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Value Creation in the Late Twentieth Century: The Rise of the Knowledge Worker

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'This continual progression of knowledge and experience' says Babbage, 'is our great power.' This progression, this social progress belongs [to] and *is* exploited by capital.

BABBAGE, *quoted by* MARX, Grundrisse

The increasing importance of computers, software, and electronics-related technologies is only the most prominent feature of an all-encompassing re-alignment of the cutting edge of capitalism to emphasize information and knowledge creation. The expenditure of human energy in physical activity is becoming less and less important as a source of value.' As a result, business must try to increase profits by harnessing the enormous value-added that results from the creativity of human beings working in groups. This value is created, not only by researchers and designers, but also by technicians and even operators at manufacturing sites or, more properly, at 'systemofacture' sites (Hoffman and Kaplinsky 1988).

This chapter builds on earlier work by authors such as Morris-Suzuki (1984) in an effort to untangle current thinking about the nature of value-creation in the late twentieth century With the collapse of Fordism, previously accepted norms of the nature of work and the source of value are being fundamentally disrupted. These changes, which are extremely complicated and global, are puzzling to the managers and theoreticians of capitalism. At the same time, they have provoked remarkably little interest on what remains of the Left. However, if there is to be a new radical agenda, it will once again have to return to the nature of production or, put somewhat differently, the question of value creation.

Knowledge and Value Creation

The new emphasis on creating knowledge leads to a new view of capitalist value creation, since in several dimensions the emphasis on knowledge overthrows conventional notions of work. Curiously, these dimensions are not new but are rather the culmination of the logic of the capitalist system as a whole. In the *Grundrisse* Marx outlined the dimensions of this change:

> In this transformation, it is neither the direct human labour he himself performs, nor the time during which he works, but rather the appropriations of his own general productive power, his understanding of nature and his mastery over it by virtue of his presence as a social body – it is, in a word, the development of the social individual which appears as the great foundation-stone of production and of wealth. (Marx 1973, 705)

It is the ability of human beings to use their intellectual capabilities to create new solutions that is the transformative force of the contemporary period. Such knowledge creation is a profoundly social activity, one that is the result of both individual effort and social interaction. The inventive event almost by definition is not confined to working hours but rather can occur at any time. Marx captured the essence of this capacity, which is at the core of capitalist mode of production, but which has remained cloaked by fetishistic thinking of work as a fundamentally physical process.

Despite the profound nature of this transformation there has been little consideration of its implications. The most notable exception is Morris-Suzuki (1984), who began an explicitly Marxist strand of theorizing about the implications of the current capitalist restructuring. Her argument that capitalism is entering an era that will be characterized by 'perpetual innovation' suggests that the forces and relations of production are creating an era of accelerated change and are simultaneously being reorganized to meet the needs of this era. These changes have already undermined the Fordist institutions that provided the general framework for US social relations. A similar constellation of forces and relations is also driving a reorganization of the global spatial division of labor (for more on this, see Sayer and Walker 1992).

Management theorists are now preoccupied with trying to understand how organizations must be reorganized to facilitate the accelerated creation of social knowledge and its application to products (Drucker 1993). The increased centrality of knowledge is leading to theoretical chaos in conventional economics and business studies, which are based on a scarcity model. Business theoreticians are actively attempting to conceptualize these changes and provide a roadmap to help corporations to plot strategies in the current conjuncture. The parallels between their concepts and what Marx called the 'group social mind' is uncanny. Inherent in the terms being proposed is the recognition of the importance of the intellectual and social components of the work process. Hence the proliferation of a new business lexicon in an attempt to encompass these changes – for example, learning-by-doing, learning-by-using, learning-from-customers, expeditionary marketing and the factory as a laboratory [2]

For the most part, the Left dismisses these discussions as ways to assert more control and extract more value from workers – merely postmodern versions of management speed-up strategies. This is, however, a profound underestimation of the aims of capital. These new concepts and metaphors are part of attempts to 'reengineer' the role and activities of workers into a new logic of accumulation. Of course, in the most fundamental sense this new logic is no different from any earlier ones. However, more than ever it is explicitly based upon the power of humans (as part of social groups) to create value by constantly reconfiguring the work process and/ or developing entirely new products to create new needs.

There is a social creation process for all products. Yet there are important differences between the knowledge value-added and the physical value-added. For example, pure knowledge goods such as software and databases can be possessed and enjoyed jointly by as many as make use of them. This is a fascinating capitalist creation because, as Thomas Jefferson argued, knowledge is not susceptible to exclusive property. Moreover, knowledge transmission is incomparably less expensive than its creation (David 1992). In effect, the consumption of knowledge is easily collectivized but is difficult to privatize. Capital has responded by trying to use the political arena to guarantee its private appropriation of socially produced knowledge.

The nature of physical production is also evolving in the direction Marx hypothesized. Marx conceptualized capitalism as a social relationship and argued that production would become increasingly socialized. Whereas the traditional craftsman worked as an individual, factory production depended on cooperation among workers. Thus, while Braverman (1974) lamented the deskilling of the individual worker, the increasing complexity of production means that workers as a class have greater collective skills than ever. This becomes even more apparent once one accepts that technicians, engineers and scientists are also workers (Marx 1973, 1040).[3] It is only this greater array of skills that allows the creation of ever more sophisticated and complicated technical artifacts.

Knowledge: The Critical Production Factor

The driving force in the economy has become knowledge creation, handling and application as the social production process becomes digitalized and brought 'on-line' with the increasing ability to reduce analog materials to a digital form as exponentially more computer power becomes available at essentially constant cost.4

Successful production has, of course, always been more than the simple sweating of labor power. In a sense, there is a resemblance here to Marx's distinction between relative and absolute surplus value. Capital can put enormous numbers of workers together in low-paid work in which mere muscle-power is exploited. However, the value generated by these workers pales in comparison to that created by knowledge workers who design a new software program or develop a new pharmaceutical.

Increasing computer power permits routine thinking such as adding columns of numbers to be replaced by the computer. This resembles the development of numerically controlled machine tools, which initially were not even able to fully replace human physical motions. However, these machine tools have evolved to the point where they can now perform routines that are not possible for humans. Similarly, the computer originally replaced functions humans could perform, such as simple repetitive calculations. However, its evolution has proceeded to *the point* at *which the computer now performs functions* humans could never perform. For example, large relational database programs provide the tools to analyze enormous quantities of data and discover statistical relations heretofore unknown. In some ways, rapid information-processing capabilities have made large databases metaphorical ore deposits to be mined. The compilation of these databases permits computers to sift through data from store scanners so management can immediately spot consumption trends and make strategic decisions to restock shelves or even adopt sales strategies targeted at specific stores associated with certain demographic characteristics. Using a wide area network, computers can be connected to automated warehouses that can operate on a 'lights-out' basis as robots stock and retrieve items. Previously, it was less expensive to use the brain and memory of a worker but the decreased cost of computing has permitted replacement of the clerical worker's routine knowledge by machines.

The changing role of the white-collar worker is matched by earlier and ongoing transformations of the factory that began with the application of inanimate energy to production and the reassignment of the work to machines. These developments reinforce Marx's observation that already in the 1860s workers were becoming machine minders. The machines required minding because it was still difficult to engineer feedback loops in machines that would enable them to self-adjust. From the usage of the word 'minding' we can see that machines had no minds and were apt to get into trouble without a person constantly monitoring them.

The increasing ability to characterize machine operation algorithmically and then to quickly process the enormous amount of information necessary to rigorously characterize object movements in time-space permits the removal of workers from machine minding and direct operations. Rapid advances in understanding how to process solid materials fuse electronic information-processing capability and mechanical engineering (Kodama 1991).5 These 'intelligent' machines are able to undertake production with far less human intervention. Due to improved sensor technology and increasingly uniform standardized tools, the machines can sense impending tool failure, report to a central computer, and replace the tool without human intervention. In essence, these machines can mind themselves.'

The linkage of machines to sophisticated electronics has transformed the economics of owning manufacturing machines. Whereas a machine previously was seen as an asset, it is now simply a tool that will rapidly become obsolete. Suppliers improve the electronics portion of machines so rapidly that newer models are significantly more productive than previous ones. Machining is thus rapidly becoming an extension of the electronics industry (Yamazaki 1994).

Such rapid change is not confined to traditional industries. A similar process is under way in printed circuit board component insertion. Component-insertion machines have been developed to reduce the role of human insertion. However, the rapidity of improvement in machines and components means that the previous models become obsolete and lose value rapidly (Kawai 1992). Moreover, whereas it had been possible for human beings to insert components manually, this is now impossible due to the small size of components and their increasing complexity.

As Marx (1977, 528) observed, moral depreciation of machines becomes an ever greater cost to the capitalist. Thus, the introduction of electronics has made machines more productive, but simultaneously, because of rapid technological change, has led to extremely rapid depredation. This places extraordinary pressure on factories to operate constantly, because value is lost to obsolescence every moment the machines are not in service.

The rapidity of price declines in computers has created a situation in which personal computer and workstation producers often cannot assemble and sell the systems before the system's value has decreased. To cope with this problem, increasing numbers of assemblers are reorganizing their global production networks. For example, computer logic boards are usually assembled in low-wage countries in Asia. These are then shipped to the US without central processing units (CPUs). The assemblers then add the CPUs in the US immediately before shipment to customers. The reason is that CPUs are decreasing in cost so quickly that in the two to three weeks it takes to ship the PC to the US the CPU may already have lost 5 to 10 percent of its value. As a result it is less expensive to do final assembly closer to the customer. If the CPU were inserted in Asia, the loss in value could be sufficient to eliminate the assembler's profit.'

The rapidity of this change is dramatically altering the nature of value creation. No longer is it possible to think of commodities simply as physical manifestations of value; it is not their physicality that loses value, but rather the knowledge embedded in the commodity that loses value in the marketplace. This rapid devaluation of commodities is spreading from the computer industry to many others as the information revolution/perpetual innovation economy continues to accelerate.

The Innovation Economy

With knowledge in its various manifestations as the increasing arbiter of value, innovation has become the key to securing a favorable location in the global capitalist system. As a result, product life-cycles are becoming shorter. Businesses have little choice except to rapidly innovate or risk being outflanked. An example of this accelerating pressure is Hewlett Packard. During the 1980s, 70 percent of HP's orders came from products less than three years old but in the 1990s 'that changed to be products less than two years old. The lifetime of a product simply [is getting] shorter and shorter' (Platt 1993,146). Whereas the obsolescence of industrial equipment was formerly measured in decades, the rapidity of change, especially in electronics, is now affecting all products. Previously, such change applied only to consumer items such as fashion goods, but it is now ubiquitous.

Technological advances in electronics are incessant and frequently dramatic. For example, in Winchester hard disk drives the areal density of information storage is increasing at 60 percent per year, and in semiconductors memory capacity doubles every other year, but in both industries prices remain roughly constant or even decline. Thus, the price per bit of information is decreasing exponentially. Moreover, lower prices mean that integrated circuitry in invading ever more products, and as memory capacity and the speed of information retrieval and processing increase, it becomes possible to digitize new activities. One observer describes the process thus:

> These fastest growing product [areas] are miniaturized systems built around embedded, often dedicated microprocessors (or microcontrollers) with embedded software for control and applications. They are multi-functional, combining computing functionality with communication, consumer with office, etc. ... They are also networkable, that is, their capabilities are significantly enhanced by being networked together into larger information systems ... Taken together these products define a new electronics industry segment. (Borrus 1993, 20)

Electronics is thus being driven not by discrete innovations, but rather by incessant waves of branching innovations that are generating a constantly proliferating range of products. Through this process new industry sectors are being created, separated and merged. The increased processing power and functionality of new products in turn permit new tasks to be undertaken by machines. These new capabilities rapidly become needs. For example, whereas an Internet link was formerly a luxury for engineers, scientists and a few computer buffs, in five years it has become a convenience and is rapidly becoming a necessity.

Software and Value Creation

Software exists, in a general sense, as any set of instructions that directs a machine to undertake a sequence of actions. Even a stamp mold for a metal-stamping machine can be considered a software program.' Software, then, can be conceived of as the instructions or knowledge that controls a set of activities. This lack of physicality gives software some characteristics of a service, while in other ways it resembles a commodity. Interestingly, software (like musical recordings) need only be produced once because reproduction is simple. This contrasts sharply with most other goods, which require significant quantities of capital and labor to produce more units and are consumed upon usage.

The character of software as the driving force in the innovation economy is important because it makes explicit the fact that it is the knowledge embedded in a commodity that creates its value. Moreover, this knowledge is expressed only in the commodity's strictly physical attributes. So, for example, the gears that control a watch have been replaced by quartz crystals and silicon circuitry. The lines and gates etched onto the silicon now contain the same objectified knowledge as did the metal gears. The preponderance of the value of the electronic watch is transferred to the integrated circuitry and the design-intensive user interface, the watch face and shape. This is also true in the case of personal computers. Here again the value is in the sophisticated integrated circuitry and the human interface that allows people to interact with it.

Packaged software is even more unusual in that its value has become completely dephysicalized and is nearly completely contained in the algorithms. The media on which the software is transported accounts for only a tiny portion of the total value. The software itself is merely a tool that can be loaded onto a computer to perform various activities such as setting type or calculating equations. But in contrast to tools, software has no physical components and cannot wear out. In essence, software operates forever.

But software, especially that not embodied in a physical product, is also unusual because it is so easily copied and distributed. This means that it is difficult to ensure that computer program usage will be synonymous with ownership. The capitalist produced the program to secure exchange value; however, for the user it is merely a use-value. The cost of copying the software for another user is nearly zero, and copying it does not harm the initial owner's use-values. Thus, for the software program seller there is the constant threat of copying – a serious undermining of the concept of scarcity.

Packaged software can also be thought of as merely a machine installed in a computer to process abstract symbols. But the software requires its users to learn how to use it. This means that the ability of software companies to capture value is related to our willingness to learn how to use their programs. For example, if a user can be convinced to adopt a word processing package, it is likely that the consumer will be locked into what Arthur (1988) has described as a path-dependent trajectory. This means that the consumer by investing in understanding and becoming proficient with a certain program will likely continue to use it or upgraded versions that have a similar human interface. From this perspective, in the aggregate the users have invested far more time in learning to use a software program than did the developers. In this sense, users have had more to do with making Microsoft Word successful than did Microsoft. The most impressive case of the control that results from this user-generated lock-in is the adherence by users to either the Microsoft Windows or the Apple Macintosh operating systems. The customer lock-in these two companies have achieved provides them with control over a range of other equipment purchases. John Sculley, former president of Apple Computer, observed this when he said, 'It's becoming apparent that the real cost is not the hardware or even the software. The real cost is teaching the user' (Stern 1989). For the users the lock-in operates to make them reluctant to change computer applications or operating systems.

Only gradually did companies become aware that controlling the consumer was the key to success in the new information economy. In effect, they could achieve success by attracting the (social) investment of consumers learning to use their product. This observation, combined with the intense competition, has prompted the software companies to bundle their products with new computers. To further this capture, sets of applications are being packaged into suites so as to exclude competitors from the consumer's hard disk.9

Software is not the only powerful new way to create value. Database creation is also becoming important. The collection and organization of data create a valuable tool for other users. As an example, a database of addresses of all software companies in the US assembled for scholarly purposes could simultaneously be a valuable marketing tool. Put somewhat more generally, what was formerly a scholarly activity now has a shadow existence as a possible commodity. Moreover, this transformation is not confined to databases. For example, Eric Olin Wright, a University of Wisconsin sociologist, created a set of social categories related to an individual's class location. It might be possible to use these to create marketing strategies, especially in politics. The increasing development of information processing and the growth in the importance of ideas thus provide new modalities for accumulation.

Intellectual Property in Think Work

Private property is a necessity for creating a commodity. Before we examine intellectual property, it is useful to examine the quintessential private property, land. Land privatization in various countries was crucial for building a working class and with it an industrial system. In England the Enclosure Acts were the vehicle for this privatization, which was accomplished through the use of force as well as legislation. However, three hundred years later what had been considered 'theft' is now considered natural. Even though in most of the capitalist world land is private, there are still social formations where private land-holding is unthinkable. For example, Native Americans still do not treat land as a commodity to be bought and sold.[10]

Land is a relatively unambiguous type of property because it has a physicality that allows it to be surveyed, measured and quantified. Furthermore, a physical barrier can be erected to prevent intruders from using it. More generally, 'material property has the feature that use by its owner excludes use by anyone else. Ideas, being nonmaterial, are nonexcludable. Thus, in the absence of government sanction, ideas have the character of public goods' (Evenson and Putnam 1987).

For Marx the central private property relationship in capitalism is, of course, the ownership of the means of production. Ownership of the means of production is what provides the capitalist with the right to claim the fruits of production, although products are, in fact, socially created. Here again, in contemporary society there is little objection to the fact that capital owns the results of manufacturing.

The institution of private property has not remained confined to physical goods. Rather, the status of property has gradually been extended to intellectual and social creations, the result of constant efforts by capital to extend and enlarge the scope of property rights. The most important of these extensions is to a heterogeneously diverse set of social 'rights' that are roughly grouped under the term 'intellectual property'. The concept of intellectual property extends across an entire spectrum of 'protections' for human creations, which include trademarks, patents for plant varieties and copyrights for integrated circuit masks.

The search for moral or other justifications for private property has a long history. Over the years bourgeois economists have developed (and abandoned) numerous justifications for granting intellectual property protection to inventors. The most enduring argument has been purely pragmatic: intellectual property rights encourage innovation. However, even this argument is not strongly supported by empirical research and is contradicted by a variety of studies (see, for example, Nelson 1990). In the semiconductor industry there is ample evidence that patent protection has actually not been of much importance (Risberg 1990, 249; Braun and Macdonald 1978).

The increasing strength of intellectual property and especially patent protection is that industrialists have had a continually growing financial interest in limiting access by others to inventions developed in their laboratories. The difficulties in enforcing property claims are obvious. For example, it is inexpensive to reproduce software or clone a known gene. This easy appropriability creates a major obstacle to success in recovering a return on investment for ideas or symbol-related objects. Thus, the power of the state is necessary to enforce intellectual property claims.

The legitimacy of intellectual property rights is fundamentally questionable because the innovator is treated as an individual, when invariably the impetus and knowledge underlying the innovation are drawn from the social stock of knowledge. This knowledge is part of the social milieu. Recent legal battles over copying the look-and-feel of graphical user interfaces in operating systems are interesting because almost all of these iconic interfaces have origins in the social milieu existing in Silicon Valley in the 1970s (Freiberger and Swaine 1984). For example, Apple Computer has sued repeatedly to try to prevent others from developing an interface that has the look-and-feel of the Apple Macintosh interface, even though the Macintosh was based upon ideas that were largely appropriated from the Xerox Palo Alto Research Laboratory. Apple plucked the ideas out of Xerox and other sources in Silicon Valley. These ideas were then developed and packaged in a form suitable for commodity production.

Intellectual property protection is being driven by the fact that it is increasingly the mental creations of thinking workers that is creating human value. However, this knowledge and creativity are very hard to contain within the boundaries of the firm. The response of US corporations as been to demand government protection for their products.

The Knowledge Factory

The previous sections examined the intellectual part of the production process. The knowledge theoretic framework forces a reconceptualization of the nature of productive activity. As Marx argued, IThe products of human industry] are organs of the human brain, created by the human hand; the power of knowledge objectified' (Marx 1973, 706).[11] The factory has been characterized from a variety of perspectives. As noted earlier, the factory is increasingly being conceptualized and managed as a learning environment (Fruin 1992; Kenney and Florida 1993; Adler and Cole 1993). There is increasing evidence that the world's best production facilities operate on such principles. The operation of the factory as more than just a facility for reproducing the blueprints of engineers was systematically developed by Japanese industry to ensure that the factory constantly improved products and processes. It is the understanding that the factory is a laboratory with workers capable of innovation that was the breakthrough. In other words, managers actively develop strategies for harnessing the fundamental human capability to transcend previous solutions and discover new solutions.

Japanese industry also emphasized the social or collective nature of work. The fundamental unit for all shopfloor activities, including innovation, is the team. As Cole (1989) and others have demonstrated, the core of continuous improvement is the harnessing of teams to develop solutions for problems. This is striking in its contrast to Taylorism/ Fordism, in which the work process was divided and subdivided into individual efforts. These 'individuals' were isolated and compartmentalized. The new capitalist production system combines the division of production into discrete routinized steps while simultaneously resocializing the workplace and consciously managing this socialness of the production process.

The factory that is to be operated like a laboratory requires that the production process must be conducted in a rigorously controlled environment.' As in a laboratory, where each step in the experiment must be rigorously characterized so that it is reproducible, the factory's operations require similar documentation. This allows parameters to be changed and the results strictly compared with previous activities. The concept of the factory-as-laboratory continues the argument that production is not only the application of human labor to the object, but more important, the imparting of human knowledge and capabilities to the product. Thus, as Marx pointed out, factory labor was the productive consumption of machinery – but this consumption can be made still more efficient. Whereas the traditional assembly line was built according to plan and then remained static until a new model was introduced, today's assembly line is constantly being improved by employing the intellectual capabilities of workers and technicians.'

A similar concept has been developed by Adler (1993) through a study of the Toyota system at the GM-Toyota joint-venture NUMMI plant in California. He concluded that standardization 'is not only a vehicle and a precondition for improvement but also a direct stimulus. Once workers have studied and refined their work procedures, problems with materials and equipment quickly rise to the surface.' It is only possible to experiment when all the parameters are controlled so strict comparisons can be made. In his brilliant work on automobile suppliers, Fujimoto (1994) observed that at each stage in the value chain humans imprint a product with human effort and creativity or information. The input is human knowledge and the output is congealed human information and knowledge. In effect, the consumer is purchasing the objectified information that the previous producers have imparted to the product. Fujimoto argues that the molds used for plastic injection molding or the stamps used for metal stamping should be conceived as software. The key to these molds is not the physical material from which they are made, but rather the human ingenuity and thought that is embodied in them. In effect, they imprint these ideas onto the raw material (metal or plastic) with which they are being used. These molds are thus knowledge-transfer tools.

The steel that Toyota purchases is really physical material imprinted with information." The various information media have a particular molecular structure and myriad other specifications. If the media specifications are not met (if, for example, the steel sheet has various flaws), then the possibility of a faulty transmission of the desired information increases. From this perspective a defect is a faulty communication. Thus, as the purity and exactness of dimensions of materials increases, their `message' becomes simpler and less subject to surprises.

In this environment, routine factory housekeeping is important. The traditional dirty US factory encouraged unplanned events or 'accidents', and injuries or defects were therefore constant occurrences. The longer and greater the noise or entropy remains in the system, the longer it has to affect/infect the factory operation. From an information theoretical perspective it means that the transmission of information and knowledge from the concept to the object will not be as true. Thus, a piece of trash left in an aisle at NUMMI is an indicator that though the plant is successful, it is still not ideal.

Some carelessness may be tolerable in an auto assembly plant, but not in semiconductor and LCD fabrication facilities. In these plants carelessness immediately affects the serviceability of the output. Not only is extreme cleanliness necessary, but even vibrations and other disruptions must be eliminated. In these fabrication facilities humans have no physical contact with the product but instead monitor and adjust the process through sensors and by reprogramming computers.

In the materials industries there are standard products and specialty products. The specialty products are made in smaller batches and are usually designed for specific purposes. These specialty products command higher prices than the commodity materials. This is because the specialty materials have more unique 'messages' or knowledge imprinted in them. Machines are similarly the purchase of human knowledge and capability objectified. The purchaser, whether consumer or industrialist, must then operate the machines in such a way as to make use of the machine's embedded knowledge. For the capitalist to accomplish this there are two necessities: first, the producer must have an end-product as a goal. Second, the machine operators must effectively transmit this goal to the product.'

With regard to the inputs, the purchasing capitalist wants incoming material to be rigorously characterized and entirely predictable. When there is no divergence from specifications, the inputs are no longer a source of risk or unexpected events. The production process runs smoothly and thus creates less entropy. As the process is more rigorously routinized and characterized, it becomes increasingly susceptible to robotization. Human decision-making is no longer needed at that node in the production process until the unexpected occurs. In effect, human order has been imposed on a part of the natural `order'.

In an environment where knowledge creation and commitment are crucial the nature of the wage relationship must also change. Currently, for US management the operative principle appears to be that employees are disposable factors of production. The question of why workers would be willing to create knowledge for a firm in an environment in which they are expendable is – or should be – an important conundrum for management. More likely, a viable solution to the current situation would be for workers to receive what Roobeek (1987) termed a 'reliability wage', paid to ensure worker involvement in the work process. As the production process becomes more automated, workers use ever more capital and any operation downtime becomes extremely costly because both the machines and the components are depreciating. In this situation, somewhat better pay may encourage worker participation in an innovative production process, and this may be less expensive than having undependable workers and rapid turnover.

Conclusion: The Global Innovation Economy

The changes in work and production outlined here have profound implications for those concerned with changing the capitalist system. The effort by business to integrate the workers into a laboratory-style production process is a new capital logic based on involvement and limited forms of worker autonomy. This means that traditional unions may find it difficult to resist the demands of capital. If workers can be made to feel responsible for the production process, old forms of resistance will be weakened, since workers may no longer see themselves in solidarity against management.

Those seeking to transform social institutions face some difficult questions: Is it progressive to push greater worker involvement and socialization of the production process, though this may be in capital's interest? Or would it be better to resist team work, greater involvement and the workers' use of their brains to make the production process ever more efficient? If current managerial thinking is realized on a large-scale, what are the implications for alternative perspectives? Implicit in this essay is the position that the current capitalist agenda, as expressed by the theoreticians of capital and prominent businessmen, is far more radical than that of most labor leaders in the developed countries.

Notes

1. Of course, physical labor will not disappear completely. There are still a number of production activities that do not require significant thinking, but rather are merely undertaking highly routinized activities. For example, in the garment and footwear industries much of the production process requires little intellectual input from the workers. These activities are increasingly being moved to areas with inexpensive labor.

2. Even during this monumental restructuring of the very way capitalism thinks about production, the Left is intent either upon defending old institutions or continuing its preoccupation with the culture and politics of race and ethnicity.

3. Marx observes this quite presciently when he writes: 'The real lever of the overall labour process is increasingly not the individual worker. Instead, labour-power socially combined and the various competing labour-powers which together form the entire production machine participate in very different ways in the immediate process of making commodities, or, more accurately in this context creating the product. Some work better with their hands, others with their heads, one as a manager, engineer, technologist, etc., the other as overseer, the third as manual laborer or even drudge. An ever increasing number of types of labour are included in the immediate concept of productive labour, and those who perform it are classed as productive workers, workers directly exploited by capital and subordinated to its process of production and expansion.'

4. The information theoretic also underlies the technology of genetic engineering (Kenney 1984; Yoxen 1983). The use of computers has been crucial to the development of biotechnology, especially in machines such as DNA sequencers.

5. For a discussion of some of the reasons for automation, see Noble 1984.

6. The entire field of machine sensing has not been adequately examined from a theoretical perspective. However, the ability of machines to receive, catalogue, process and 'act' on environmental inputs is a powerful branch of engineering. This allows machines to react to environmental change in limited but increasingly sophisticated ways (Imai 1994).

7. The market is so rapidly evolving that the current price leader, Packard Bell, has eschewed final assembly in Asia and currently does final assembly in Sacramento, California.

8. I am indebted to Takahiro Fujimoto for making this point.

9. The value for the consumer is that these applications are tailored to operate together.

10. In some countries private property in land is not nearly as secure as in the US. For example, in Mexico there are often peasant occupations of land. These occupations

were one of the flash points in the Zapatista revolts in Chiapas.

11. For a further discussion of these concepts, see Kenney and Florida (1993).

12. Freeman (1985) first referred to the factory as a laboratory. This idea was later developed more fully in Kenney and Florida (1993).

13. This has progressive and regressive aspects. The worker is exploited more thoroughly and simultaneously is more fully integrated into the logic of capital. Conversely, the forces of production are increased, efficiency is improved and the labor-time embodied in each commodity decreased.

14. This point has strange parallels with McLuhan's argument that the medium is the message!

15. The importance of design, once again, reinforces Marx's observation of the importance of the 'social' – a good design appeals to the consumer and thus allows the value embedded in the product to be realized.

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