing real wages appears to be decreasing. In regards to it, a number of researchers (Abraham & Sasikumar, Mitra, Srivastava & Balakrishna, 2017) have studied for the period 2004-05 to 2016-17 across all sectors of industry: Those sectors with a larger percentage of casual workers are exhibiting some but low growth, while industries with a large percentage of regular workers are exhibiting negative in the most recent periods."Furthermore, there has been positive wage growth in Medium High Technology (MHT) Industries and High Technology (HT) Industries; however, this is a skill-biased trend. The entire analysis period (1980-81 to 2015-16) provides negative trends (-0.16) for the LT Industries, while all other sectors experienced positive trends.

Figure 4: Labour Productivity, Capital Intensity and Real Wage



Source: INDIA KLEMS data base, Version-2019.

The study estimates the Correlation coefficients to evaluate the relative influence of technological intensity on real wages in India's industrial sector at both the aggregate and disaggregated levels. It also looks at how real wages are affected over time by the technical composition of capital. The capital's technical composition during the post-reform era suggests that capital has gradually replaced labour in the majority of industrial sectors. One explanation for the decreasing percentage of wages is this kind of capital-labour substitution. This structural change probably contributed to the stagnation of real wages by weakening labour demand. Additionally, the empirical findings point to a decoupling compensation, an uneven distribution of the benefits of technological advancement, even though industrial sector has outpaced it and productivity gains have not translated into corresponding real wage growth.

The correlation results indicate that, across technology groups, real wages exhibit a weak and statistically

insignificant association. In the low-technology-intensive (LTI) and medium-technology-intensive (MTI) sectors, the coefficients are small and statistically insignificant, suggesting that productivity improvements have not been systematically transmitted into higher real wages. A similar lack of significant association is observed between real wages and capital intensity, implying that rising technological intensity or capital deepening has not exerted a direct or robust influence on wage determination. The relationship between labour productivity, capital intensity and real wages is shown in Figure 4. The overall analysis of labour productivity has produced some trends that can be identified, with significant variation occurring between different capital intensities and real wage rates within industries characterised by high levels of technology. In contrast, wood and pulp/paper industries demonstrate little evidence of wage/technology variation.

Table 3: Correlation Coefficient between real wage rate and Technology Composition

Sector	Lp and $\hat{W}$	Tc and $\hat{W}$	W/VA and $\hat{W}$
LTI	-0.132045	-0.162068	0.392319
	(p=0.684581)	(p= 0.721184)	(p= 0.062636)**
MTI	0.146125	0.0124858	0.386165
	(p= 0.364946)	(p= 0.953415)	(p= 0.042693)**
HTI	0.0141357	0.131876	-0.074053
	(p= 0.914188)	(p= 0.314205)	(p= 0.636437)
ALL	-0.125189	0.1236512	0.344245
	(p= 0.424324)	(p= 0.432475)	(p= 0.14363)

**The result is significant at p< 0.05; **The result is significant at p< 0.10.*
*t values are in parentheses; *t values are significant at 5% level.*

Conclusion

The Industry 4.0, advanced technology, robotics, artificial intelligence, and algorithms, is proceeding at an unprecedented pace. The future of production is expected to be managed by machines, with over 50 billion connected machines projected worldwide (Albertsmark and Wirtschaft, 2001). Production processes will be fully automated with the employment of intelligent machines, and humans will only be utilised as production factors in specific situations. The increased automation and potential widespread use of robots in non-industrial sectors have sparked a debate about the future of work and the possibility of a "jobless future" marked by artificial intelligence and robotics on a large scale (Freeman and Pere 1988). This detailed analysis illustrates the changing characteristics of the Indian economy toward greater capital intensity, corroborated by previous studies demonstrating a significant change from other countries in terms of capital intensity in manufacturing (Sen and Das, Tejani, Verma, Hasan et al. 2015). The increased capital intensity is largely a result of the relative price of capital being less than that of labor wages, thus making it easier for firms to substitute labor for capital. Skill levels and job duties are important factors influencing the effects of technology; thus, the effects of technology will often favour one segment of workers over others. Over time, there are different patterns of bias, and it has not always been biased in favour of skilled workers (i.e., early 20th century manufacturing technologies were defined as being skill-complementary; earlier periods showed evidence of skill-replacing bias). In 1980s and 1990s in USA a rapid rise in skill biased technical change (Autor et al, 1998). Since skilled labour could be supplied at decreasing relative prices, it was reasonable to expect that developing and using skill-complementary technologies would soon become less

expensive than they had previously been. The research indicates that real wages have increased along with skill complementarities. In addition, there is evidence from Indian researchers that "wage polarization" appears to have occurred during the period following India's liberalization. First and foremost, workers should be treated fairly; second, a more comprehensive social safety net should be provided to all workers. Therefore, the efficient implementation of policies designed to link productivity and wage growth must occur in order for our economy to return to a long-term path of growth that is stable.

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