Prometheus, Vol. 19, No. 2, 2001

The Drive to Codify: Implications for the Knowledge-based Economy[1]

JOANNE ROBERTS

ABSTRACT *This paper critically explores the forces driving the codification of knowledge, together with the implications of codification for the evolution of the knowledge-based economy. It is argued that tacit knowledge is neglected in the drive to codify with important consequences for the process of knowledge creation and innovation. The drive to codify knowledge is briefly considered in the context of higher education and then through the practice of knowledge management within firms. The paper is exploratory in nature and seeks to outline policy concerns and directions for further research.*

Keywords: codified knowledge, tacit knowledge, knowledge-based economy, information and communication technologies, higher education, knowledge management.

Introduction

The ability to create, disseminate and apply knowledge efficiently is now central to competitiveness at both firm and national level. The economies of the advanced industrialised countries are increasingly referred to as knowledge-based or knowledge-driven economies.[2] The ability to transfer knowledge between economic agents is essential for its efficient use. However, many difficulties arise in relation to the market exchange of knowledge. The nature of knowledge, particularly the degree to which it may be codified, influences the ease with which it may be transferred between economic agents and the extent to which it may be protected through the establishment of intellectual property rights (IPRs). Consequently, the commercial creation and use of knowledge encourages the process of codification. Furthermore, the codification of knowledge has been promoted in recent years by the expanding capacities of information and communication technologies (ICTs) to assist in the accumulation, storage, processing and transmission of information. As a result, the current period is witnessing a strong drive to codify knowledge, leading to the neglect of tacit knowledge.[3] This paper critically explores the forces behind efforts to codify knowledge, together with the implications of this drive for the evolution of the knowledge-based economy.

Prometheus ISSN 0810-9028 print/ISSN 1470-1030 online © 2001 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/08109020110050003

An appreciation of the forces driving the codification of knowledge, together with the consequences of such codification, is essential for those concerned with the development of the knowledge-based economy, including policy-makers, business managers and academics. The benefits arising from the codification of knowledge must be carefully assessed and weighed against the neglect of tacit knowledge from both an economic and a social perspective. The long-term consequences of codification, including path dependence, are assessed here in terms of their impact on creativity and innovation generally.[4] It is argued that the codification of knowledge favours procedural thinking and creativity whilst also reducing ambiguity and uncertainty. Intuitive thinking and serendipitous creativity, which often occur in ambiguous and uncertain circumstances, are consequently neglected.

The paper begins with an examination of the nature of knowledge. The mechanisms through which knowledge may be exchanged between economic agents are then considered. This is followed by an examination of the forces driving the codification of knowledge, including economic and technological factors. The drive to codify knowledge is then briefly explored, first in the context of higher education and secondly through the practice of knowledge management within firms. This is followed by a discussion of the implications of the drive to codify knowledge for the development of the knowledge-based economy. The paper concludes by briefly outlining policy concerns and directions for further research.

Knowledge: Codified and Tacit

The emergence of the knowledge-based economy has stimulated research into knowledge in the context of economic activity, particularly its acquisition through learning and innovation.[5] This section similarly explores knowledge from an economic perspective. The complex nature of knowledge is considered through an examination of its dynamic qualities and its connection to a specific social and cultural context. Moreover, particular attention is given to the distinction between tacit and codified knowledge. An understanding of the nature of knowledge is essential if the drive to codify knowledge, and its implications, are to be fully appreciated.

In microeconomic analysis, knowledge, like information, is characterised as a public good since it is non-excludable and non-rival, and its production is characterised by high levels of indivisibility. This view of knowledge is challenged by recent developments of the Schumpeterian and Marshallian approaches, which stress the distinction between knowledge and information.[6] It is this latter view that is adopted here. Consequently, it is useful to begin by elaborating on definitions of knowledge, information and data.[7] *Data* are defined as a series of observations, measurements, or facts in the form of numbers, words, sounds and/or images. Data have no meaning but provide the raw material from which information is produced. *Information* is defined as data that have been arranged into a meaningful pattern. Information must relate to a context to have meaning.[8] In relation to information, *knowledge* is defined as the application and productive use of information. However, knowledge is more complex than this limited definition suggests.

Knowledge is distinct from information; indeed, it is more than information, since it involves an awareness or understanding gained through experience,

familiarity or learning. At a personal level, knowledge requires a relation between the 'knowing self' and the external world. Knowing is an active process that is mediated, situated, provisional, pragmatic and contested.[9] Furthermore, in some instances and respects, knowledge may be individually centred, while in others it may be collectively held.[10] Compared with information, knowledge involves a much wider process that involves cognitive structures that can assimilate information and put it into a wider context, allowing actions to be undertaken.[11]

Connected to the distinction between knowledge and information is that between tacit or implicit knowledge and codified or explicit knowledge. Knowledge is codified if it is recorded or transmitted in the form of symbols (e.g. writing or drawings) or embodied in a tangible form (e.g. machinery or tools). Through the process of codification, knowledge is reduced to information that can be transformed into knowledge by those individuals who have access to the appropriate code or framework of analysis. For the individual, it is necessary to make an initial irreversible investment to acquire the relevant code.[12] In a sense, 'knowledge is a retrieval structure: the agents possessing a certain type of knowledge can retrieve both information based on this knowledge and other, similar, pieces of knowledge'.[13] Importantly, such a retrieval structure may be made up of both codified and tacit knowledge.

Tacit knowledge is non-codified knowledge that is acquired via the informal take-up of learning behaviour and procedures;[14] it is often referred to as know-how. In their study of organisational knowledge, Nonaka and Takeuchi identify two dimensions of tacit knowledge.[15] First, there is the technical dimension encompassing skills or crafts. Secondly, there is the cognitive dimension consisting of schemata, mental models, and beliefs that shape the way individuals perceive the world around them.

Importantly, tacit knowing consists of knowledge that is indeterminate in the sense that its content cannot be explicitly stated. Polanyi demonstrates this point in relation to the possession of a skill:

> If I know how to ride a bicycle or how to swim, this does not mean that I can tell how I manage to keep my balance on a bicycle, or keep afloat when swimming. I may not have the slightest idea of how I do this, or even an entirely wrong or grossly imperfect idea of it, and yet go on cycling or swimming merrily. Nor can it be said that I know how to bicycle or swim and yet do *not* know how to coordinate the complex pattern of muscular acts by which I do my cycling or swimming. I both know how to carry out these performances as a whole and also know how to carry out the elementary acts which constitute them, though I cannot tell what these acts are. This is due to the fact that I am only subsidiarily aware of these things and our subsidiary awareness of a thing *may not suffice to make it identifiable* (original emphasis).[16]

Consequently, an important characteristic of tacit knowledge is that it cannot be articulated and is therefore uncodifiable. Cowan *et al.* make a useful distinction between articulable knowledge that is codified and that that remains uncodified.[17] Uncodified articulable knowledge is often assumed to be tacit, although it is clearly distinct from tacit knowledge because it is codifiable. The codification of articulable knowledge depends on the economic incentives to codify.

The distinction between tacit and codified knowledge is an important one, as is the relationship between the two types of knowledge. Knowledge is rarely

completely tacit or completely codified; usually a piece of knowledge can be placed somewhere in the range between completely tacit and completely codified.[18] Moreover, Polanyi argues that '[w]hile tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is *either tacit* or *rooted in tacit knowledge*. A *wholly* explicit knowledge is unthinkable' (original emphasis).[19]

The relationship between tacit and codified knowledge is complex and contributes to the dynamic nature of knowledge.[20] Nonaka and Takeuchi, elaborating on their idea of knowledge conversion in the context of the organisation, stress the mutual complementary nature of tacit and explicit knowledge, arguing that they 'interact with and interchange into each other in the creative activities of human beings'.[21] Their dynamic model of knowledge creation 'is anchored to a critical assumption that human knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge'. Moreover, knowledge conversion 'is a "social" process *between* individuals and not confined *within* an individual' (original emphasis). Knowledge transfer through socialisation consequently contributes to the creation of new knowledge.

Lundvall and Johnson support the view of knowledge as embedded in the social context and recognise that important elements of tacit knowledge are collective rather than individual.[22] Indeed, Lave and Wenger argue that a community of practice, which they define as 'a system of relationships between people, activities, and the world; developing with time, and in relation to other tangential and overlapping communities of practice' is an intrinsic condition of the existence of knowledge.[23] Knowledge, especially tacit knowledge, is embedded in a social and cultural context. However, codified knowledge is also context dependent, in the sense that it depends on codes that are usually context specific.

This brief review of the nature of knowledge has highlighted the distinction between codified and tacit knowledge and the relationship between the two. Furthermore, the importance of the social and cultural context for both the transfer and creation of knowledge has been noted. The drive to codify knowledge is in part explained by the ease with which codified knowledge may be transferred between economic agents across time and space. It is then to the process of knowledge transfer that attention now turns.

Knowledge Transfer

Knowledge transfer occurs when knowledge is diffused from the individual to the group and beyond. Much knowledge, for example, is transferred through social and cultural exchanges. Knowledge is transferred through processes of socialisation, education and learning. Knowledge may be purposefully transferred, or it may be transferred as an outcome of other unrelated activity. Organisations and institutions have a central role in the transfer of knowledge. In the economic environment, firms and markets, together with the legal and commercial institutional arrangements within which they operate, are central to the process of knowledge transfer. Indeed, firms can be viewed as repositories of knowledge that effect the transfer of knowledge through the activities of management, and personnel more generally, as well as through the establishment of routines.[24]

Codified knowledge, with the appropriate contractual arrangements, may be transferred across time and space, embodied in a tangible form as blueprints or

patents, in machinery, as part of licence and franchise agreements or trade between agents. However, if a body of knowledge contains a significant tacit element, the transfer of the codified part alone may fail to facilitate the successful transfer of knowledge.[25] There are, then, tacit elements of knowledge that can be transferred successfully only through a process of demonstration facilitated through face-to-face contact between the transmitter and receiver.[26] Hence, the transfer of tacit knowledge over distance requires the movement of people, without which tacit knowledge must be discovered independently.[27] Over time, tacit knowledge is passed from one generation to another through apprenticeship-type learning. It is, though, important to recognise that the successful transfer of some tacit knowledge may require the presence of a very particular aptitude on the part of the recipient without which such knowledge cannot be transferred.[28] When certain tasks become redundant, tacit knowledge is lost at the level of the individual, the organisation or the community. If required at some point in the future, it must be rediscovered or reinvented.

The extent to which knowledge may be easily transferred depends on the degree to which the codification process successfully captures the essence of the knowledge to be transferred. However, the codification of knowledge also has implications for its appropriability. According to Saviotti, the appropriability of knowledge depends on: (a) the degree of codification; (b) the fraction of the population of agents knowing the code; and (c) the distribution of knowledge among the agents who are potential users of knowledge. In general, as knowledge matures it becomes more codified, more evenly distributed among agents, and less appropriable.[29] Consequently, if appropriability is to be sustained as knowledge becomes increasingly codified, it is necessary to protect it through various mechanisms.

The establishment of formal IPRs through, for example, patents, copyrights and trademarks, is one method of protecting codified knowledge. The current IPR regime is largely the product of an industrial era in which the protection of tangible artefacts rather than intangibles was of central concern. Nowadays, traditional IPR mechanisms may not provide comprehensive protection even when knowledge is embodied in a tangible form. Therefore, in some circumstances, the best way to protect key strategic knowledge may be to keep it within the boundaries of the firm, in the form of trade secrets, by restricting access to the relevant code, or indeed, by avoiding the formal codification of knowledge. In some instances, the tacit nature of strategically important knowledge may be of advantage to the firm in the sense that it is less likely than codified knowledge to be disseminated beyond the boundaries of the firm. However, non-codified knowledge can be transferred to competitors through the labour market. Firms seek to avoid the loss of strategic knowledge in this way through the combination of codification and the implementation of a strategy to protect core knowledge. Clearly, codification can both aid and hinder the protection of knowledge. Retaining strategically important knowledge, whether tacit or codified, within the boundaries of the firm is a key challenge for knowledge-based businesses.

The transfer of knowledge through market exchange presents a number of difficulties that have been explored by those studying the economics of information.[30] Briefly, difficulties arise because of the asymmetric distribution of information in the transaction between buyer and seller. The exchange of knowledge gives rise to problems of adverse selection and moral hazard that may prevent such transactions occurring in the open market.[31] Furthermore, difficul-

ties arise because knowledge is in many instances a public good characterised by non-excludability and non-rivalry. Others can use knowledge once obtained, even though the original owner still possesses it. This makes it difficult to turn knowledge into property.[32] Moreover, it is generally much cheaper to reproduce knowledge than to produce it.

According to the transaction cost approach to the organisation of economic activity, the risks and uncertainties associated with the market exchange of knowledge suggest grounds for vertical integration.[33] However, much tacit knowledge is developed interactively and shared within networks, which provide an alternative to the traditional markets *versus* hierarchy organisational dichotomy.[34] Market failures also provide grounds for government intervention to ensure that the benefits arising from the exchange of knowledge are optimised from both a private and a social perspective.[35] Hence, governments are actively engaged in stimulating the transfer of knowledge through the promotion of education, training, and research, as well as through policies that promote innovation and mechanisms to protect intellectual property. Government agencies also have a role to play in terms of providing mechanisms of validation and certification, thereby helping to counter the problem of asymmetric information present in the market for knowledge.

The extent to which knowledge is codified or tacit has implications for the methods by which it may be accumulated, stored, processed and transferred between economic agents. Knowledge that is predominately codified can be easily replicated and transferred at low or zero marginal cost. Knowledge that is largely tacit is relatively more difficult and costly to transfer since socialisation and learning procedures require co-presence and co-location between the transmitter and receiver. One might expect codified knowledge to circulate more freely and over greater geographical distances than tacit knowledge. The lower cost of distributing codified knowledge, together with the greater ease of quantifying and protecting it, provide strong economic incentives to codify knowledge. Consequently, codified knowledge may well come to dominate the knowledge-based economy in a national and global context. However, tacit knowledge is an increasingly important source of regional competitive advantage, contributing to the formation of location-specific clusters of innovative activity in certain sectors.[36]

The Drive to Codify Knowledge

The drive to codify knowledge is stimulated by a range of forces, including political, social, economic and technological. The concern of this paper is with the economic and technological forces driving codification. Nevertheless, it is worth briefly considering the political and social dimensions of codification since they provide essential elements constituting the context in which, and through which, the interpretation of knowledge occurs.

Political and Social Dimensions of Knowledge Codification

The codification of knowledge gives it a degree of permanence not present in non-codified or tacit knowledge. Embodied in individuals and social groups, tacit knowledge is more prone to dissipation. Hence, the vast majority of knowledge of past events is embodied in tangible or codified form. Such knowledge, of course, reflects the priorities of those sections of society with access to the mechanisms for

recording knowledge. In Europe, until the spread of the printing press in the fifteenth century, the Church had a near monopoly on the supply of literacy skills and written texts. Consequently, the Church was able to exercise control over the validation and circulation of knowledge.

In the current era access to the tools to codify knowledge in terms of the written word are widely available. However, not all codified pieces of knowledge hold the same level of authority. For example, through the practice of peer review, knowledge published in academic journals gains validity and authority. The power of institutions, from the Church to learned societies, to determine the validity of knowledge must be recognised. According to Foucault, power and knowledge imply each other: 'there is no power relation without the correlative constitution of a field of knowledge, nor any knowledge that does not presuppose at the same time power relations'.[37] Undoubtedly, then, the drive to codify knowledge has a political dimension.

There are also social dimensions to the drive to codify. In even the earliest civilisations, people left records of their existence and way of life, whether embodied in images represented in cave paintings or inscribed on the walls of burial chambers, or the writings of historians and social critics. Codifying knowledge is a means of asserting cultural identity. As the mechanisms of knowledge transfer have developed from the spoken to the written word and to the media image, society reflects itself in the records that emerge. In some senses, the drive to codify knowledge in the social sphere is part of the evolution of cultural and institutional structures that seek to assert and ensure identity, stability and continuity.

Economic Dimensions of Knowledge Codification

In the most ancient cultures, the first signs devised to record information were counting devices. Early systems of writing, such as Egyptian hieroglyphs, emerged around 3000 BC and were of the pictographic–ideographic variety, requiring an appreciation of the writer's cultural background for accurate interpretation.[38] Nevertheless, such systems permitted the recording of a broad range of information, thereby supporting the economic and political structures of the societies in which they emerged. The introduction by the Phoenicians, around 2000 BC, of writing by means of an alphabet enabled the expression of any concept that can be formulated in language. The record-keeping requirements associated with the extensive trading activities of the Phoenicians helped stimulated this innovation.[39] In a sense, then, the codification of knowledge has always been closely aligned to economic activity, whether to count sheep or to control and organise international trade.

Without doubt, economic considerations provide a strong incentive to codify knowledge. In the knowledge-based economy, the assets that provide a firm's competitive advantage are embedded within organisational routines and its workforce. The incentives to codify knowledge are not just concerned with the control of knowledge within the firm, but also with the commodification of knowledge enabling the market exchange of intangible assets. As noted earlier, codified knowledge can generally be transferred more easily and at lower cost than tacit knowledge. Hence, the desire to reduce the cost of knowledge transfer, whether within the boundaries of the firm or in the market, stimulates the codification of knowledge. Moreover, codification enables the protection of

knowledge through the establishment of traditional IPRs or through restrictions on access to the relevant code.

The desire to protect knowledge is stimulated by a number of factors. First, knowledge is increasingly the primary source of competitive advantage for firms. Secondly, the great expense necessary to create new knowledge provides a strong incentive to protect it in order to appropriate the full returns from investments in research and development. As a result of codification, knowledge can be protected through contractual mechanisms, replicated at low cost, transferred between economic agents and easily quantified against given criteria. Hence, the codification of knowledge facilitates its commodification. Furthermore, new technological developments have significantly reduced the cost of codification while simultaneously offering new opportunities to exploit knowledge assets through, for example, computer-mediated forms of transfer.

Technological Dimensions of Knowledge Codification

The extent to which the codification of knowledge occurs is inextricably linked to the available technology. From clay tablets to papyrus scrolls, from the printed book to the World Wide Web, each technological development has increased the ease with which knowledge may be codified and distributed. The computer is the ultimate tool of codification, reducing knowledge to a series of binary digits. The computer, together with the communication networks to which it is linked both locally and globally, are now fundamental to economic and social interaction in advanced countries.[40] Once knowledge becomes information through the process of codification, it can flow freely across distance and time. ICTs enable the efficient and effective recording of expertise and allow it to be accessed through, for example, online libraries, data banks and the Internet. Access to knowledge on the scale now possible is of great benefit since it has the potential to contribute to increased productivity and creativity among the workforce. Those seeking to solve problems are now able to draw on an enormous body of information and ideas. Codification and computing power combined assist in the creation of new knowledge, enabling the analysis of information in a way previously unavailable. For instance, the application of computing power to assist in the coding of human DNA in the human genome project is giving rise to a rapidly developing body of knowledge.

The scope offered by the computer for the analysis of information and data is enormous and seemingly endless. Consequently, computer-based methods of collecting, collating, analysing, storing and transmitting information are being applied to an increasing number of areas of economic and social activity. The codification of articulable knowledge ultimately depends upon the economic incentives to undertake the process of codification. As Cowen and Foray note, technological change can affect the economics of codification in four ways:

1. through the development of new languages (in which we also include reconstructing lost languages), which might allow the codification of knowledge previously thought inherently tacit;
2. through changes in our ability to create models of phenomena and activities;
3. through changes in the technologies of coding and decoding, on the basis of existing languages and models; and
4. through improvements in the technologies of storage, recording and diffusion of messages.[41]

By reducing the cost and expanding the scope of codification, technological developments are promoting the codification of knowledge.

The Rise of Codification

For advanced nations, knowledge is the only source of sustained competitive advantage.[42] In order to retain competitiveness, firms must engage in systematic knowledge-creating activity. As new knowledge is created, so the body of both codified and tacit knowledge expands. In this sense, the rise of codification may be seen as part of this general process of knowledge expansion. However, the argument here is that the expansion of the knowledge base is not the sole reason for the intensification of the codification process. Rather, there is a shift in the general approach towards handling and creating knowledge, a shift that favours the codification and commodification of knowledge. This approach to knowledge is characterised by the desire to reduce uncertainties and ambiguities, and promote a more rational approach to knowledge creation and acquisition. The rise of the codification of knowledge, then, is leading to the marginalisation of the intuitive and tacit elements of knowledge and their role in knowledge-creating activity.

The growth of the codification of knowledge can be witnessed in many instances in advanced countries. In this section, attention is drawn to two areas where the drive to codify is evident. The first is the higher education sector, where government policies, designed to promote the efficient expansion of the supply of knowledge workers, are encouraging the codification of knowledge. Secondly, the knowledge management case shows the process of knowledge codification at the level of the firm. Together these examples demonstrate the widespread nature of the current drive to codify knowledge. Moreover, they serve to illustrate that the drive to codify knowledge is present in both the public and private sectors.

Higher Education

In today's global economy, national governments are restricted in their ability to manage their domestic economies. Education, however, remains one area, of central significance to economic growth and prosperity, which they are still able to influence. Hence, education systems throughout the advanced economies are being subjected to increased levels of scrutiny. Politicians and industrialists have sought to ensure that universities address more adequately their priorities by delivering a healthy supply of knowledge workers, including 'symbolic analysts' which, according to Reich, are essential for a nation's prosperity in the twenty-first century.[43] In response to these demands, efforts are being pursued to improve both the efficiency and quality of service as well as to extend access, flexibility, and life-long learning. These have resulted in the introduction of various changes in the system and nature of higher education in advanced industrialised countries. A key component in these developments is the shift towards the commodification of knowledge through a process of codification.

In the UK, for example, the Dearing Report[44] emphasised the need for graduates to acquire the key skills of communication, numeracy, use of ICTs and learning how to learn. To demonstrate that the demands of government and business are being addressed, universities are introducing mechanisms to measure the provision of knowledge and skills. In so doing, the emphasis falls on the structures of provision and learning rather than on the content. As Robins and Webster argue, the current

obsession with skills, competencies, and process learning is leading to a conception of the student as an information-processing machine.[45] In the context of computer-assisted education, Borgmann draws a parallel between the mind of the learner and the personal computer: both are able to retrieve and process information, but both know nothing.[46] Students are learning procedural knowledge, giving them an understanding of how to do things. Tacit knowledge is often referred to as know-how. However, as demonstrated earlier, tacit knowledge is more complex than an appreciation of procedure. Knowledge is being codified but so too is the process of knowledge acquisition and creation. Students are learning a rigid procedural form of thinking that is not open to ambiguity and serendipity.[47] Learning and thinking in a procedural manner certainly has value. However, procedural thinking and learning must not be privileged to the exclusion of other less formulated methods of thinking and learning.

Furthermore, mechanisms to quantify and codify the knowledge which students acquire, such as specific learning outcomes, together with systems to validate the content of courses at local and national levels, have become widespread. The authenticators of knowledge embodied in degrees awarded from institutions of higher education are increasingly administrative agencies charged with the task of validating quality. Their attention is directed towards procedures and structures rather than knowledge content.

To extend access to higher education, we are witnessing the standardisation of the provision of courses and content. The knowledge transferred through higher education is increasingly codified knowledge. Indeed, there is a danger that the supply of such standardised, highly codified courses will, with the use of ICT-assisted distance learning, cover wide geographical areas and thereby deprive students of access to local knowledge. The drive to codify provision is further stimulated by the desire to exploit the opportunities of ICTs for distance and asynchronous learning in the form of, for example, the Internet, e-mail based tutoring, bulletin boards, and computer-mediated learning generally. However, as Brown and Duguid note, such forms of delivery must be viewed as complementary to traditional forms of learning.[48] The social context, which is a crucial element in the learning process, cannot be adequately replicated in electronic form. Contacts with tutors and peer groups constitute important vehicles for enabling the absorption of knowledge through the process of discussion and learning together. In this process, tacit and codified knowledge interact leading to the creation of new knowledge.

The acquisition of tacit knowledge cannot easily be quantified. Consequently, its value is not fully appreciated. Moreover, the role of academics in the transfer of knowledge is being reduced. Efforts to extract and codify the knowledge embodied in the minds of lecturing staff are well advanced from unit descriptors in which knowledge of course content is made explicit, to the delivery of all course content to students on-line as text-based material. In the process, the lecturer's knowledge is extracted, enabling the university to appropriate further income from it through the franchising of courses to other institutions and through distance learning programmes. In this way, many academics are being subjected to a process of de-skilling.[49]

Knowledge Management

The realisation that knowledge is the most important resource has led firms to look closely at their knowledge assets and intellectual capital in terms not only of how to

exploit them or account for them, but also of how to develop knowledge within the firm through innovation. The 1990s witnessed the rise to prominence of the discipline of knowledge management within both the business environment and academic circles.[50] Knowledge management is a new approach to the problems of competitiveness and innovation-confronting organisations. It may be defined as 'any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organisations'.[51] The application of knowledge management strategies has become widespread among firms.

The emphasis of the discipline of knowledge management is on identifying and codifying the firm's knowledge assets so that they can be both fully exploited and fully protected as a source of competitive advantage.[52] Since the firm cannot own its workforce, it must find means of securing employee loyalty. Alternatively the knowledge held by such workers must be disembodied, separated from the workforce and embodied in machinery and data banks. In such a way, the firm seeks to protect its assets and in so doing it reduces the bargaining position of the workforce. Just as academics in the higher education sector are being de-skilled, so too are many knowledge workers. However, for some highly skilled sections of the workforce, this strategy is not possible. If these workers are to be productive, they must have a high level of autonomy and must handle highly idiosyncratic knowledge, which is difficult or costly to codify. To secure the loyalty of such employees, firms must provide favourable working conditions and remuneration packages.

The importance of managing tacit knowledge, embodied in experts, is recognised in the field of knowledge management. Nevertheless much of the emphasis, in practice, is on explicating this knowledge into more codified forms. Orr's study of photocopier repair technicians at Xerox PARC highlights the deficiencies of codified knowledge embodied in repair manuals compared with the non-codified knowledge exchanged between technicians in a social context during, for example, breakfasts and lunches together.[53] Despite such evidence, much attention has been directed towards the technologically assisted codification and distribution of knowledge within the firm. With the use of ICTs in the form of Intranets, Internet, data bases, on-line expert systems, groupware and so on, a firm can build a multimedia repository of rich explicit knowledge.[54]

The application of ICTs, which can certainly facilitate the efficient use of knowledge and information within the firm, requires the establishment of knowledge/information infrastructures. Consequently, the focus of knowledge management among firms tends to be predominantly on the establishment of procedures supported by ICT infrastructures, whilst practice is less well represented in the systems of knowledge management established. Nevertheless, the relationship between practice and process is an important one, and emphasis on one to the detriment of the other can diminish the success with which knowledge is managed.[55]

In a study of 31 knowledge management projects, Davenport *et al.* identified four broad types of objectives: to create knowledge repositories; to improve knowledge access; to enhance knowledge environment; and to manage knowledge as an asset.[56] The achievement of each of these objectives may be assisted with the use of technology. However, a combination of technical and human elements is necessary in knowledge management projects.

> Unlike data, knowledge is created invisibly in the human brain, and only the right organizational climate can persuade people to create, reveal, share, and use it. Because of the human element in knowledge, a flexible, evolving structure is desirable, and motivational factors for creating, sharing, and using knowledge are very important. Data and information are constantly transferred electronically, but knowledge seems to travel most felicitously through a human network.[57]

In recognition of such findings, recent developments in knowledge management have increasingly sought to address 'the people side', developing methods for assessing and improving the organisational culture.[58]

From the two examples given above, we can see that there is a drive to codify knowledge within the higher education sector and within firms. Moreover, it is clearly possible to identify economic and technological forces promoting this trend, as well as political and social influences. In part, these examples can be seen as indicative of a general trend in society related to the changing nature of knowledge. For example, Lyotard has highlighted the commodification of knowledge, with its value coming to depend increasingly on its performativity.[59] The changing nature of knowledge, and especially its codification, has important implications for the development of the knowledge-based economy.

Implications of Codification

The dynamic nature of knowledge is dependent on the interaction between tacit and codified knowledge in a social context.[60] The codification of knowledge, together with its transfer through technologically mediated channels, neglects the social context in the sense that the individual in isolation absorbs codified knowledge. The excessive codification of knowledge may lead to knowledge becoming more static since its interaction with tacit knowledge may be reduced. The role of tacit knowledge in the innovation process is widely accepted.[61] Consequently, if the emphasis on the codification of knowledge leads to the neglect of tacit knowledge, the capacity for innovative activity will diminish.

Secondly, the need to cover the initial costs of codification may lead firms to hold back on the distribution of new knowledge, especially if this new knowledge requires the development of a new system of codification. Moreover, the codification of knowledge may give rise to monopoly power over codes, and path-dependence. As Cowan and Foray note, the value of codification depends on the stability of the knowledge environment: '[w]hat makes an environment unstable is that the languages and models contain ambiguity, and perhaps exist in multiple forms. It is the elimination of the multiple forms and the further elucidation of the models that creates the stability'.[62] However, stabilising the knowledge environment is costly. Consequently, once stabilised there is an incentive to maintain the structures that sustain a stable knowledge environment. However, the ambiguities that exist in unstable knowledge environments are rich sources of creativity and variety. In this way, the path-dependent nature of codification reduces the scope for creative and innovative activity.

Finally, the process of codification, in particular through technological mechanisms, has an impact on the cognitive frameworks and nature of understanding gained by those individuals applying knowledge. As dependence on computer technology in the creation of knowledge increases, the limitations of

technology will come to restrict human creativity. For the computer to unleash its immense processing power, it must be supplied with codified knowledge. All that it absorbs must be reducible to zeros and ones. As yet, the computer can deal only with finite elements; it cannot cope with infinity or ambiguity. As Bolter notes:

> . . . computer language is at every level univocal: each statement is either entirely clear or simply wrong, and to guarantee its clarity, the language possesses a rigid syntax of permissible expressions . . . the ambiguity that is so important to human communication is fatal to the computer.[63]

Codification seeks to remove ambiguity, but the ambiguity and uncertainty present in the non-codified expression of knowledge offer opportunities as well as threats.

The limitations inherent in the computer have more worrying consequences when transferred to the human mind. The desire to imitate the human brain by creating artificial intelligence has been a constant force behind the development of computer technology. However, in the current period 'the issue is not whether the computer can be made to think like a human, but whether humans can and will take on the qualities of digital computers. For that . . . is the fundamental promise and threat of the computer age'.[64] As Polanyi wrote 'we can know more than we can tell',[65] and this is a characteristic that distinguishes humans from computers.[66] Unlike computers, the actions of humans are not always based on rational calculations. Humans are characterised by bounded rationality,[67] which may account for limitless knowledge since it allows imagination and irrational experimentation that may lead to the articulation of new knowledge. For example, the computer processes language as a collection of arbitrary symbols, but in the human mind the 'processing' of language involves memory which is 'by nature resonant, setting up word associations that defy logic, giving connotations to words beyond their definitions, drawing analogies between the outside world and the words that represent it'.[68] It is in this way that new knowledge and insights are gained, a process that is even more extensive when minds are brought together in a social context. The processing of information by computers eliminates the possibility of resonance or analogy interfering with the rules of logic. In effect, the computer dispenses with tacit knowledge. However, to subject all human activity to the rules of logic and reason would be a counterproductive and destructive enterprise since there are areas that cannot be the matter of rational deliberation.[69] Elements of the creative process constitute one such area.

Although, the codification of knowledge is highly beneficial, we must remain alert to the dangers of neglecting the tacit dimension for it is here that uncertainty and ambiguity can lead to the articulation of new knowledge. Intensive codification of knowledge, although assisting the innovation process in many areas through the scope for analysing vast quantities of information, if allowed to permeate through all fields of activity, may well lead in the longer term to a general reduction in the pace of innovative and creative activity. The benefits of codification may prove to be short-term if codification leads to a reduction in the level of social interaction present in the processes of learning and innovation, while also imposing a rigid rational structure onto the process of knowledge creation.

Conclusion

This paper has critically explored the forces behind efforts to codify knowledge, together with the implications of this drive for the evolution of the knowledge-based economy. It has been argued here that tacit knowledge is neglected in the drive to codify, and that this has important consequences for the process of knowledge creation. Because the codification of knowledge favours procedural thinking and creativity to the detriment of intuitive thinking and serendipitous creativity, excessive codification has long-term negative consequences for the process of knowledge creation and innovation generally.

Accordingly, this paper raises a number of important issues for policy-makers, business managers and academics seeking to understand the economic and social aspects of knowledge. First, there may be a role for policy-makers to provide a counterbalance to the forces driving the codification of knowledge by encouraging the creation and circulation of tacit knowledge. In particular, this could be achieved by reducing the domination of economic forces in publicly funded education and research, thereby encouraging broad-based learning and research activity. If the rise of a codified knowledge economy is to be avoided, it is essential that the workforce is capable of dealing with knowledge in its broadest sense. Furthermore, as noted above, codification may be used to reduce uncertainty and risk in the market exchange of knowledge. Hence, the state could develop mechanisms to alleviate the risks involved in the market exchange of knowledge, perhaps by providing new forms of IPRs to adequately protect non-codified knowledge and intangible assets. Policy initiatives could also encourage the formation of formal and informal networks in the private, public and social sectors to facilitate the transfer and creation of tacit and codified knowledge for non-commercial purposes. In this way, a nation's knowledge base can be enhanced with positive externalities for business enterprises that draw on the wider knowledge base in the process of innovation. Policy-makers might also provide supportive mechanisms to allow firms to engage in innovative and knowledge-transfer activities in areas where levels of ambiguity and uncertainty would normally prevent involvement. Such initiatives can provide a counterbalance to the rational approach to knowledge processing that pervades economic activity in the present technological era.

Secondly, businesses seeking to maintain their competitiveness would be wise to recognise the role of tacit knowledge within their organisations. Although, the codification of knowledge may secure a firm's monopoly power for a period of time, the present era is characterised by fast technological change that can lead to the rapid and sometimes unexpected obsolescence of knowledge. Fluid knowledge environments, characterised by a mix of codified and tacit knowledge, are more likely to be able to respond quickly and effectively to such change. It is only in recent years that the focus of knowledge management practices has turned to tacit knowledge within the firm and this should be encouraged.

Finally, the issues raised in this paper indicate that further research is necessary to gain a full appreciation of the consequences of codification, and the neglect of tacit knowledge. Research should go beyond the examination of the initial consequences of the codification of knowledge and question also the impact that codification may have on the process of knowledge creation itself. The dynamic relationship between tacit and codified knowledge is poorly appreciated and would also benefit from further research attention. Such research is essential if a deeper

understanding of the dynamics of the knowledge-based economy is to be achieved. Policy-makers, business managers and academics have much to learn from, and contribute to, such research efforts.

The current trend towards the codification and commodification of knowledge is being driven by a combination of economic and technological forces. This trend, if left unchecked, could lead to the development of a codified knowledge economy where the primary economic activity is the processing of information. In such an economy, the natural creative force of human kind would be in danger of being undermined by the twin forces of economic and technological rationality. To ensure prosperity in the twenty-first century, nations must engage in the creation, distribution and application of both tacit and codified knowledge. This requires an acknowledgement of the counterproductive nature of attempts to remove the ambiguity and uncertainty attached to the tacit dimension of knowledge.

Notes and References

1. An earlier version of this paper was presented at the Eighth International Joseph A. Schumpeter Society Conference, 28 June–1 July 2000, University of Manchester, UK.
2. OECD, *The Knowledge-Based Economy*, OECD, Paris, 1996; Department for Trade and Industry, *Our Competitive Future: Building the Knowledge-Driven Economy*, London, Cm4176, 1998.
3. D. Lamberton, 'The knowledge-based economy: a Sisyphus model', *Prometheus*, 15, 1, 1997, pp. 73–81.
4. R. Cowan and D. Foray, 'The economics of codification and the diffusion of knowledge', *Industrial and Corporate Change*, 6, 3, 1997, pp. 595–622.
5. Cristiano Antonelli, *The Microdynamics of Technological Change*, Routledge, London, 1999; Max Boisot, *Knowledge Assets: Securing Competitive Advantage in the Information Economy*, Oxford University Press, Oxford, 1998; Peter Drucker, *Post-Capitalist Society*, Butterworth-Heinemann, Oxford, 1993; Bengt-Ake Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter, London, 1992; Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, Oxford, 1995.
6. Antonelli, *op. cit.*
7. See, for example, Boisot, *op. cit.* for an extended discussion of the distinction among knowledge, information and data.
8. Albert Borgmann, *Hold on to Reality: The Nature of Information at the Turn of the Millennium*, University of Chicago Press, Chicago, 1999.
9. F. Blackler, 'Knowledge, knowledge work and organizations: an overview and interpretation', *Organization Studies*, 16, 6, 1995, pp. 1021–46.
10. J. Howells, 'Knowledge, innovation and location', in J. R. Bryson, P. W. Daniels, N. Henry and J. Pollard (eds), *Knowledge, Space, Economy*, Routledge, London, 2000, pp. 50–62; B.-Å. Lundvall and B. Johnson, 'The learning economy', *Journal of Industry Studies*, 1, 2, 1994, pp. 23–42.
11. J. Howells and J. Roberts, 'From innovation systems to knowledge systems', *Prometheus*, 19, 1, 2000, pp. 17–31.
12. Kenneth Arrow, *The Limits of Organization*, Norton, New York, 1974, pp. 39–40.
13. P. P. Saviotti, 'On the dynamics of appropriability, of tacit and codified knowledge', *Research Policy*, 26, 1998, pp. 843–56 (p. 848).
14. J. Howells, 'Tacit knowledge, innovation and technology transfer', *Technology Analysis and Strategic Management*, 8, 2, 1996, pp. 91–106 (p. 92).
15. Nonaka and Takeuchi, *op. cit.*, p. 8.
16. M. Polanyi, 'The logic of tacit inference', *Philosophy*, 41, 155, 1966, pp. 1–18 (p. 4).
17. R. Cowan, P. A. David and D. Foray, 'The explicit economics of knowledge codification and tacitness', *Industrial and Corporate Change*, 9, 2, 2000, pp. 211–253.

18. Saviotti, *op. cit.*, p. 848.
19. Polanyi, *op. cit.*, 1966, p. 7.
20. Boisot, *op. cit.*; Nonaka and Takeuchi, *op. cit.*
21. *Ibid.*, p. 61.
22. Lundvall and Johnson, *op. cit.*
23. Jean Lave and Etienne Wenger, *Situated Learning. Legitimate Peripheral Participation*, Cambridge University Press, Cambridge, 1991, p. 98.
24. Edith Penrose, *The Theory of the Growth of the Firm*, Blackwell, Oxford, 1959; Richard Nelson and Sidney Winter, *An Evolutionary Theory of Economic Change*, Belknap Press, Cambridge, MA, 1982.
25. For example, during World War I, the French, needing an additional supply of their 75mm field guns, sent the blueprints to the US. However, the Americans could produce guns of the required quality only after a team of workmen went to show them how (see David Landes, *The Wealth and Poverty of Nations*, Abacus, London, 1999, pp. 278–79).
26. J. Roberts, 'From know-how to show-how: the role of information and communication technologies in the transfer of knowledge', *Technology Analysis and Strategic Management*, 12, 4, 2000, pp. 429–43.
27. D. MacKenzie and G. Spinardi, 'Tacit knowledge, weapons design, and the uninvention of nuclear weapons', *American Journal of Sociology*, 101, 1, 1995, pp. 44–99.
28. An individual can acquire the tacit knowledge required to drive a Formula One car like Michael Schumacher or to play a violin like Yehudi Menuhin only if that individual possesses the relevant aptitude. Indeed, in the process of acquiring tacit knowledge through learning, individuals add to this knowledge through their own experiences and innate abilities, developing their own knowledge in an idiosyncratic manner.
29. Saviotti, *op. cit.*, p. 843.
30. See for example Arrow, *op. cit.*, 1974; Kenneth Arrow, 'Classificatory notes on the production and transmission of technical knowledge', *American Economic Review*, Papers and Proceedings 59, 1969, pp. 29–35; *idem*, 'Technical information and industrial structure', *Industrial and Corporate Change*, 5, 3, 1996, pp. 645–52; G. J. Stigler, 'The economics of information', *Journal of Political Economy*, 69, 1961, pp. 213–25.
31. Adverse selection (hidden information) refers to a situation when one party in a potential transaction is better informed about a relevant variable in the transaction than the other party. It is an *ex ante* information problem. Moral hazard (hidden action) refers to action which parties in a transaction may take after they have agreed to execute the transaction. It is an *ex post* information problem.
32. See Arrow's discussion of technical information, *op. cit.*, 1996.
33. Oliver E. Williamson, *Markets and Hierarchies: Analysis and Anti-trust Implications*, Free Press, New York, 1975; *idem*, *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, Macmillan, London, 1985.
34. D. Foray and B.-Å. Lundvall, 'The knowledge-based economy: from the economics of knowledge to the learning economy', in OECD, *Employment and Growth in the Knowledge-based Economy*, OECD, Paris, 1996, pp. 11–32.
35. Lundvall and Johnson, *op. cit.*; Geoffrey Hodgson, *Economics and Utopia: Why the Learning Economy is not the End of History*, Routledge, London, 1999.
36. P. Maskell and A. Malmberg, 'Localised learning and industrial competitiveness', *Cambridge Journal of Economics*, 23, 1999, pp. 167–86; C. Lawson and E. Lorenz, 'Collective learning, tacit knowledge and regional innovation capacity', *Regional Studies*, 33, 4, 1999, pp. 305–17.
37. Michel Foucault, *Discipline and Punish: The Birth of the Prison*, Penguin, Harmondsworth, 1979, p. 27.
38. Mario Pei and David Marshall Lang, 'Alphabet', *Microsoft Encarta 98 Encyclopedia*, Microsoft Corporation, 1998.

39. The Phoenicians, a sub-group of the Semitic people, were outstanding navigators and merchants who established trading posts all over the eastern Mediterranean and beyond between 1800 BC and 1000 BC. The alphabet developed by the Phoenicians forms the basis of Western writing today (Borgmann, *op. cit.*, pp. 40–46).
40. Manuel Castells, *The Rise of the Network Society*, Blackwell, London, 1996.
41. Cowan and Foray, *op. cit.*, p. 609.
42. Drucker, *op. cit.*
43. Symbolic analysts solve, identify, and broker problems by manipulating symbols. They make a significant contribution to the value of productive activity, and therefore command high rewards in the knowledge-based economy. See Robert B. Reich, *The Work of Nations: Preparing Ourselves for 21st Century Capitalism*, Vintage, New York, 1992.
44. The National Committee of Inquiry into Higher Education, *Higher Education in the Learning Society* (Dearing Report), HMSO, London, 1997.
45. Kevin Robins and Frank Webster, *Times of the Technoculture: From the Information Society to the Virtual Life*, Routledge, London and New York, 1999, p. 190.
46. Borgmann, *op. cit.*, p. 206.
47. The use of computers in education has been criticised on the grounds that they encourage procedural thinking to the detriment of less structured methods of learning and thinking. See, for example, Theodore Roszak, *The Cult of Information: A Neo-Luddite Treatise on High-Tech, Artificial Intelligence, and the True Art of Thinking*, University of California Press, Berkeley, 1994; Joseph Weizenbaum, *Computer Power and Human Reason: From Judgement to Calculation*, Penguin, Harmondsworth, 1984; Borgmann, *op. cit.*
48. John Seely Brown and Paul Duguid, *The Social Life of Information*, Harvard Business School Press, Boston, MA, 2000.
49. D. F. Noble, 'Digital diploma mills: the automation of higher education', *First Monday*, 3, 1, http://firstmonday.org/issues/issues3_1/noble/index.html, 1998.
50. See, for example, Thomas Davenport and Laurence Prusak, *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, MA, 1998; Nonaka and Takeuchi, *op. cit.*; Dorothy Leonard-Barton, *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*, Harvard University Press, Boston, 1995; Thomas Stewart, *Intellectual Capital: The New Wealth of Organizations*, Currency/Doubleday, New York, 1997.
51. Harry Scarbrough, Jacky Swan and John Preston, *Knowledge Management: A Literature Review*, Institute of Personnel and Development, London, 1999, p. 1.
52. *Ibid.*
53. Julian Orr, *Talking about Machines: an Ethnography of a Modern Job*, ILR Press, Ithaca, 1996.
54. M. H. Zack, 'Managing codified knowledge', *Sloan Management Review*, 40, Summer 1999, pp. 45–57.
55. Brown and Duguid, *op. cit.*
56. T. H. Davenport, D. W. De Long and M. C. Beers, 'Successful knowledge management projects', *Sloan Management Review*, 40, 1998, pp. 43–57 (pp. 44–45).
57. *Ibid.*, p. 56.
58. R. Hull, 'Knowledge management practices and innovation', in B. Andersen, J. Howells, R. Hull, I. Miles and J. Roberts (eds), *Knowledge and Innovation in the New Service Economy*, Edward Elgar, Cheltenham, 2000, pp. 142–58.
59. Jean-Francois Lyotard, *The Postmodern Condition: A Report on Knowledge*, translated by Geoff Bennington and Brian Massumi, Manchester University Press, Manchester, 1984.
60. Nonaka and Takeuchi, *op. cit.*
61. Nathan Rosenberg, *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge, 1982; G. Dosi, 'The nature of the innovation process', in G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds), *Technical Change and Economic Theory*, Pinter, London, 1988, pp. 221–38; J. Senker, 'Tacit knowledge and models of innovation', *Industrial and Corporate Change*, 4, 2, 1995, pp. 425–47.
62. Cowan and Foray, *op. cit.*, p. 620.

63. David Bolter, *Turing's Man: Western Culture in the Computer Age*, Penguin, Harmondsworth, 1986, p. 131.
64. *Ibid.*, p. 190.
65. Michael Polanyi, *The Tacit Dimension*, Routledge, London, 1967, p. 4.
66. For a detailed discussion of this point see Weizenbaum, *op. cit.*
67. H. A. Simon, 'A behavioural model of rational choice', *Quarterly Journal of Economics*, 69, 1955, pp. 99–118.
68. Bolter, *op. cit.*, p. 146.
69. Polanyi, *op. cit.*, 1967.