The Productivity Paradox:
ICTs, Knowledge and the Labour Market

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Abstract

The variety of research and theoretical reflection attending to the productivity paradox exemplify the growing and deepening intellectual division of labor in social science. For some observers, the productivity paradox does not exist in reality, it is a measurement construct or represents a matter of mismeasurement that conceals real gains that are made. For other scholars although real it represents but a transitory phase not unlike the transition of other technological systems such as the diffusion of electric power that may take, as did other learning processes, a long time. All these and other factors likely play a role but one of the most profound reasons for the productivity paradox may well be the transformation of the modern economy into a knowledge-intensive economy and the attendant transformation of the economy including the labour market as well as the world of work. This paper explores the hypothesis that the productivity paradox is linked to the growth of the number of knowledge-based workers in modern society and the consequences of this growth for the world of work.
Introduction

When it comes to the economic affluence of a nation and the ability of a country's economy to improve the standard of living of its citizens and compete internationally, social scientists are in an unusual agreement that productivity "in the long run is almost everything" (Krugman, 1994:13). Manuel Castell's (1996:80) throughout his extensive study of modern society as a network society seconds this observation and concludes that "productivity is the source of the wealth of nations". 1 Not only shifts in standards of living follow from changes in productivity performance. Less immediately related non-economic transformations in response to unequal national productivity gains occur including major changes in the balance of global power relations. In this light, Krugman (1994:17) comments somewhat despairingly, the slowdown of "American productivity growth since the early 1970s becomes the most important single fact about our economy."

Global competition represents the linkage path that combines information and communication technology (ICT), organizational change and productivity growth. Productivity gains are stratified. Productivity improvements or the lack thereof do not occur in a linear fashion throughout the economy nor among all divisions within a firm or segments of the work force. In the advanced economies the challenge is no longer "to make manual work productive... the central challenge is to make knowledge workers productive" (Drucker, 1999:141). And the tools modern knowledge workers increasingly deploy are information and communication technologies.

A similar equally widespread agreement among economists, policy makers, sociologists and educators extends to the notion that "structural changes" in the modern economy transform the labor market and generate demands for specific skills. Changes associated with the emergence of the knowledge-intensive economy are seen to engender an increased need for skilled workers (e.g. Baldwin and Gellatly, 1998: v) or a growing presence of knowledge workers in the economy. 2

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1 The reasons Castells (1996:468) offers in support of his label of network society for the emerging social structures throughout modern society refer to a historical trend in which the "dominant functions and processes in the information age are increasingly organized around networks. Networks constitute the social morphology of our societies, and the diffusion of networking logic substantially modifies the operation and outcomes in processes of production, experience, power, and culture." For a critique of aspects of Castells theory of society see Stehr (1999).

2 I will only cite one more example of the by now rather orthodox claim in science, in education, the economy and in much of the public realm that there is a technology driven demand for highly workers. That claim also resonates strongly with technological determinism: Davenport (1997:2) deferring to Peter Drucker's ideas on the knowledge society explicates the term knowledge-based economy and indicates that the characteristic technological basis of the knowledge-intensive economy, namely information and communication technology, biotechnology, and new materials have created a "remarkable demand for highly educated workers, not only to
Two or three decades ago, Daniel Bell and others began to explicate their idea that industrial society is giving way to a post-industrial society. One of their central tenets was to refer to the centrality of theoretical knowledge as constitutive for post-industrial society. According to Bell (1968:158), the crucial political questions post-industrial society will face "deal with education, talent, and science policy. The rapid expansion of a professional and technical class, and the increased dependence of the society on scientific manpower, suggest a new and unique dimension in social affairs: i.e., that the economic growth rate of a postindustrial society will be less dependent on money than on 'human capital'."

In the discussion and controversies surrounding the productivity paradox, these and related observations about the decline in the economic importance of the forces of production that shaped industrial society are rarely moved toward the center of the analysis or linked to observations about the nature of the productivity puzzle even though they now form the premise of many general analyses of the modern economy as a knowledge-based economy. I will try to link the analysis of the productivity paradox in this paper to the emergence of knowledge as a source of economic growth and changes. I will argue that the productivity paradox can be better understood if one recognizes three empirical facts. First, highly skilled labor appears on the scene before information technology. Second, the increasing importance of highly skilled labor is not a reaction to demand for such labor, but rather there is an autonomous (i.e. societally driven) supply shift. And third, information technology actually helps entrepreneurs and managers to catch up with and reverse the rising labor costs implied by this supply shift. Therefore, the productivity paradox can help us to understand that we are not faced with a technology driven transition from industrial to informational society but rather with a societally driven transition from an industrial to a knowledge society. In this sense, then, we have entered a new modernity.

The Productivity Paradox

In the last two decades economists in particular have been puzzled and even irritated about the apparent lack of measurable productivity gains in goods producing and services industries in OECD countries in response to or in conjunction with the immense investments in recent years in information and communication technologies. The choice of labeling this phenomenon the "productivity paradox" results from the disjuncture between the immense economic expectations and promises that have been engendered by the "computer age", on the one hand, and the apparent lack of sustainable economic payoffs resulting from the enormous investments by corporation and the state in information and communication technologies, on the other hand.

advance and manage the technologies themselves, but to serve as experts in the finance, production, and marketing of the new products and services which the technologies produce." What is remarkable about Davenport's assertion is that Drucker is one of the few economists who has indicated that the really intriguing dynamics of growth of knowledge workers is the extent to which such gains may not be demand but supply side driven (see Drucker, 1968:1992:279). I will return to this point in detail later in the paper.
In 1990 alone, U.S. businesses invested $61 billion in hardware, $18 billion in software and $75 billion in data processing and computer services (U.S. Department of Commerce, 1991). Attewell (1994:24) sums up previous research on the productivity paradox affirming its existence and comments that "no study documents substantial IT effects on productivity." Although conceptual, methodological and data difficulties that extend to the very definition of productivity do exist in the information that are typically utilized in generating these findings, they do not appear to invalidate the results completely. Given the excessive and often repeated claims about the transformative capacity of information technologies one could even be tempted to ask, why have productivity gains that can be attributed to ITCs not been even more spectacular?

As in intellectual version of the continental drift, the social sciences disciplines are moving farther and farther apart (cp. Luhmann, [1991] 1993:2). Given the socio-cognitive state of contemporary social science, it is not surprising that the growing literature on conditions for the possibility of "productivity growth", let alone the nature and consequences of the "productivity paradox" is not accompanied by a common conception of its meaning and empirical referents. There is no agreement on why productivity varies, let alone on what and how one might account for the essentially contested observation that the growing diffusion of information and communications technologies at work have not improved the productivity of firms as measured by official statistics. For example, is the productivity paradox in the field of ICT a signal that mirrors a more global signal that displays a secular decline in productivity gains? Distinctive research cultures and networks have grown up around the notion of the productivity paradox; networks that do not communicate with each other and pursue their own strategies in examining the issue of the productivity payoff of modern information and communication technologies. These points have been elaborated in the proceedings of a recent OECD conference, The Social Sciences at a Turning Point?, and particularly in the contribution of Langenhove (1999).

The variety of research and accounts of the productivity paradox exemplify the growing and deepening division of labor in social science and its essentially contested nature. For some observers, the productivity paradox does not exist in reality. The productivity puzzle is a measurement construct or indicative of a mismeasurement of outputs that conceals real gains that are made (cp. Quinn, 1996; Diewert and Fox, 1997). But even if the puzzle should exist, the magnitude of the problem is small upon first examination since investments into computers form a relatively minor part of all capital input. For others although the paradox is real its represents but a transitory

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3 Castell's (1996:78) expresses the suspicion that the poor validity of the economic statistics might be responsible for the productivity puzzle and therefore may not even be real: "It may well be that a significant proportion of the mysterious productivity slowdown results from a growing inadequacy of economic statistics to capture movements of the new informational economy, precisely because of the broad scope of its transformations under the impact of information technology and related organizational changes." However, he does not indicate how one might be able to specifically "heal" the deficiencies of the current statistical regime.
phase not unlike the productivity lag produced by the transition to technological systems in the past such as the diffusion of electric power. And as in the case for other learning processes, it takes a protracted period of time before the economic benefits show up (cp. David, 1990; Petit and Soete, 1997; Davenport, 1997). Still other observers see the productivity paradox not as a gap that reflects economic realities. Its persistence is rather an indicator of intellectual or theoretical deficits in economic discourse (cp. Jorgenson, 1997). 4 Last but not least, some economists have signaled that the danger has passed and that the productivity paradox disappeared by 1991 (e.g. Brynjolfsson and Hitt, 1996; Sichel, 1999).

Sociologists and scholars from other disciplines who have paid attention to the issue of the productivity paradox have attempted to explain (de-aggregate) the paradox in a great variety of ways. In particular, they have tried to identify various social and organizational mechanisms that undercut or stretch out the potential productivity payoffs from ICTs in firms. Attewell (1994:48) suggests that productivity payoffs from investments in information technology may result from a series of trade-offs within firms at both the individual as well as collective level. For example, the “potential benefits of the technology may be channeled into alternative directions—either doing the original work more efficiently (productivity enhancing) or doing a different kind of activity or the same activity more often.” Pinsonneault (1998) has pointed to the differential patterns of association between the usage of information technologies and the nature of managerial work in different firms.

Employing Information and Communication Technologies

I would like to frame the issue of the productivity paradox in a radically different manner leaving neoclassical conceptions of rational economic conduct and of work behind. Perhaps the most fundamental yet unexamined assumption of the essentially contested accounts of the productivity paradox is the idea that the deployment of information and communication technologies entirely follows the logic of all economic behavior. Investments into tangible and intangible capital is motivated up front and primarily driven by the desire to enhance the profitability, competitiveness, and productivity of firms that decide to embark on such investments. There is no reason to doubt that such motives play a key role in investment behavior and that expectations of senior managers who invest in information technologies are that robust gains in productivity will be commensurate with

4 Jorgenson (1997:4) sees the productivity paradox as arising from the prevailing identification of “productivity growth with technological change”. Technological change and productivity gains are distinct. Productivity growth is but a minor component to growth. Technological change occurs, he argues, as a result of investments; economic growth also is due to capital investment. Capital investments can be categorized into investments into tangible assets, human and intellectual capital. The purchase of computers constitutes an investment into tangible assets. But the key concept in this context, intellectual capital remains but a vague and perhaps even more irritating to economists an unmeasured and unmeasurable concept.
the cost of modern ITCs. In the absence of such expectations it makes no sense to speak of a productivity puzzle. The question therefore becomes whether conventional economic motives and forces are the exclusive or even main reason for the heavy commitment of funds into ICTs. It is not only the possible lack of any visible and robust payoffs in terms of the orthodox motives of economic conduct or the kinds of everyday frustrations that accompany the use of information technologies (cp. Landauer, 1995) and often speedy obsolescence of skills that generate doubt about the persisting force or viability of such normative dependencies and asymmetries in the relation between the employment of new technologies, the nature of the world of work, production processes and profits.

In a knowledge-based economy other, and as I want to stress, additional processes are at work that account for the transformation of the work place and the world of work and therefore for the growing and employment of information and communication technologies even though global and/or local empirical signals as far as the payoff, as measured by conventional economic indicators, are difficult if not impossible to obtain. If it can be shown that such additional reasons also and increasingly account for the widespread marshalling of ITCs at work, it follows that the productivity paradox assuming that it is real can be evaluated in a very different light and has to say the least, multiple causes. The main weakness of neoclassical perspectives of work is the failure to attend to the social context of work. Key qualitative features of the world of work such as job satisfaction, social networks, management style and the quality of the products and services, are left out. In fact, “social context and social connections envelop the world of work” (Tilly and Tilly, 1998:13). In knowledge-intensive economies, I would want to maintain the relevant social context of work acquires even greater significance for the competitiveness of a firm, its innovative capacity and profitability. Differences in social context that should not be simply stripped away are of particular importance as one explores differences in the world of work across time. I want to explore the possibility that the productivity paradox constitutes a global signal for a dramatic transformation of the economy generally and the world of work characteristic of that economy in particular.

The loss of agency or the world of work in industrial society

5 My cautious observations about a gradual rather than an abrupt, decisive transformation of the economy of industrial society into a knowledge-based economy that fully displaces and renders obsolete the earlier economic formations resonate with Werner Sombart’s ([1927] 2000: ) reflections about erroneous expectations that economic systems can change in dramatic even violent ways: “All those opinions are mistaken which expect a violent upset of the existing economic constitution and a sudden change of the bases of economic life. This opinion too misjudges the nature of economic development, which always proceeds in the form of a gradual, ‘organic’ reshaping of existing conditions. A new economy ‘grows’, like a plant, or an animal. Forcible interventions may well destroy, but they build nothing. All previous history confirms the accuracy of this observation.”
The meaning associated with the term “labor” or “work” today is a product of industrial society. The dominant perspective of industrial society sees its technological regime closely linked to mass production systems, intensive productivity gains and the capacity to produce an abundance of goods as well as hierarchical forms of work organization and control. In the end, the (capitalist) logic always contributes to a massive alienation of workers, or as argued more recently, to an extensive de-skilling of the work force (e.g. Braverman, 1974; Gill, 1985). Although the lament about the de-skilling of the individual worker often is associated with the work of Harry Braverman, there are numerous predecessors. The predecessors include Helmut Schelsky. Schelsky (1954:20) asserts: “The closer we approach automation, though without ever fully reaching it, the greater the degree to which work becomes spiritless and stressful and the lesser the extent to which it requires interest in technical matters and skills or, even initiative of any sort.” Even earlier, in an essay entitled “The machine, the worker and the engineer,” Robert K. Merton (1947:80) refers to numerous social implications of labor-saving technology including the “enforced obsolescence of skills” and the loss of status as well as self-image that accompanies the de-skilling process of workers.

Merton assumes, as does the later de-skilling thesis, that the obsolescence of skills is irreversible. In light of the kind of production technology used, a compensating process presumably is not considered likely. The increasing employment of laborsaving technology produces the enforced obsolescence of skills among the workers. The social and psychological consequences of discarding acquired skills are mainly connected to the demotion of status (including the possible loss of the public identity of the job) and the destruction of the positive self-image of the worker, stemming from the once confident use of those skills. Merton (1947:80) anticipates an “alienation of workers from their job and the importance of wages as the chief symbol of social status are both furthered by the absence of asocial meaning attributable to the task. Increased specialization of production leads inescapably to a greater need for predictability of work behavior and, therefore, for increased discipline in the workplace.”

Massive power asymmetries in work organizations exist and the struggle for power is a zero-sum game. The ability of management to preserve and exercise domination is assured by virtue of holding on to or monopolizing knowledge about the conceptions on which production is based. Knowledge is located in specialized departments only. That is, the successful separation of execution and conception is the key to the control and the persistent degradation of the worker. Employees are mere executioners of tightly prescribed and increasingly fragmented tasks. The new version of the oppression thesis also generalizes about the work place without any credit to the imagination of the worker and specific conditions of work. Any resistance by employees that may be evident is merely in response to the oppressive control exercised by management. The thesis minimizes,

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6 It is worth noting that the meaning of the term’s work and labor now are used almost interchangeably. Labor in contrast to work may or was seen as based in circumstances in another person’s direction and control while work refers to what directly maintain one’s existence and is carried with relative autonomy.
consistent with Marx’s portrait of the labor process in capitalist society, the active ability of the worker to affect his or her working conditions. Technological developments simply reproduce the domination of capital over labor, often on a more repressive scale contributing to what Merton (1947:80) as indicated called an “enforced obsolescence of skills.” The depressing conclusion therefore can only be that work in the modern factory continues to be trivialized and that the “Taylorist philosophy is in many cases still being carried over to the era of microelectronics systems in manufacturing” (Gill, 1985:87). 7

Agency or the world of work in knowledge societies

It is by no means a novel observation that the social organization of work is changing and that the nature of the change has to do with what originally constituted, at least according to Marx and Engels, the condition for the possibility of the division of labor in society: the separation of labor into manual and intellectual labor (cf. Marx and Engels, [1932] 1960:28). Although physical labor and the expenditure of human energy in such tasks will not disappear entirely in knowledge societies, the dominant trend is away from manual labor to intellectual labor, and therefore to a corresponding increase in the role knowledge and learning play in shaping work, the ability to work and continued employment.

More recently, fascination with the constraining features of the social and material conditions which allegedly give rise to persistent hierarchy and isolation of the individual in the workplace, have been somewhat replaced by equally strong convictions about a new division of labor a new technology and new logics of organizing production that are described as permissive forms of domination (cf. Sabel, 1991:24; Hirst and Zeitlin, 1991; Sabel, 1995). The social distribution of power in the workplace may, as a result, no longer constitute a zero-sum game. These views are linked in turn to the distinction between the declining regime of mass manufacturing (“Fordism”) and the growing system of “flexible specialization” in production (cf. Piore and Sabel, 1984). As a result, technology is not seen as an essentially dehumanizing force but as one that enables or at least holds the promise of participation in the affairs of work. This in turn moves the notion of the growing condition for the possibility and importance of “subjectivized conduct of work” (Böhle, 1998:241) into the center of the analysis of the world of work.

The extensive use of technology does displace least-skilled work. For example, in a case study of the impact of computer-aided design on skills in U.S. aircraft and automobile manufacturing industry, Salzman (1989:260) finds that “the technology is relatively effective at... automating the least skilled work (the simplest connections in this case) leaving only the most skilled aspects for the designer.” Whether one should really be concerned

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7 Several authors have adopted the term “neo-Fordism” to describe the convergence of information technology and the managerial orientation of “Fordism” (cp. Massey, 1984; also Jaeger and Ernste, 1989: ).

8 A brief description of the emergence, nature and recent challenges to mass production in the automobile industry in North America and Europe described as Fordism may be found in Dankbaar (1995).
about such a change is a different matter. It certainly does not represent an instance of de-skilling. Computer aided design is not the “Trojan Horse of Taylorism” but its opposite, a counter-tendency to a Taylorist organization of work.

In the sphere of work, the profound anxieties about the destructive ways of technology are now replaced by animated discussions about freedoms from control. The vocabulary of intentionality and agency or collaboration and working together, thought to be obsolete, reappears in discussions of work, production and the social organization of work (e.g. Cavestro, 1989). Paradoxically, the technology once feared to have become self-regulating now (de-)regulates itself in the sense of negating regulation.

The distribution and utilization (deployment) of knowledge is not necessarily as one-sided as accounts have stressed the ease with which superiors in modern factories and offices manufacture consent and impose control. Knowledge as a capacity for action is not easily monopolized. Nor is knowledge a one-dimensional and static phenomenon. Knowledge is contingent, contestable, multiple and shifting. Subordinates do not always need to control as much knowledge as their superiors perhaps do in distinct instances or precisely the same forms9 in order to effectively resist and override controls imposed by management and owners.

If it is indeed the case that modern technology enlarges the capacity to act not only among management, but also among its employees, it would follow that employment regimes that rely on command, control and coercion to ensure performance constitute an increasingly ineffective basis for the coordination of production. Social relations in the workplace could therefore be best shaped by what Max Weber ([1913] 1981) has called Einverständnishandeln, or social action that derives from mutual trust. Social relations in the workplace that are based on trust may displace those linked to its opposite, namely distrust. Distrust is, of course, at the heart of the social organization of work that relies on the principles developed at the beginning of the century by Frederick W. Taylor or Henry Ford. Mutual expectations that invoke trust rather than distrust may not only be more typical in organizations that require considerable flexibility, initiative, and autonomy (cf. Heisig and Littek, 1995), but could also be a “rational” response by management to enlarged capacities of action, including the employees’ abilities to resist.

However, in spite of the discovery of growing role of agency in the world of work in knowledge societies, another leading assumption about the labor market that remains unaffected to this day are that skills the individual is expected to bring to the world of work are those which the preexisting system of work demands and imposes. In an even more general sense, Pierre Bourdieu (1973:72) describes the assumptions (or laws as he calls it) that govern such asymmetric social relations as the tendency of structures “to reproduce themselves by producing agents endowed with the system of predispositions which is capable of engendering practices adapted to the structures and thereby contributing to the reproduction of the structures” of

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9 The so-called scientific management principles that Taylor developed were, for example, designed to limit and restrict the exceptional control workers often had with respect to forms of knowledge that related directly to technical and performance-related knowledge on the shop floor.
labor. In other words, it is a widely shared assumption is that growth of the number of knowledge workers in the modern economy occurs in response to the requirements the world of work especially its modern technological regime imposes. And as long as one holds on to this assumption the productivity puzzle becomes an even more severe enigma. The share of highly paid and highly skilled workers grows yet a consummate payoff is not in sight.

The growth of knowledge workers

Peter Drucker presents a much more surprising and perhaps plausible hypothesis about the reasons for the growth of the number of knowledge workers in modern society. He suggests that the stimulus for the increasing demand for knowledge-based work has to do less with more difficult and complex job skills, changing technological regimes, the growing complexity and specialization of the economy or enhanced functional steering and coordination needs. The growth of knowledge workers has more to do with the substantial extension in the working life span of individuals and the enhanced knowledge with which individuals come to the labor market in the first place. The observed shift toward knowledge-based jobs should not be seen to result from changing occupational preference and choices of new entrants to the labor market, although changes in preferences of job content and ways of achieving job satisfaction certainly are part of the transformation. In the United States for example full scale labor force entry of adult college trained baby boomers coupled with steady retirements of less-educated persons who reached working age during the 1930s and 1940s resulted in quantum increases in the average educational endowment of the labor force. Prime working age participants with four years or more of college training rose by 64 percent to 25.5 million during the 1980s and those with one to three years rose by 58 percent to 20.8 million (Wetzel, 1995:60).

If we follow Drucker, it is not so much the demand for labor and particular skills as the result of more complex and exacting jobs, but the supply of highly skilled labor that underlies the transformation of the world of work. More specifically the “direct cause of the upgrading of the jobs is … the upgrading of the educational level of the entrant into the labor force” (Drucker, 1968:279). 10 Whether the transformation of work in a world of knowledge work by knowledge workers constitutes a historically unique development or will continue to be major attribute of work in the future is

10 Among the surprising even amazing properties of the transformation of the labor market is that the American economy was able to "satisfy the expectations of all these people with long years of schooling…. As a result of the change in supply, we now have to create genuine knowledge jobs, whether the work itself demands it or not. For a true knowledge job is the only way to make highly schooled people productive...That the knowledge worker came first and knowledge work second - that indeed knowledge work is still largely to come—is a historical accident. From now on, we can expect increasing emphasis on work based on knowledge, and especially skills based on knowledge" (Drucker, 1968:285).
an open question. It is likely once the world of work has been thoroughly transformed that “demand” attributes will become more prominent attributes influencing the texture of the labor market. 11

The much more common perspective is that rapid diffusion of information and communication technologies has altered the production process and the delivery of services and that the employment structure has changed as a result. The new technologies increase the demand for highly skilled workers. Put more technically, most observations “model changes in workforce skill as a function of changes in industry capital intensity and industry-level investment in computer equipment” (Doms, Dunne and Troske, 1997: 254).

At the present time, there are no empirical studies, to my knowledge, that explicitly examine the relationships stipulated by Drucker. However, two recent intensively discussed and researched economic issues that arrive at largely unanticipated results may offer at least an indirect measure of confirmation of the Drucker’s thesis. First, a large volume of empirical studies of the US labor market triggered by the observation that income inequalities between well-paid and more poorly paid jobs have risen in recent years considerably, prompted economist to ask what developments may be responsible for these income trends. In particular, the relations between technological change, skill level and income have been studied. The primary assumption examined in these studies is that the increasing polarization of the labor market may be linked technical changes that in turn cause firms to hire more highly skilled labor (Gottschalk, 1997). Second, there are research designs directed toward analyses of the causes of the “productivity puzzle” that could be relevant.

For the researchers concerned with the growing polarization of income levels, two explanations are of particular interest. First of all, the growing differentiation of pay for skilled and lesser skilled labor may be caused by technological change. More precisely, the increase in demand for skilled labor and a growing proportion of skilled workers in the labor force is seen as induced by technical developments (Johnson, 1997). The second explanation has a family resemblance to the first account: the demand for technologically more sophisticated products and services has triggered a growing need for a highly skilled work force (cf. Bernard and Jensen, 1997:5). In short, changes that can be attributed in one way or the other to demand induced forces provoke a change in the balance of skilled to lesser skilled workers. And, as a result, these transformations in the nature of

11 John Kenneth Galbraith dismisses Drucker’s argument out of hand. He affirms the orthodox view about the relation between education and the labour market and considers Drucker’s perspective as evidence for the typical self-complacency and pretension of the educator misreading the real power balance in society in the process. Galbraith (1967: 238) suggests it is the “vanity of educators that they shape the educational system to their preferred image. They may not be without influence but the decisive force is the economic system. What the educator believes is latitude is usually latitude to respond to economic need.” In other words, Galbraith insists that the demand-side explanation generally favored by economists (as well as employers, educators and educational policy makers one should add) primarily accounts for the increase in skilled work.
demand activate and accelerate a growing inequality in incomes by skill levels.

In a broadly based cross-sectional empirical study at the level of individual manufacturing firms and using individual rather than aggregate data for the American economy, Doms, Dunne and Troske (1997) for example have examined the relationship between technology use, the education, occupation and wages of the employees in the manufacturing sector. As the data reproduced in Table 1 show, one is able to conclude that there is a growing covariance between the degree of technology use in firms, that is to say, the progress made in automating both the development and the production process, and the educational level of the employees. The conclusion therefore not only is that “skilled workers and advanced manufacturing technologies are complements” but also that the proportion of employees “in skilled occupations rises significantly with the number of technologies employed” (Doms, Dunne and Troske, 1997: 261, 263; see also Berman, Bound and Geliches, 1994) as well as the proportion of employees not directly active in the production process. A variety of controls confirm these findings. In addition, the authors report that employees in firms with extensive technology deployment earn higher wages and salaries.

The cross-sectional data however cannot offer an answer to questions about the timing of the observed marked substitution in favor of skilled labor in the manufacturing firms that are technology intensive. As a result, Doms, Dunne and Troske attempt to extend their analysis by relating the utilization or adoption of different technologies over time in these firms to changes in the different variables such as the wage levels, the proportion of employees not directly involved in the production process etc. Aside from methodological problems such a procedure may have as the result of the absence of valid longitudinal data, the overall result of their efforts to operationalize “technology adoption” is that “technology adoption is relatively uncorrelated with the changes in the nonproduction labor share, workers wages, or labor productivity” (Doms, Dunne and Troske, 1997: 277).

One possible “explanation” for the “negative” finding would be that the firms the author included in their study already employed or hired a large number of highly skilled employees prior to the adoption of new technological means. Thus, “if plants that adopt technologies have more skilled workforces prior to adoption, then we would expect that the pre-adoption wages and labor productivity should be correlated with future technology use” (Doms, Dunne and Troske, 1997:277). The results of their study once more are far from transparent. The author sum up the relation they are able to document as follows: “Plants that adopt a large number of

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12 The degree of technology intensity in individual firms was measured by the authors of the study by counting the number of technical processes or devices such as computer driven machines, robots and so on found in the plants (see Doms, Dunne und Troske, 1997: 287-288 for a detailed description of the different processes and devices).

13 In concrete terms, “the positive relationship between technology use and the percent of skilled workers is primarily due to a dramatic increase in the percent of scientists and engineers in the most technologically advanced plants” (Doms, Dunne and Troske, 1997:263).
new technologies have more skilled workers both pre- and postadoption” (Doms, Dunne and Troske, 1997:279). As Drucker assumes, one cannot preclude the possibility in other words that highly skilled employees force the modernization of their work places, in the first instance. It is likely therefore that the supply of skilled workers rather than the demand for workers with such skills that constitutes the motor of the rapid and radical transformation of the world of work. 14

A further but confirmation of Drucker’s thesis of a supply induced transformation of the world of work is aggregate data about the growing “skill level” of the population in most OECD countries. According to Johnson (1997:42), the relative skill supply measured as a ratio in the population of high school to college equivalency in the US has risen from .105 in 1940 to .496 in 1993. In five decades, the proportion of the population with a college education has increased fivefold. The increase of college educated labor is particularly strong in 1970s, reflecting a growing proportion of college students in the latter half of the sixties. It would be far too simple to suggest that the tremendous increase in the collective skill level of the work force simply occurred in direct response to market forces. Although individuals will respond to perceived market opportunities, the fit not only in terms of time between perceived market opportunities and education could hardly be expected to be exceptionally close. Too many other factors and forces impinge upon those choices and after many years of education perhaps result in “higher skill levels.”

In the modern economy, knowledge is the most important resource. As a result the production of knowledge and learning are the most significant processes in the knowledge society. Public policy in turn must be attuned and attend to these features of modern society (cf. Alexander, 1997). 15

Knowledge societies are changing with rapid speed. For this reason alone it is not sensible to adopt a strict demand or storage model of the kinds of skills and competencies that schools, universities and other educational institutions ought to deliver. Future occupational requirements of the world of work and their obsolescence are difficult if not impossible to anticipate or predict. The close even intimate linkage between prior curriculum and subsequent occupational tasks that is often expected and demanded cannot

14 In response to the question of the reasons for the immense growth of the service sector in recent decades, Landauer without referring to Drucker, also offers an account that stresses factors induced by the demand for jobs. Thus, new jobs were needed, so new services were invented. Many new or expanded services depended on computers: a plethora of investment instruments -- complex new mutual funds and trading schemes, a deluge of new insurance policies and options, a myriad of debit and credit cards, dozens of new kinds of bank accounts and novel banking services offered from widely dispersed branches and machines, multitudes of new medical techniques and therapies, fast food restaurants, fast copy stores, fully filled planes with frequent flyer plans, mom and pop mail order firms, direct marketing, PC maintenance, and so forth (Landauer, 1995:74-75).

15 Concerns that the quality of the available jobs may not be compatible with rising educational levels (Harman, 1978:209) correspond to exactly the opposite perspective, namely that the quality of the world of work is primarily driven by the nature of the demand.
be accomplished. A decisive feature of the labor market in knowledge societies is its unpredictability and the insecurities that the substance of educational needs can be determined by future features of the labor market and the world of work. The storage model – schools and universities supply those skills and competencies that can be immediately utilized at work – has to be replaced by a model that couples work and education under conditions of uncertainty and agency.

Outlook

Economic theories and research that deal with the productivity paradox for the most part continue to be linked in a rather close fashion to the production process of industrial society, its organization and outcomes. Moreover, the lingua franca of economic theories remains tied to an imagery which displays agents as inflexible creatures entangled in single-purpose, dedicated structures of purposes which imposes its rhythm, often over generations, on passive individuals and groups. As long as economic organizations and regimes such as the labor market are reconstructed as inflexible and largely one-dimensional, the gradients of inequality will be steep and the effects of its logic long lasting. Discourse on the role of economic agents will be concerned with the coercion, that is, the constraints, the vulnerability and effective impotence of individuals and groups in the face of power exercised by the powerful. But new realities require a new language of the world of work. The new language should, in contrast, stress agency, malleability, flexibility, multi-purpose resources, volatility, heterogeneity etc. of social structures and the extent to which individuals and social groups as embedded in their relationships with others have the capacity to employ and transform these structures, once the generalized vulnerability to the forces of the conventional logic of economic conduct has been reduced to a significant degree. The condition for the possibility of greater and more broadly based agency is knowledgeability or a bundle of more widely accessible social competencies and their impact on social structures of inequality accelerating chances for actors to re-fashion social constructions.
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Table 1: Technology Use, Education, Wages and Occupation at U.S. Manufacturing Plants, 1988-1990

<table>
<thead>
<tr>
<th>Precision-craft</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>of workers with at least</td>
<td></td>
</tr>
<tr>
<td>a college degree</td>
<td>(1)</td>
</tr>
<tr>
<td>of nonproduction workers with at</td>
<td></td>
</tr>
<tr>
<td>least a college degree</td>
<td>(2)</td>
</tr>
<tr>
<td>production workers with at least</td>
<td>(3)</td>
</tr>
<tr>
<td>some college</td>
<td></td>
</tr>
<tr>
<td>of workers in managerial,</td>
<td>(5)</td>
</tr>
<tr>
<td>scientific, engineering, or</td>
<td></td>
</tr>
<tr>
<td>of nonproduction workers</td>
<td>(6)</td>
</tr>
<tr>
<td>of total wages paid to</td>
<td></td>
</tr>
<tr>
<td>nonproduction workers</td>
<td></td>
</tr>
<tr>
<td>Plants using less than 4</td>
<td>9.4</td>
</tr>
<tr>
<td>technologies</td>
<td>24.1</td>
</tr>
<tr>
<td>Plants using 4 to 6 technologies</td>
<td>12.2</td>
</tr>
<tr>
<td>Plants using 7 to 8 technologies</td>
<td>14.0</td>
</tr>
<tr>
<td>Plants using 9 to 10 technologies</td>
<td>16.2</td>
</tr>
<tr>
<td>Plants using 11 to 13 technologies</td>
<td>15.2</td>
</tr>
<tr>
<td>Plants using more than 13</td>
<td>33.1</td>
</tr>
<tr>
<td>technologies</td>
<td></td>
</tr>
<tr>
<td>Full sample</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>27.9</td>
</tr>
<tr>
<td></td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>40.5</td>
</tr>
<tr>
<td></td>
<td>47.2</td>
</tr>
</tbody>
</table>

*There are 3251 workers in the sample that work in plants using less than 4 technologies, 4690 (4-6 technologies), 6403 (7-8), 5914 (9-10), 5931 (11-13) and 7844 workers in plants using more than 13 technologies. Source: Doms, Dunne, and Troske 1997: 262.*