

The Growth of Complexity and the Knowledge Economy

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ABSTRACT

This article considers the some of the consequences of the ongoing growth of economic complexity, variety and specialisation, in both products and processes, in modern capitalism. The drivers of this process are the widening of markets, the growth of competition, and the search for new product innovations and market niches. Under the assumption that such trends continue into the future, a number of imaginable developments are considered. Among these is the possibility of increasing inequality of income between skilled workers and the unskilled underclass. A second issue concerns the transformation of industrial relations in the more advanced sectors of the economy, as a result of the growing specialisation of knowledge. A third and related topic is the general difficulty of information accreditation in an increasingly complex economy. In turn, this connects to the fourth issue concerning the temporal and spatial delimitation of work itself.

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This paper considers a tendency that is common to all forms of capitalism and has become increasingly manifest in the twentieth century. This is a tendency towards increasing socio-economic complexity and greater specialisation of skills.¹ After considering some of the basic forces behind this process, the paper goes on to consider the possible implications of increasing specialisation and complexity in advanced capitalist economies. The aim is not to make rigid predictions but to explore some developmental scenarios on the basis that these increases are ongoing.

One of the issues considered is the possibility of increasing inequality of income between skilled workers and an unskilled underclass. A second issue concerns the transformation of industrial and employment relations in the more advanced sectors of the economy, as a result of the growing specialisation of knowledge. A third and related topic is the general difficulty of information accreditation in an increasingly complex economy. This has implications for the role of state and the functioning of democracy. The fourth issue concerns the temporal and spatial delimitation of work itself. Without any in-depth discussion, some policy issues will be briefly highlighted.

It must be emphasised that the above is a very broad-brush account of possible future developments in a knowledge-intensive economy. Not only is there no inevitability about them, they can themselves be expressed and sustained within a number of quite different institutional frameworks.

1. The drivers of capitalist change

Capitalism is a social formation in which markets and commodity production are pervasive, including capital markets and labour markets. In terms of structural reformation as well as output growth, capitalism is the most dynamic economic system in human history. The driving logic of capitalism involves the expansion and diversification of multiple markets. As capitalism expands, fresh and established corporations seek ever-new opportunities for trade and gain. As competition intensifies within particular markets, corporations innovate and diversify their products, in an unceasing creation of new market niches in the drive for profit (Chamberlin, 1933; Rueschemeyer, 1986).

The growth of capitalism is neither monotonic nor inexorable, but as long as the system is expanding then it involves this increasing diversification of processes and products. The competitive pursuit of profit pressures firms to invest in new technology or new skills. In this competitive quest for innovation, the frontiers of science and technology are advanced,

¹ The following arguments are largely derived and slightly modified from Hodgson (1999).

leading to new fields of knowledge and enquiry. New and varied organisational forms are devised to increase productivity and to manage an exponentially expanding number of products and processes.

Accordingly, there is a long-run tendency in capitalist economic systems towards greater complexity, driven by powerful economic forces and leading to the widening of markets and greater product diversification. The definition of complexity is notoriously problematic (Rosser, 1999) but we can make an outline attempt. Complexity is not the same as variety (Saviotti, 1996). Variety refers to a diversity of types. Complexity exists only when such variety exists within a structured system. In short, complexity is *interconnected* variety. By this definition, increasing economic complexity means a growing diversity of interactions between human beings, and between people and their technology. As complexity increases, more and more 'bits' of information are required to specify interactions and changes within the structured system.

Even under capitalism, increasing complexity is not inevitable. For instance, it can be interrupted by political, economic or environmental catastrophes. However, it is reasonable to explore a scenario of increasing complexity, with its possible implications for the twenty-first century.

Some have suggested that the growth of modern systems of communication and the development of new techniques of analysis may help us overcome the challenges of an increasingly complex world. In many respects these technological developments may help. But they cannot make the problems of complexity go away. Innovation and change mean that there will always be new problems of analysis and the potential for cognitive overload. Furthermore, the nature and dispersion of knowledge is such that there will always be difficulties in dealing with tacit, context specific, and idiosyncratic knowledge and skills. The new information technology can help us deal with some, but not all, aspects of growing complexity, and it cannot neutralise its underlying forces.

For the above reasons, it is appropriate to consider possible scenarios involving increasing socio-economic complexity. *The core supposition is that in core sectors of the economy, the processes of production and their products are becoming more complex and sophisticated. All social activities, in consumption as well as production, are infused with greater complexity.*

2. Changing levels of knowledge and skill

The next step is to consider the impact of growing complexity on the level, diversity and distribution of skills within the economy. The growth of socio-economic complexity does not automatically imply increasing levels of skill or knowledge on behalf of workers or consumers. It is possible that automation and artificial intelligence might facilitate a growing diversity of products and processes, without comparable increases in average levels of skill.

In the first volume of *Capital*, Karl Marx (1976, pp. 549, 788) argued that the growth of machine production, with increasingly sophisticated machines, would lead to a deskilling of the workforce. Harry Braverman (1974) later developed this idea in a famous and highly influential work. Many writers, of both science and fiction, have considered a technologically sophisticated economy of the future in which human innovation and learning have stagnated. In the place of humans, largely artificially intelligent machines would administer the varied processes of production. Technology would be used extensively, not to enhance human creative powers, but by as much as possible to replace them. Some economic growth would

occur, but it would not result from substantial human learning or innovation. It would emanate largely from a growing output of physical goods and automated services.

This brave new world of menial jobs, unemployment and robots is consistent with the supposition of increasing complexity, but it does not entail any general increases in knowledge and skill. This scenario of general deskilling is possible, but not inevitable. It is not clear why any re-tasked worker will *necessarily* be placed in jobs involving a lower level of skill. After all, the simpler and more mechanical types of skill are often the ones more readily replaced by machines. Based on a one-sided theoretical argument and inadequate empirical evidence, the Marx-Braverman prediction has failed to materialise. In reality, the evidence indicates that levels of workplace skill have increased rather than decreased in the twentieth century, at least in the developed countries (Ashton and Green, 1996). Historical evidence also suggests that machines can enhance skills rather than reduce them (Goldin and Katz, 1996).

However, while the march of complexity within capitalism does not always lead to deskilling, it does not universally nor inexorably lead to upskilling either. More diverse and multifaceted outcomes are likely. Within several developed countries, including the United States and Britain, the last two decades of the twentieth century depict a pattern of development in which skill levels for a substantial proportion of the population have increased, while at the same time there is the growth of an equally significant underclass of relatively unskilled workers, who are either unemployed, or in comparatively insecure and low-paid jobs.

In specific institutional contexts, the outcome of increasing complexity within capitalism is likely to be an increasing inequality of skill levels, with an elite of highly trained and qualified skilled workers at one extreme, and a substantial, unqualified and excluded underclass at the other. The precarious position of the underclass is further undermined by the development of the global division of labour and by competition from firms in developing countries who are mass-producing goods and services at much lower costs.

The result of this dispersion of skills within developed countries could be a growing inequality in income, wealth and influence within society. However, this outcome too is by no means inevitable. While some countries – notably the United States and Britain – have witnessed a significant increase in inequality of income since the 1970s, other countries – notably Germany – have resisted this trend. The explanation for the German exception lies probably in a greater emphasis on intermediate training and apprenticeships, and mechanisms to train and relocate workers of relatively lower skill (Nickell and Bell, 1996). Capitalism does not have a singular logic. Different institutional frameworks can yield significantly different outcomes.

With this important caveat, it is possible to focus on the processes that can lead to upskilling among a substantial segment of the population. As complexity increases, still higher levels of skill and adaptability are required of many, especially for those coping with innovations, those dealing with new and unpredictable phenomena, or those making judgements with respect to complex relationships or large amounts of varied information.

This increase in skill levels has two main dimensions. There is the first the level of each particular skill or set of skills, and second the degree of specialisation between skills. The level of each skill can be measured roughly in various ways, including by an estimation of the

amount of time it takes to train, on the average, to reach that skill (Hodgson, 1999, ch. 10).² The degree of specialisation is a reflection of the number of distinct professions or occupations, according to some appropriate definition of those terms.

For the twenty-first century, it is reasonable to consider a scenario involving not only increasing complexity but also increasing skill levels and an increasing degree of specialisation for a substantial segment of the population. Of course, this does not rule out the possibility that there is also a substantial underclass of unskilled and unemployed.

As complexity grows within the economic system, it is likely that there will be demands for higher and higher levels of skill in particular specialisms. Some skills and professions will become obsolete. A skills escalator can emerge, where frequent retraining is required to relocate in the more skilled and more highly remunerative jobs. Retraining is easier and less risky for those that already have acquired high skill levels. Most types of skill involve transferable as well as non-transferable elements. Workers with some general skills and past achievements are more likely to warrant and afford the investment in training. In contrast, unskilled workers lack many transferable skills, and training has a more risky benefit, even if its expenses can be met. Without remedial policies and subsidies, some may never get on to the skills escalator. A further widening of inequality can result. This makes the issue of widening of access to education, and the expansion of further and higher education, a policy priority for governments.

3. Increasing specialisation and the transformation of industrial relations

As argued above, increasing complexity is likely to be associated with rising skill levels for a segment of the population. It is also likely to lead to a higher and higher degree of specialisation of knowledge, activities and professions. The increasing diversity of products and tasks, along with the growing sophistication of knowledge, is likely to be paralleled an increasing variety of skills and occupations. New specialisms emerge to deal with the multiplying facets of the increasingly complex socio-economic system. At the same time, for each individual worker, it becomes more difficult and costly to transfer readily from one specialism to another. Workers with advanced and transferable skills, and with enhanced capacities to rapidly learn and adapt, are more and more at a premium. We have a scenario of enhanced skills and growing knowledge intensity.

Unlike other commodities, one of the peculiarities of the buying and selling of information is that its nature is not known until after it is purchased (Nelson, 1959; Arrow, 1962). This problem can also exist with the hiring of skilled and specialised labour power. With skilled and specialised workers, it is less likely that the employers or managers will share the same skills and be able to evaluate the worker in depth. The persons interviewing the potential employees for the job may not be versed in the particular skills being sought, and will thus be unable to make a fully-informed judgement of their abilities. The hirers often do not know what they have hired.

Difficulties of this kind do not arise simply at the selection and appointment of an employee. They remain during the subsequent period of employment. By definition, employment involves potential control and supervision by others. However, as Peter Drucker

² The problem of measurement of skills is discussed in more detail in OECD (1996), Stasz (2001) and Elias and McKnight (2001).

(1993, p. 107) put it: 'the organization is increasingly composed of specialists, each of whom knows more about his or her own speciality than anybody else in the organization.' This creates a supervisory problem. If the worker has the highly specific and idiosyncratic skills that are needed in a complex economy, then the extent of proficient supervision and control of the worker depends also on the possession of relevant capabilities by the supervisor. As a result of increasing complexity and specialisation, in an increasing number of cases these supervisory capabilities will be lacking. Close and highly evaluative supervision, based on a hierarchy of command, will be less viable, simply because the nominal supervisors will not know the best way of doing the job, or even the precise purpose of the specialist job itself. The specialist worker will know better.

The shift from physical to intellectual work also compounds the problem. Even though managers lacked complete knowledge of the idiosyncratic skills required in action-centred work, at least they could observe the physical activity and its output, and make semi-informed judgements concerning the efficiency and aptitude of the worker. In contrast, with intellectual skills – involving symbolic manipulation, selection of appropriate information and thoughtful judgement – meaningful supervision is less viable (Zuboff, 1988). We can readily observe manual work, but it is impossible to see what is going on in someone's head. 'Knowledge employees cannot, in effect, be supervised' (Drucker, 1993, p. 65).

At the same time, developments in information technology make sophisticated surveillance of the workforce possible. However, such surveillance would mainly concern the location and visible engagement of the workers, not the workings of the mind, nor the evaluation of the details of knowledge-intensive work. If managers cannot know what their workers know, then neither can a video- or computer based monitoring system. Furthermore, the installation of surveillance systems is likely to undermine the culture of trust and co-operation which is necessary for the full development of the knowledge economy. As work becomes more complex and knowledge-intensive then these problems are compounded.

In a scenario of rising skills and increasing specialisation, detailed direction concerning what to do and how to do it, will become less viable. Without finding evaluators with similar expertise, the possibility of assessing the worker's capacities and performance will be limited. Detailed and effective supervision is thwarted by problems of complexity. In any case, only a small portion of what people do on a job can be monitored effectively and in detail. As complexity and specialisation increase, managers are less likely to have the requisite skills to monitor tasks effectively, and this scrutinisable portion becomes a smaller and smaller fraction of the whole.

Consequently, in the employment contract, the key characteristic of detailed managerial control is increasingly bounded and impaired as a result of the growing complexity of the production process and the increasing specialisation of labour.

The organisational response to this decline in the potential for direct supervision of work is to encourage internal commitment and self-motivation. These replace authority as the primary spur to productive activity. The firm uses 'mission statements' and develops its own cohesive moral community. The ethic of obligation replaces the direct command. As Shoshana Zuboff (1988, p. 291) put it: 'internal commitment and motivation replace authority as the primary bond between the individual and the task.'

To some degree, problems associated with a degree of complexity and specialisation existed in early industrial capitalism, even when manual workers were operating looms, digging ditches or sharpening pins. Workers have always possessed some tacit and other skills beyond the reach of managerial comprehension. But in the modern, complex, knowledge-

intensive economies the predicament has become immensely more compounded and severe. In particular, what were formerly regarded as exclusively managerial, administrative or organisational capabilities are more and more being expected of other workers, not nominally described as managers. The old distinctions between the conception of a task and its execution, as elaborated in the 'scientific management' of Frederick Winslow Taylor (1911), are breaking down. In practice, the division between the two is increasingly difficult to enforce or sustain.

The upshot of this development are that matters of organisational restructuring and employee participation in some decision-making are placed high on the corporate and statutory policy agenda. The meaning of the employment contract is stretched to the limit, creating normative and legal tensions that may suggest its radical reformulation into something quite different. Insofar as these developments spread, this bodes the end of the classical employment relationship and the transformation of the modern corporation, and the evolution of a quite different economic system.

Clearly, any such developments will be facilitated by a culture of trust, but restricted by any effort of detailed, managerial surveillance. The age-old, supervisory habits of management may die hard. Alternative social mechanisms of accountability and trust are precarious and difficult to develop. But the development of the knowledge economy places them at the top of the agenda.

4. Problems of information accreditation

Increasing complexity and specialisation are likely to be associated with similarly increasing amounts of information being communicated. With a huge growth of relevant and accessible information, there are important problems of *selection* of relevant information and of the *accreditation* of the selected information.

The problem of information accreditation has become particularly relevant on the electronic media. With the reduction in publication costs and the growth in number of books and journals, the problem has intensified in more traditional media as well. A rapidly expanding amount of information is available, but its quality and reliability is often open to question. Until quite recently, the filtering and accreditation of information was maintained largely by universities, libraries and a few commercial publishers, each keen to select the most important and reputable items, and to protect its own academic and institutional reputation. By contrast, in the last few years, the explosion in scale of the electronic media, and the growth in the number of academic journals and publishing institutions, has made the verification and accreditation of information all the more difficult. It is not enough to find the information somewhere within the enormous electronic and paper haystack. The information cannot be relied upon unless it stems from some reliable authority, or its origins are verified.

The problem of information overload faced by any decision-maker have now reached acute proportions. It is simply impossible to analyse or make use of all the relevant information that is available. Unavoidably, all methods of dealing with these problems involve selection criteria which are both normative and cursory. Whether we use our own judgement, or that of a sophisticated computer program, the use of relatively superficial criteria is unavoidable. In a situation of complexity and information overload, it is not possible to scrutinise all information fully. As the information explosion continues, greater use will be made of information screening agencies and systems of selecting appropriate information and knowledge, involving institutional certification and the testimonials of experts. These are the

unavoidably imperfect means by which we attempt an inevitably semi-informed judgement of the value of the knowledge that we have yet to assimilate, and could no more than partially assimilate in principle.

Faced with an increasing choice of complex goods and services for sale, the consumer faces a related problem. To cope with the abundance of choice and lack of appropriate technical information, reliance is made on brand name reputation. In this case the private corporation becomes the accreditor of quality, with all the attendant problems and dangers in this solution.

But the processes of selection and accreditation face the problem of infinite upward regress: who accredits the accreditors? A hierarchy of evaluating and accrediting agencies may emerge, but some institution has to act as accreditor of last resort. This is a necessary but a dangerous solution. The state may be suited to take the place at the top, as the ultimate quality assurer. However, this solution is only viable if the state has, and is seen to have, both competence and legitimacy. Failing the existence of these qualities, there is the danger of totalitarian control and consequent abuse of the information but this ultimate assuring institution. On the other hand, in the absence of adequate institutions by which information can be accredited, there is a danger of degeneration into a semi-anarchy of competing claims with questionable credentials. The dilemma between institutional power and degenerative anarchy is unavoidable.

Arguably, the state could play the role of accreditor of last resort but only on the basis of its own openness towards information and its full, democratic legitimacy. Furthermore, there should be a system of checks and balances, involving appraisals of the quality assurance procedures and the promotion of supplementary agencies of accreditation. Multiple accrediting and advising institutions, perhaps both public and private, are required.

5. The temporal and spatial delimitation of work

Charles Handy (1984) has argued that the 'gathered organisation' – where all skills are possessed by the firm on the basis of employment contracts, typically organised together in specific localities – will be gradually replaced by the 'contractual organisation', relying heavily on subcontracting and contracts for services, often with people working from home or from other dispersed locations. However, there are compensating and remaining advantages for the continuance of the employment contract. The relative security of the employment contract, compared with self-employment, encourages workers to remain with the firm and facilitates teamwork. Some teamwork requires extensive and long term face-to-face interaction with other workers.

Nevertheless, the development of the internet or other telecommunications has made it possible for much work to be done at home, away from the nominal workplace. The result is a breakdown of the territorial division between home and work. In historical terms, this territorial division is in fact quite recent. Up until the early phases of the industrial revolution, much work was done in or near the home. It was the rise of the modern factory system – initially becoming widespread in Britain in the nineteenth century – that first separated the spheres of work and recreation for a large number of citizens. These boundaries may not endure. Not only is it possible for a substantial amount of knowledge-intensive work to be done at home, cheaper travel and the rise of the global economy have widened the sphere of leisure, and extended the ties of immediate family to around the world. Both work and recreation have become more global, and this trend is likely to continue. The local, territorial confinements of work, leisure and family may become a thing of the past.

These geographical and other developments have important temporal implications. We have considered the increasing role of specialist and idiosyncratic knowledge, the loosening of managerial authority, and the decline of the 'gathered organisation' in one locality. Crucially, as a result, the stipulation in the employment contract of a number of hours to be worked loses much of its operational significance and meaning. Even if she remains formally and legally an employee, the knowledge worker may require periods of contemplation, reading, research or study that cannot always be confined to official office hours. Indeed, scheduled hours spent of the office can themselves assume a ritualistic vacuity. Work will be taken home, and performed for hours or days in a domestic, rather than a supervised, environment. Leisure activity may become just as important for mental recuperation than it has for physical recuperation in the past. All these considerations make the concept of 'hours worked' less and less operational and meaningful. The boundary between work and leisure becomes blurred, making a temporally bounded contract of 'employment' an anomaly.

Further, the specialist and idiosyncratic nature of work makes detailed regulation or supervision of defined periods of knowledge work difficult or impossible. As has already become common in many professional and managerial positions, employment contracts do not stipulate a minimum or guideline number of hours to be worked. Instead, the tasks required in the job are vaguely and broadly specified.

These developments bring dangers as well as positive possibilities. As organisations develop their culture of employee commitment, productivity may be enhanced but new problems arise. The nature of knowledge-intensive work, the growth of an ethic of corporate obligation, and the difficulty of regulating work by specifying a fixed number of hours, bring the concomitant risks of overwork, resulting from social pressure, or even from an encultured to work itself.

By its nature, knowledge work means a shift from time-keeping to normative control, permitting indefinite extension and intensification. Today, overworked knowledge workers are prevalent in both the West and Japan. Their existence has enormous implications for the viability of the family and the community, and for health and social security policies in particular. The roots of this problem lie partly in the social mechanisms of enculturation that inculcate dedicated commitment to the complex problems of the organisation. The fact that knowledge work is not so readily delimited to fixed periods of time, and can be extended to the home and periods of former recreation, is also a cause of the difficulty. The problem of the knowledge intensive society is not simply the extension of access to the means of acquisition and use of knowledge. It is also to protect the knowledge worker from overwork.

6. Concluding remarks

For developed countries keen to sustain economic growth and to diminish unemployment, education-centred economic policies have a special and additional significance today. In the last two decades of the twentieth century there has been rapid economic growth in a number of developing countries. New technologies have taken root and there have been substantial advances in levels of skill. This has led to the situation where a huge global workforce in the developing world can now take on, at much lower wage costs, much of the manufacturing work formerly confined to the developed countries. The developed world now imports cheap but sophisticated manufactured goods and computer software or hardware from India or East Asia. Accordingly, in the West there has been a dramatic loss in employment opportunities for workers in manufacturing and elsewhere.

In developed countries and elsewhere, the acquisition of alternative, viable skills, for which there is sufficient local demand at higher wage costs, is necessary to reduce this unemployment. Given the institutional and cultural conditions of the developed world, it is not possible to compete with the newly industrialised countries in terms of lower costs. Instead, the strategy must be to concentrate on knowledge-intensive, high quality, goods and services. In pursuit of this approach the developed West has no acceptable alternative but to invest massively and continuously in education and training.

The increasing relative importance of the knowledge worker has important potential implications for the distribution of income in the future, as it has had in the past. Income inequality has widened in many countries since the 1970s, most markedly in Britain and the United States. While institutional, political and other changes have clearly affected the distribution of income, there is strong evidence that rising skill differentials, and rising relative wages for skilled and experienced workers, are a major force behind the change (Gottschalk, 1997; Johnson, 1997; Topel, 1997; Wood, 1994).

A problem is to break the link between growing knowledge intensity, on the one hand, and growing pecuniary and social inequality, on the other. Whatever complementary measures are deployed, the only substantial and enduring strategy must involve heavy investment in education and learning, to widen access to knowledge and to increase the relative and absolute supply of skilled and educated workers. In the face of rapid and dramatic global and technological changes, massive increases in effective expenditure on education and training are required to reduce both unemployment and inequality. Countries that have travelled more than others down this road, particularly Germany, have not witnessed such a significant increase in income inequality since the 1970s, and have been more able to train and relocate workers of relatively lower skill (OECD, 1993). We can learn many lessons from international comparisons of this type. One of them is that the logic of globalisation and the learning economy implies no single model for national success.

It is not simply the 'amount' of education and learning that is important, but its quality, access and distribution. Real knowledge is not distributed more widely simply by improving access to the internet, for example. Knowledge and learning work at different levels, combining both the general and the specific, and the tacit and the codifiable. The recent German experience emphasises the importance of widening the distribution among the population of detailed, technical skills. Many of these skills are tacit, and require on-the-site training. In addition it is necessary to enhance flexible and transferable skills. Many of these involve capabilities of a more abstract and conceptual nature. There is little value, for instance, in educating a workforce simply in the use of one particular technology, when any such technology is increasingly likely to become obsolete in a short period of time. To face the challenges of the future, people do not simply need to learn. They need to learn how to learn.

Furthermore, the purpose of education and learning is not simply to enhance the skills of people at work. In an ever-more complex economy and society, knowledge is required to act effectively as a consumer and a citizen. Expert knowledge is required, and at the highest level this is inevitably confined to the specialists. But no expert is infallible. There is the unavoidable problem of scrutiny and accreditation. In a democratic society the citizen must also play a major, if not ultimate, part in this process.

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