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Where Did Good Jobs Go? Acemoglu and Marx on Induced (Skill Replacing) Technical Change

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Abstract

The paper lays out a hypothesis about the effect global oversupply of labor had on induced technological change, clarifying how it might have contributed to the demand reversal for high skill workers and other recent observed trends in technological change in the US. The argument considers the effect of market friendly political/institutional transformations of the 1980s on technology as they created a potential for an integrated global labor market. The innovations induced by the promise of this potential eventually culminated in the creation of global value chains and production networks. These required large set up costs and skill enhancing innovations, but once in place they reduced the dependence of expanding low skill employment around the globe on skill intensive inputs from advanced countries, giving rise to the well-observed high skill demand reversal and sputtering of IT investment.

JEL Classification: F60, F15, O30, E10, B51

Keywords: income inequality, job polarization, skill downgrading, induced technological change, organization of work, craft economy, global production networks

I. Introduction

The US employment growth was robust in the 1990s (Krueger & Solow 2002). New jobs created centered on non-routine tasks hard to computerize, both high and low on the skill spectrum, causing job polarization as mid-wage, mid-skill level jobs disappeared (Goos, Manning & Salomons 2014; Autor, Katz & Kearney 2006; Acemoglu & Autor 2011). However, since around 2000, job growth slowed down (Moffitt 2012, Charles et al 2105), manufacturing job losses increased (Charles et al 2012, Siu & Jaimovic 2012, Pierce & Schott 2014) and demand for high skill workers stagnated (Beaudry, Green & Sand 2014, 2016; Valletta 2016; Mishel, Shierholz & Schmitt 2013). The better and higher education no longer appeared to be the panacea in the new millennium they once seemed. Despite the more recent relative tightening of the labor market, nominal wage growth remains significantly lower than before the financial crisis (Hong et al 2018) and there appears little sign of a turnaround in demand for good jobs. Offshoring (Blinder 2007, Frey & Osborne 2013) and import competition (Autor, Dorn, and Hanson 2013; Pierce and Schott 2012, Acemoglu et al 2014) remain threats, and with new labor displacing innovations over the horizon, technological unemployment, traditionally considered improbable, is no longer as readily ruled out (Summers 2013; Spence 2014; Frey & Osborne 2015, Brynjolfsson & McAfee 2014; Ford 2015).

Job polarization and *skill downgrading* are two conceptual narratives that purport to explain recent labor market trends. The former focuses on the mechanization of routine tasks, the substitution of computers for labor in one sphere after next causing the destruction of not only many clerical white-collar office jobs but also repetitive blue-collar ones as well. In this view, technological change is still seen as broadly skill enhancing, eliminating skills only when they are rigidly tied to routine tasks (Acemoglu & Autor 2011, 2012). The idea of skill biased technological change in turn goes back to the long-held view that technological change increases the demand for skills while education raises their supply (Tinbergen 1975, Goldin & Katz 2010). This framework until recently provided a good description of a variable but steadily rising return on education throughout much of 20th century, bolstering the view that technological change must be skill enhancing (Acemoglu 2002, 2003, Goldin & Katz 2008, Hamermesh 1999). The alternative narrative by contrast questions if technology is still skill enhancing (Valletta 2016). The slackening demand for high skills is observed to cascade down from the very top down the skill distribution in a broad array of occupations, not just across as the polarization view would have us predict but within broad occupation categories as well. The demand reversal for high skill workers is often tied to the retarding effect of technological maturation on the productivity growth of skilled workers. The falling trend of IT investment (as ratio of GDP) in the early 1990s is thought to give credence to this view.

Until not too long ago, international trade and technological change were considered two possible explanations of increased income inequality in the US, and, of the two, the more likely culprit was considered the latter (Krueger 1993, Acemoglu 2002, 2003). Earnings inequality appeared to be the main driver of income inequality, itself in turn thought to be increasing because of the skill bias in technological change. As Acemoglu (2002) put it, "The recent consensus is that technical change favors more skilled workers, replaces tasks previously performed by the unskilled, and exacerbates inequality," leading him to conclude, "it is perhaps natural to view the increase in inequality over the past several decades as a direct consequence of technical change." Such consensus hardly exists today. Wage inequality ceased to explain income inequality around the turn of century (Lemieux 2006, Card & DiNardo 2002, Autor, Katz & Kearney 2006), while the demand reversal for high skills (ad falling education premium) raised questions about the notion that technological change is inherently skill biased.

As "big picture" questions about the *causes* of income inequality and the nature of technological change reopened the falling labor share has moved to the center of debate as the main driver of inequality.[1] While little agreement exists on its cause, two views appear to have gained prominence in the recent literature on the topic. One argues that global economic integration is the main culprit (Rodrigues and Jayadev 2010, IMF 2007, Chp 5), emphasizing two channels: the negative effect of capital mobility on workers' bargaining power (Harrison 2002, 2011 and Guscina 2007); and the positive effect of global supply chains on the effective labor supply as it made it possible to tap lower wage low skill labor reserves abroad (Hung & Hammett 2014, Doe et al 2017). The focus of the second view has been on the effect of rapid advance in IT technologies on the relative price of investment goods (Karabarbounis and Neiman 2013, 2014), which it is argued has incentivized firms to replace labor by capital. This raised the question whether the capital labor elasticity of substitution is greater than one, since factor shares in a Cobb-Douglas type production function would not be affected if it is not.[2]

This paper contributes to the first literature, addressing two gaps: how is workers' diminished bargaining power and global economic integration is connected with (i) trends in technology; and, (ii) the demand reversal for high skill workers in the US and other advanced economies. It lays out a hypothesis about the effect global oversupply of labor might have had on induced technological change. It starts out with a discussion of Acemoglu's theory and introduces two revisions to it inspired by Marx - one technical and the other conceptual. The former involves eschewing the traditional methodology of aggregate production functions where high and low skill workers enter as alternative factors, focusing instead on how their complementarity plays out in the representative firms' employment decision as innovations change its scope. The approach helps explain how technological change can reduce the proportion of high skill jobs in

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[1] There seems by now agreement that the downward trend in the labor share is no art effect. Two main measurement problems identified in this literature relate to the labor compensation of self-employed individuals and the depreciation of capital (Gollin 2002 and Bridgman 2014).
[2] Yet, a third view has emphasized the rise of monopsonic labor markets. See also Autor et al (2017).

the aggregate without a fall in their productivity - when, in fact, quite the opposite is likely to be the case. The main idea is that the demand for high skill workers is higher the higher is their productivity when high and low skills are alternative factors, but not when high skill services enter as overhead in low skill production. In this latter case, the demand for high skills derives from the size of low skill employment and is thus proportionally lower the more productive they are.

An alternative conception of technological change lies behind this revised approach, where the idea is that innovations are simultaneously both deskilling (skill replacing) and reskilling (skill enhancing). Technological change can then cause deskilling in the aggregate not so much because it raises the productivity of high skills in relation to low skills, but rather because it alters the proportionality (or balance) condition between the two types of skills such that expanding low skill employment becomes less dependent on high skills. The important question is thus how the direction of innovations alters the proportionality condition that reflects this dependence. A related issue is the endogeneity of labor supply. Not only oversupply of low skill labor supply can influence the trajectory of technological change, but the technologies it induces can also positively feedback on it, the labor supply, as well. This raises the intriguing possibility that innovations might also be induced by the mere potential or possibility of increasing the labor supply.

The organization of the paper is as follows. Section I gives a brief overview of Marx on the transformation of organization of work and how innovations that are simultaneously deskilling (replacing) and reskilling (enhancing) can result in reducing demand for skilled workers in the aggregate. Section II focuses on induced technological change, discussing its effect on the balance between reskilling and deskilling innovations. It introduces a reduced form model to first discuss and then revise Acemoglu's (2002b) analysis of induced technological change based on the above-mentioned themes from Marx. The section ends with a discussion that draws out the implications of this revised model in connecting the diminished bargaining power of workers (and global oversupply of labor) to the demand reversal for high skill workers and the observed trends in technological change. The paper ends with a brief conclusion.

i. Marx on *Deskilling* and *Reskilling* Technological Change

Three themes summarize the gist of Marx's discussion of induced technological change: (i) the reorganization of work is both a precursor of and precondition for deskilling innovations; (ii) the impetus for such reorganizations can arise from major shifts in labor market conditions, where labor supply can have a significant endogenous component; and, (iii) reskilling among high skill workers is a prerequisite and a side effect of such transformations. The lopsided labor market conditions Marx observed were a characteristic of the 19th century capitalism, resulting from the steady flow of workers displaced in the countryside into towns in search of employment.

The resulting plethora of unskilled workers were not however readily employable because production, organized predominantly along craft lines, required a high level of skills they lacked. The organization of work had to be transformed before capitalists could profitably employ low skill workers. Such transformations were however not only a passive response to the increased supply of labor but were also the means of proactively bringing it about. In other words, the labor supply was in part endogenous as reorganization of work not only made it possible to hire unskilled male workers but also the women and children who were hitherto considered outside the relevant labor force.

In a craft economy the product is customized and few if any economies of scale exist. The system works well in the production of non-standardized goods as it flexibly adjusts to different job requirements, shifts in demand and relative prices. But, on the downside, craftsmen need a long time to acquire their skills and can thus be a bottleneck in production. Moreover, the need for teamwork makes individual crew members hard to replace, imposing yet another constraint on output as altering the crew size raises adjustment and coordination costs in the short run, causing diminishing returns to quickly set in when output expands.

These drawbacks were an impetus in shifting production towards standardized goods that were cheaper, though often inferior, substitutes for custom crafted goods. The cost advantage was achieved by scale economies made possible by breaking down each complex task performed by skilled workers into a series of routine tasks that could be performed by low skill workers (Sokoloff 1984). By reorganizing work, the unifying thread of production could become a preset sequence of routinized sub-tasks instead of the master craftsman who flexibly paired complex skills with the variable tasks customized jobs required (James & Skinner 1985). The resulting fall in requisite labor skills in production made workers easier to replace, and craftsmen ceased to be a bottleneck. This also set the stage for the introduction of machinery, since a mechanical arm could replace an organic more easily when it performed a simple, routinized task (Sherwood 1985, MacKenzie 1983).

Re-skilling is part of this narrative as well. Some craftsmen had to acquire new skills to oversee the reorganization of work, while at the same time the expansion of standardized production raised demand for a new breed of craftsmen such as engineers, designers and managers. (Golding and Katz 1998, Wright and Singlemann 1983).[3] Standard and *craft* work organizations had to coexist, because if nothing else the specialized, product-specific machinery used in low skill standardized production could not be mass produced themselves (Piore and Sable 1984). The high and low skill workers, each with its different organization of work worked with different types of machines. The machines used in standardized low-skill work were designed

[3] In some accounts of the rise of *mass production* economy the emphasis on *deskilling* technological change tends to overshadow attention on *reskilling* innovations (Braverman 1974; Marglin 1974; Aglietta 1979). Various criticisms of Braverman are compiled in Wood (1982), and an account of reskilling in Marx's work that perhaps errs on the other side is Adler (1990).

with a view to minimize workers' pre-training costs, and thus tended to be *product-specific* and *single-purpose* so that they could be operated easily with little training and skills (Piore & Sable 1984). By contrast, the machines high-skilled workers used enhanced skills, designed to assist versatile high skill operators (Nell 2005).[4] While the latter were inherently skill enhancing, the former were clearly not.

Jobs thus bifurcate based on their work organization, a theme that remains equally valid today. The low-skill workers perform routinized (and gradually mechanized) work to produce standardized goods, while high skill jobs comprise diverse set of tasks organized along craft lines that produce customized goods and services. How computers enter the labor process captures the difference between the two well: while in the latter they work for the worker in the former the worker works for them. They assist high skill workers in performing multi-dimensional variable tasks, but control and regulate how low skill workers fulfill routinized tasks. Modern high skill workers' relatively inelastic supply and skill intensive work resemble the *old* artisans, and explains incidentally why high monitoring costs, Y-management and efficiency wages characterize their jobs. But, the modern craftsmen complement low skill, standardized workers rather than representing a method of production that is its alternative. This as we shall see matters greatly, since the important issue becomes the nature of the complementarity (or balance condition) between these two modes of work – i.e., how innovations enhance skills in one sphere and replace them in the other. An important consideration in pursuing this question is how technological change might disrupt the balance between these two modes of work organization, especially when its own direction is responsive to shifts in economic conditions. This is the question of directed technological change, which is discussed next.

II. Directed (Induced) Technological Change

What determines how technological change alters the balance between the high skill *new* craftsmen and low skill standardized production workers? And, what economic forces might bear upon the trajectory of technological change itself? Starting with the second, it is not unusual to think that at least a part of technological innovation is autonomous, an "accident" of its past path-dependent evolution we might neither fully foresee nor predict *ex-ante*. For instance, few people if any could envision the far-flung implications of the information revolution when it first began. As semiconductors have become more powerful over time one sphere after next could be computerized in a way that could hardly have been anticipated. But,

[4] One implication of this that will be relevant at a later stage of argument is that capital intensive investments in high skill work that leave the craft organization of work intact increase the skill gap between the two types of workers, making it more difficult or costly to substitute low for high skill work.

as Acemoglu (2002b) suggests, innovations can also be "directed" or induced.[5] He argues that the modality of these is both to *augment* the more expensive factor to economize on them while also *complementing* the one that is more abundant. These two effects compete. For instance, when an oversupply of low skill workers reduces their relative price the former effect promotes technologies that enhance craftsmen's skills because they are now more expensive, while the latter effect bolsters those that compliment low-skill workers because they are now more abundant. The relative strength of these two effects in turn depends on the elasticity of substitution between skilled and unskilled workers. The latter effect predominates if substitution elasticity is high and the overall direction of innovations end up being skill replacing, and *vice versa.* The reduced form model below depicts these two effects and show how their interaction changes when high and low skills are not alternative (but complementing) factors. The argument shows that deskilling can occur in the aggregate even as innovations are simultaneously skill replacing and enhancing and high skill workers' productivity rises.

Consider an abstract economy consisting of m identical firms that produce a homogenous good with labor alone. Employment is supply constrained and thus no unemployment exists. With a given labor supply, $N = N_0$, each firm employs N_0/m number of workers and decides on whether to employ them as craft or standardized production workers, i.e., use them in either (*high skill*) craft or (*low skill*) standardized production. The return on craft work is high at low levels of employment but diminishes rapidly as it expands. By contrast, the return on standardized work, while initially lower, remains constant as employment rises. The organization of work and high set up costs of standardized production explain the initial return differential between two types of work. With a constant wage and n other workers already employed as craft workers, the representative firm decides whether the $n + 1^{st}$ worker it employs performs *high* (craft) or *low skill* (standardized) work by comparing the respective return from each. Holding the wage (w) constant, the return on low skill workers is assumed constant, while the premium on high skill work diminishes as craft employment expands (n). Setting $m = 1$, without any loss of generality, we can express the respective returns on two types of skills as:

$$H(n+1) = h_0 - hn$$
$$L\,(n) = x_0$$

where $x_0'(w) < 0$, while h determines how fast high skill premium diminishes reflecting the cost of substitution. h_0 and x_0 are exogenously given constants.

The point E where $H(n + 1)$ and $L(n)$ intersect yields a stable equilibrium (Figure 1). The return on high skill work falls below that of low skill workers when the number of skilled

[5] Acemoglu draws on an earlier literature on induced technological change from the 1960s - see, among others: Habakkuk (1962), Kennedy (1964), Samuelson (1965) and Drandakis & Phelps (1965).

workers exceed n^*, and as some workers are switched on the margin the respective returns are equalized. Likewise, when $n < n^*$, more workers on the margin are employed to perform skilled work, again equalizing the respective premiums.

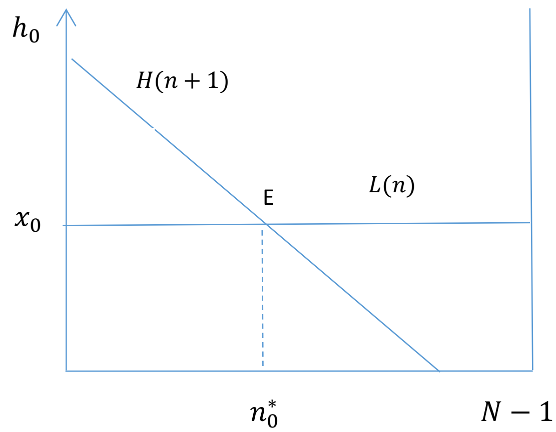

Figure 1

In equilibrium, the size of *craft* employment is related positively to the autonomous part of its return, and negatively to how rapidly it falls as more worker perform high skill work.

$$n_0^* = \frac{h_0 - x_0}{h}$$

Figure 2 depicts Acemoglu's two effects. Assuming a fall in the wage following an exogenous increase in the supply of low skill workers, the return on low skill work increases to x_0^1, raising the relative worth of high skills. *Directed* innovations can respond by targeting either making high skill workers more productive or raising the elasticity of substitution between high and low skill workers. The former shifts up the high skill premium, moving the equilibrium towards point E'', while innovations that reduce the cost of substitution move it towards E'. In the former, the "price effect" predominates and technological change is skill augmenting on balance, while, in the latter, the "market size" effect is stronger and technological change ends up being skill replacing overall. Whether deskilling occurs (point E') or not (point E'') then depends on the relative cost of these two types of innovations given, what Acemoglu (2002b) calls, the shape of the "innovations possibilities frontier." Changes in autonomous technological change can shift this frontier over time, making innovations that raise substitution elasticity more attractive. This might seem applicable in the example of more sophisticated and cheaper computers encroaching on new sectors hitherto organized along craft lines. Ubiquitous since the 1990s, this type of direct deskilling clearly has salience. Yet, the effect of another type of deskilling might have been more far-reaching.

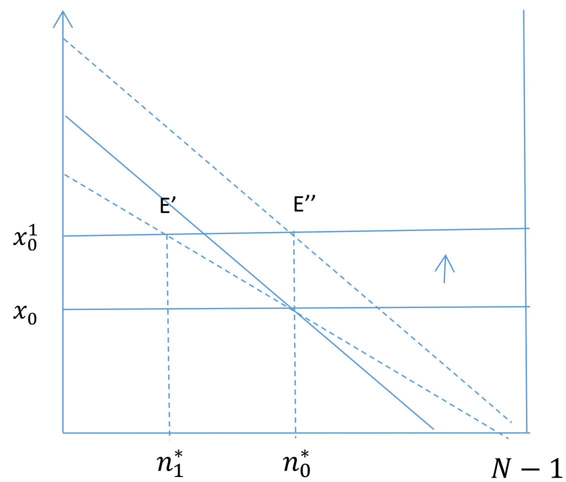

Figure 2

III.1. Deskilling *á la* Marx

When high and low skill work refers to alternative methods of producing the same set of goods, the high skill premium depends on how productive craftsmen are compared to low skill workers, and thus any improvement in their productivity militates against standardized production by low skill workers. But, when high skill work enters as overhead into standardized production the demand for high skill work derives from the size of low skill employment. As discussed above, when innovations are simultaneously skill augmenting and skill replacing the re-organization of work to standardize production replaces many skills, but at the same time creates demand for new ones, for engineers, designers, etc., whose skills are a prerequisite of reorganization of work. Since high skills complement rather than rival low skill workers, this suggests a condition of proportionality between the two types of work. How much low skill employment can be increased at constant marginal cost depends on high skill workers' efficiency.[6]

[6] Our methodology enables us to gloss over the difference in which this can manifest itself at macro and micro levels.

A simple way to capture this idea might be by introducing a technical *balance condition* between two types of work. Given a set of technical conditions of production, the amount by which expanding employment of low skill workers raises demand for high skill work can simply be assumed to satisfy some constant ratio of high skill workers to total employment:

$\gamma = n/N.$

An improvement in the efficiency of high skill work now has two dimensions: one derives from lowering γ, which determines how much low skill employment can be increased at non-increasing marginal cost; while the other is related to the positive effect an improvement in high skills can have on low skill labor supply, e.g., tap into new low skill labor pools which prevents wage pressures from building up. We can consider each dimension in turn. Focusing on γ and changes therein, we can first assume that the changes in global labor supply are exogenous.

III.1.1. *Exogenous Labor Supply*

Consider as a general starting point the question what happens when the technically required magnitude of high skill work given by the balance condition differs from the equilibrium value of demand for high skill work, n^*. For instance, assuming a fixed supply of craftsmen and a position where the balance condition is initially satisfied, what happens when an exogenous increase in new low skill workers raises total employment from N_0 to N_1? With the fall in wage the equilibrium moves to point E' in Figure 3a, where demand is equalized to available supply. But, this amount falls short of the technically required quantity of high skill workers at this higher level of employment: $\gamma N_1 > \gamma N_0$, giving rise to a shortage of high skill work. We can think of three types of 'directed' innovations that can overcome the bottleneck.[7]

In the first two, innovations relieve the shortage of high skills by either making them more productive or raising the elasticity of substitution between the two types of work. In one case, the high skill return function shifts to the right (Fig. 3a). It is as though the high skill workers' numbers have increased because they become more efficient. In the other, the slope of the high skill return decreases, showing a decrease in cost of substitution. In both cases, the equilibrium moves towards point E'' (Figure 3b). Note that deskilling occurs in neither case.[8]

[7] The adjustment process is here glossed over as the argument ignores the relative price of high skills in the interest of simplicity.
[8] Note that Acemoglu's *market size effect*, inducing innovations complementing low skills (as in Fig 2) here makes the high skill shortage worse.

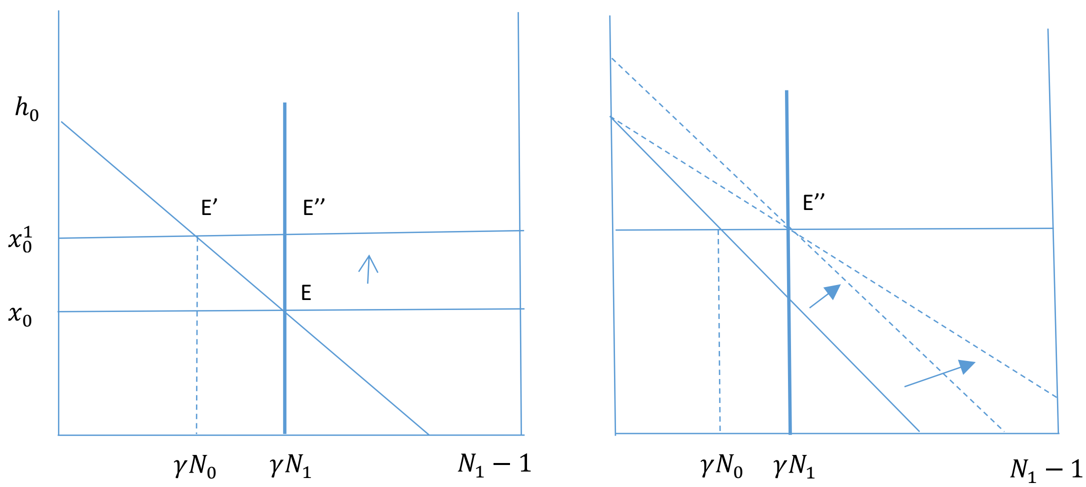

Figure 3a Figure 3b

A third possibility is when innovations target the technical balance condition. In this case, the bottleneck of high skill workers is overcome through innovations that lower the low skill employment's dependence on high skill workers. That is, innovations reduce the technical balance condition, γ, reducing the proportion with which demand for high skills rises as low skill employment expands.[9] The improved (new) skills of proportionally fewer high skill workers make it possible to raise the scale at which low skill employment can be increased at constant marginal cost. This suggests a steepening in the slope of the high skill premium function, indicating an increase in the cost of substitution, where $\gamma_1 < \gamma_0$ (Figure 4).[10] The high skill premium rises for low levels of craft employment but falls more rapidly as the demand for high skill workers now tapers off faster with an increased cost of substitution between the types of work. Unlike the previous two cases, here, deskilling occurs in the aggregate even as innovations augment *high skills*.

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[9] For instance, in the limiting case where the supply of high skill workers is fixed, and substitution is prohibitively costly, the amount by which standardized work can expand is given by the percentage fall in γ. Note that in this limiting case, $\frac{N\prime}{N} = -\frac{\gamma\prime}{\gamma}$ since, $n' = \gamma' N + \gamma N'$.

[10] Skill enhancing technologies that raise the cost of substitution tend to be capital intensive. The reverse is often true as well. Technologies that lower the cost of substitution tend to be labor intensive, associated with the types of investments that augment the infrastructure and education.

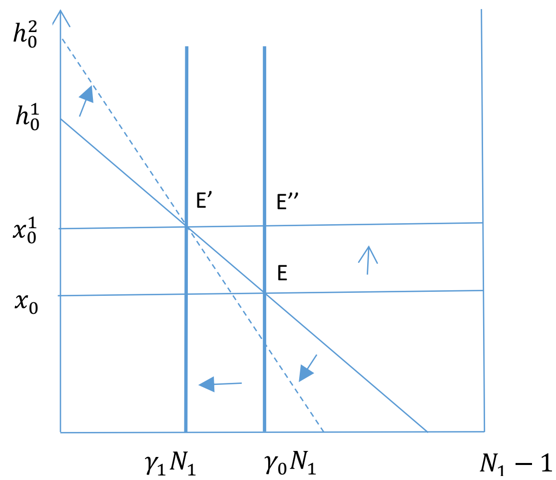

Figure 4

This third possibility is of interest as it can suggest an explanation for why the demand for high skill workers can fall even when they are not any less productive. In fact, the relationship can even be negative when the percentage fall in γ is greater than the percentage in increase in total employment. When skill complementary innovations keep reducing the rate at which the expansion of low skill employment generates demand for high skills, the more technological change augments (high) skills the more skill replacing their effect is in the aggregate. This can shed light not just on the demand reversal for high skill workers towards the end of the 1990s, but also on some of the other pertinent recent trends in average productivity, the labor share and pay inequality.

Consider the three major income streams generated by (i) high skill workers, (ii) low skill workers, and (iii) *new* low skill workers, looked at from the point of the firm. The shifts in these, denoted A, B and C, respectively, can be easier to track when the change in total employment is shown explicitly as in Figure 5. ΔA is the change in the overall size of the pie high skill workers generate - the *third-type* innovations replace the initial triangle, $x_0.E.h_0^1$, with another given by $x_0^1.E'.h_0^2$. While the high skill workers' income stream relative to the total might rise initially it tends to fall precipitously as total employment expands.[11] Even though the high skill workers are becoming more productive in this process, average productivity of *all* workers eventual falls

[11] If the supply of high skill workers is constant, as assumed in Figure 5 for ease of exposition, the change in the high skill premium with a given $n^* = \gamma_1 N_1 \approx \gamma_0 N_0$ is given by: $\Delta A = \frac{n^*}{2}[(h_0^2 - h_0^1) - (x_1 - x_0)]$, which is increasing with the increase in the *autonomous* part of high skill return and decreasing with the increase in return for low skill workers.

simply because their share in the total is decreasing. The second important change is in the income stream the 'old' low skill workers generate – denoted, $\Delta B = (x_1 - x_0)N_0$. Ignoring economies scale, the change reflects a zero-sum gain for the firm(s) at workers' expense as the influx of new workers lowers their bargaining power and the wage. Finally, the shift in income stream generated by the expanding employment of new low skill workers is denoted by $\Delta C = x_1(N_1 - N_0)$. From a long-term perspective, this might have had the strongest inducement effect on innovations. With global economic integration since the 1980s, much of the increase in low skill employment expansion (ΔC) has taken place in developing countries, while labor share fell (ΔB) and high value-added employment stagnated (ΔA) in advanced countries. Such integration has thus not only relocated lower-skill, labor-intensive stages of production in advanced countries to developing economies, but perhaps more importantly made an explosive increase of low skill employment *elsewhere* possible.

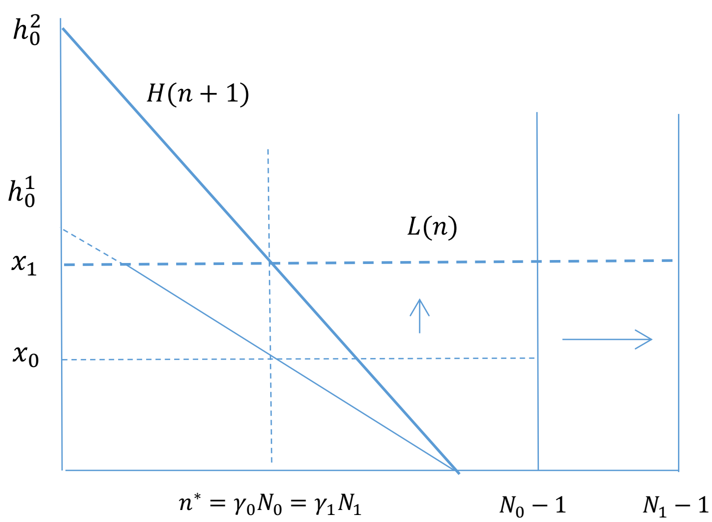

Figure 5

III.1.2. *Endogenous Labor Supply*

IMF (2007) gives an estimate of the "global labor supply", which suggests that it quadrupled between 1980 and mid first decade of the new millennium. The figure is arrived at by summing up the working age population in each country after weighing it by its export share of GDP, including the labor forces of countries newly integrated into the world market, such as China, India, and the former USSR.[12] It is important to recognize that this estimate could simply have

[12] For a more recent estimate from *McKinsey Global Institute*, see: Dobbs et al (2012).

remained an unrealized *potential* if it were not for the very technologies it induced. Once the momentous political/institutional transformations around the world removed restrictions on international trade and capital mobility, the *actual* emergence of an integrated global labor market required not only declining transportation and communication costs, but also the eventual formation of global value chains and production networks. None of these could have been possible without the skill complementing effect of IT on *high skills*. It is thus not too far-fetched to credit the internet and IT more broadly, and its enhancement effect on *high skills*, for an increasingly integrated global economy which made the explosive increase in low skill employment in its periphery possible.

Yet, the net effect was skill replacing in the aggregate. For the relative demand for high skills in advanced countries fell as innovations reduced the technical balance condition, γ, on a global scale. Global value chains and production networks required large set up costs, but their point was to expand low skill employment around the world by generating much less demand for high skills and thus at constant if not falling marginal cost. It is thus not surprising that the period of their construction – roughly after 1980s through the 1990s - is when the demand for high skills rose. But, a reversal in the demand for high skill workers – and, in fact, in new high skill complementing IT investments – would ensue once the production networks were in place.[13]

The improved efficiency of *high skills* in keeping global labor supply a step ahead of demand was crucial in this process, which explains why the fall in workers' bargaining power (not only in advanced countries but globally) was not just as a *one-off* result but something that would snowball over time. Figure 6 gives a stylized depiction. An initial fall in wage shifts up low skill workers' return, inducing innovations that not only reduce γ but also improve the efficiency with which high skill workers integrate new labor reserves into the global labor market. Assuming that labor supply expanding faster than demand, the wage falls again shifting anew the return from low-skill employment, which further induces γ-reducing and labor supply expanding innovations. The process keeps repeating itself causing equilibrium to move from E to E' and then to E'' and on, suggesting a successive diminution in the relative size of the income stream high skill workers generate over time.

[13] A similar argument is made by Spence (2011) and Spence & Hlatshwayo (2012). See also Jensen (2011) on the often-neglected globalization of services, and Milberg (2008) on the role of financialization in the emergence of global value chains.

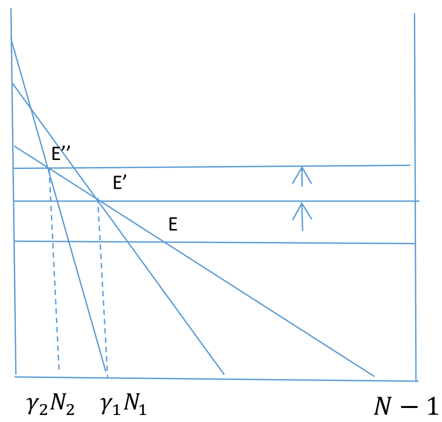

Figure 6

This account appears generally consistent with the observed trend in pay inequality - its steep rise after 1980 and subsequent fall by mid to late 1990s - that was the focus of much attention until recently. Autor, Katz & Kearns (2006) point out that much of the rise in wage inequality during this period was driven by changes in the upper half of the skill distribution. The upward spike in the return for high skills, shown in Figure 4, is not inconsistent with their findings – though, the picture is admittedly clouded by the earnings of the very top 'wage-earners' which are generally thought to be profit income camouflaged as wages. It is also not surprising that this initial effect would subside as the relative size of the high skill income stream decreases over time as in Figure 6.

III.2. Recent Literature Revisited

Recent literature recognizes global economic integration as a significant determinant of falling labor shares both in advanced and in developing countries (Rodrigues and Jayadev 2010, IMF 2007, Chp 5). Leaving aside neoclassical trade theory,[14] the explanations that link the fall in labor share with globalization tend to emphasize two channels: the negative effect of capital mobility on labor's bargaining power; and global supply chains that enable US firms tap lower wage low skill workers abroad (Hung & Hammett 2014). For instance, Harrison (2002, 2011) and Guscina (2007) find that openness to capital flows are negatively linked to wages and labor

[14] As Stolper & Samuelson (1941) makes clear, given the international differences in factor endowments, trade integration is supposed to reduce labor shares in capital-abundant advanced economies but raise them in less developed labor-abundant economies. However, the labor shares have generally been falling in the latter group of countries as well.

share, while Doe et al (2017) show a strong correlation between participation in global value chains and the evolution of labor shares. The argument here contributes to this literature, filling two gaps: One is in offering a hypothesis on how the workers' diminished bargaining power (and global economic integration) is connected with trends in technology; and, the other is in explaining the demand reversal for high skill workers in advanced economies.

The rapid advance in IT technologies figures prominently in Karabarbounis and Neiman's (2013, 2014) technology-based explanation of the falling labor share in the US. They argue that the steep decline in the relative price of investment goods caused by the IT revolution has incentivized firms to replace labor by capital, and that that explains the fall in the labor share. But, their argument skirts the question of what *induced* the technological changes that led to the rapid cheapening of computers. That this was the result of highly capital-intensive investments at a time of cheapening labor raises a puzzle they do not address. The debate that ensued following their paper has also ignored the question, focusing instead on whether the capital labor elasticity of substitution is greater than one – since, if it is not, a decline in relative price of capital should have no impact on factor shares in a Cobb-Douglas type production function. The second question, the demand reversal for high skill workers, is well-recognized but - leaving aside passing references to the technological maturation thesis - remains poorly understood. Moreover, the recent spike of interest in labor displacement due to robotization and offshoring of the labor-intensive production segments in advanced countries (Elsby, Hobijn, & Sahin 2013, Hung & Hammett 2014) might have detracted attention from the explosive increase in low skill employment in developing countries and its systemic connection to global production networks. So, the pertinent question remains: why has continued global integration of production and strong employment growth in developing countries did not result in a sustained increase in the demand for high skill workers in advanced countries?

The perspective the paper suggests on both questions can be summarized as follows. The expected payoff from tapping low skill labor pools around the world appears to have had a strong inducement effect on skill augmenting innovations that made it cheaper to invest in forging a relatively well-integrated global labor market and production networks. While labor displacement due to mechanization and offshoring elicited much attention, equally if not more important result was the diminishing relative demand for high skill workers in advanced countries since the point of global networks was to make them less indispensable in expanding global low skill employment. The argument is akin to Acemoglu's *market size effect* playing out at a global level, where innovations are induced to complement low skill labor, the globally more abundant factor, except for the two themes missing in his analysis that are highlighted here by going back to Marx. One of these is the endogeneity of low-skill labor supply. The end of the cold war and political triumph of free market orientation around the developing world is often rightfully emphasized in explaining the initial momentum towards globalization. But, what these momentous political transformations created was only a potential that could not have been realized without the new transformative technologies it induced. The other incongruent issue in Acemoglu's version of the *market size effect* is why induced innovations were highly capital intensive rather than being labor intensive – in the reduced form model above, why would they raise the cost of substitution between skills rather than lowering it. In Acemoglu's analysis, a higher supply of low skill workers would also decrease the relative demand for high skill workers, but this would come about by lowering of the cost of substitution (as shown in Figure 2 as a movement towards E'). That clearly is not what happened. If that were the case, we would have experienced wage compression rather than polarization.

III. Conclusion

Until recently, wage polarization appeared to be the main driver of income inequality, itself thought to be caused by the skill bias in technological change. Yet, on the one hand, the increase in pay inequality subsided around the turn of the millennium while income inequality continued to rise. And, on the other, there was a demand reversal for high skill workers in advanced countries, which raised doubts about the premise that technology is inherently skill biased. The paper suggests a narrative and a hypothesis, alternative to those put forth in the *job polarization* and *technological maturation* arguments that purport to explain these trends. Starting out with the premise that innovations are simultaneously skill enhancing and replacing, it argues that technological change might have tilted the balance in favor of the latter, mainly because the promise of an integrated global labor market had a strong inducement effect on innovations culminating in the creation of global production networks. What made such expectations credible for firms was the political/institutional transformations around the world that promoted market (and trade) liberalization and capital mobility, contributing to the long decline in labor's bargaining power by circumventing the barriers on competition from workers *abroad* and reducing the policy space of governments in developing countries. The basic modality of these induced technologies was to reduce the cost of expanding low skill employment, including those associated with the *input* from high skill workers. They culminated in a relatively well-integrated global labor market and production networks, which required large set up costs. But, once they were put in place low skill employment could be increased around the world by generating much less demand for high skill workers in advanced countries, giving rise to the well-recognized demand reversal for their services.

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