

D_{ANISH} **R**_{ESearch} **U**_{NIT FOR} **I**_{NDUSTRIAL} **D**_{YNAMICS}

DRUID Working Paper No. 98-2

**Learning and skills in the
Knowledge Economy**

by
Ken Ducatel
February 1998

Learning and skills in the Knowledge Economy

**Ken Ducatel,
IPTS, Seville.**

Abstract

Knowledge and learning are widely regarded as defining features of the modern economy. They are a focus of intense interest amongst policy makers as well as academics. Important recent attempts have been made to try to elucidate the interactions between the different forms of knowledge: especially codified knowledge (mainly know-what and know-why) and tacit knowledge (know-how and know-who). This paper extends this approach by arguing that the key vectors of innovation and growth lie in the dynamic interactions between codified and tacit knowledge. This basic insight reinforces the idea that effective learning takes place through a combination of experiential learning (mainly tacit) and formal learning (mainly codified), which places a large question mark over current systems of education and training which still tend to separate these phases of learning. The paper also questions approaches to teaching and learning which continue to regard 'skills' as attributes of individuals. In fact, most skills are rather specific to the social environments in which they are acquired and applied. This explains a considerable amount of the difficulty of recruiting or transferring 'qualified personnel'. In policy terms, this raises significant challenges to both employers and educators to embed learning routines into the work environment and to validate experiential learning in the workplace by accrediting these practical skills in ways which will generalise them and give them a longer term value in the labour market.

Keywords

Information, tacit knowledge, innovation.

JEL

O34, D83

Contents

Preface	7
1 Introduction	9
2 The knowledge economy	10
3 Making knowledge pay-off	12
3.1 The triangle of learning	12
3.2 Codifying experience: towards the learning organisation.....	16
4 Conclusions: institutional and practical challenges	19
References	23

Preface

DRUID welcomes guest authors to its Working Paper series especially when they break new ground in fields central to its research program. One of the themes given a high priority in the DRUID research program and in the profile of the DRUID Working Paper series is the role of learning in industrial dynamics and economic development. This paper by Ken Ducatel is original in its attempt to link theoretical contributions on the learning economy to current debates on labour market and training.

Ducatel demonstrates that the distinction between tacit and codified knowledge has interesting practical implications for the design of labour market policies and training institutions. A key issue is to find ways to better exploit the interactions between codified and tacit knowledge and this must be a major concern both for management and for policy makers.

The paper points to the need to move further ahead in analysing how the formation of knowledge in formal and experience based contexts can be made to interact and overlap in order to create an appropriate mix between specific skills and more general competencies. This will call for a co-operation between economists and experts on cognitive science. There is a need for a research strategy that includes basic research as well as process oriented case studies of how knowledge is created and absorbed in different areas and sectors.

Bengt-Åke Lundvall

1 Introduction

Knowledge and learning are now almost universally regarded as sources, or at least a fundamental condition, of competitive advantage. We can see this in policy circles with, for example the 1996 European Year of LifeLong Learning , as a recent example of an attempt to raise the awareness of the importance of learning as for all people of whatever age (CEC, 1996 - teaching and learning green paper, CEC, 1997 LifeLong learning action plan) And interest in this issue in other international forums (see for example OECD, 1996a). We also see an increasing interest in learning and the transfer of knowledge in academic writing , especially in the economics of technology and management literature (Drucker, 1993; Lundvall, 1996) .

With such a wide range of parties interested it is not surprising that there is considerable variation , if not confusion, in the way the terms are applied. In addition, and more fundamentally, there seems also to be considerable variance in the causal relations which are attributed to learning and knowledge especially as regards the practical strategies of applying knowledge and learning to industrial performance. Considerable progress has been made in this area, especially through the contributions of Lundvall (Lundvall, 1996, Lundvall and Johnson, 1994, Foray and Lundvall, 1996, etc) however there is still a lot to be done to map out this area in more detail in order to help policy makers and industrial make reasonable choices about how and where to invest in learning experiences. For if anything is already absolutely clear it is that more investment in training and education does not of itself mean that effective learning is taking place, nor that there will be an increase in useful knowledge.

But, if more training does not necessarily imply better performance, what guides do we have about where to put our efforts? The ability to understand these relationships more clearly is a fundamental building block of the European knowledge economy. Thus, the aim of this paper is to begin to suggest some of the main issues which confront us when trying to respond to the insight that the economy is daily becoming more knowledge intensive.

2 The knowledge economy

The rise of the knowledge economy lies in the observation that the ‘knowledge’ or ‘skills’ or ‘information’ based activities are playing an increasingly significant role in economic growth. However, these terms are used to cover a wide variety of different phenomena and so some greater analytical clarity is needed before we can assess the real significance of the knowledge in the economy (is the knowledge economy real, does knowledge drive growth, can it be applied and controlled in a systematic way to aid competitiveness, etc?).

Recent work by Lundvall and David and Foray (for a different approach to providing a survey of this area see Choo 1997) has helped attempts to provide a synthesis of these differing views on what we mean by knowledge. At the centre, there are two structuring issues: the form of the knowledge and its mode of transfer.

Lundvall and Johnson (1994) have suggested that knowledge can be sub-divided into four types:

- know what - which involves the transfer of codified information as facts
- know why - which involves understanding basic principles, rules and ideas
- know how - which involves direct experience
- know who - which requires direct contact between individuals, the ability to communicate, form relations of trust and so on

These four types differ in respect of how easily they can be transferred from one application to another and/or from one group or place to another. Generally, ‘know-what’ and to some extent ‘know-why’ knowledge can be more readily formalised, written down or reproduced as codified information. By contrast know-how and know-who types of knowledge are more socially embedded. They are acquired in social contexts such as the work place, or in clubs and associations, conferences or in real-live market places. This is because a large proportion of these forms of knowledge is ‘tacit’ - which means it is either not yet articulated or else it cannot be written down. It has to be acquired either by experience or direct interpersonal contacts.

There are several important implications of this division between types of knowledge and their possibility of transfer. First, when we measure the 'knowledge economy' we are nearly always limited to measuring the parts of the knowledge system which can be codified. For instance, we refer to patents, investments in formal R&D, qualifications achieved by personnel, papers published and cited, etc. Economic research is almost entirely constructed on this foundation of codifiable knowledge. This implies that we are not capturing a large part of the knowledge which is in the economy.

Second, the unmeasured (immeasurable?) part of the economy is possibly the most significant part of the economy - although this is probably worthy of debate in itself. The point is that the tacit forms of knowledge are in a sense the 'live areas' of knowledge which are not yet well defined and so are harder to transfer in a routine manner. These, then, might be the areas could provide the 'competitive edge' form firms which are trying to stay ahead of the pack. However, tacit knowledge resides in the minds of individuals and the practices and shared understanding of social groups. This makes tacit knowledge much harder to control in a completely controllable and predictable way. It implies that the social side of management really is just as important as getting efficient structures, routines and technological systems in place.

Third, Foray and Lundvall suggest that a large part of technological innovation actually represents efforts to codify tacit knowledge so that they can be transferred more effectively. But whilst this undoubtedly true as an intention, the codification can never be complete. As Nonaka (1991) suggests each step towards codification leads to the production of new tacit knowledge, even though its form may change radically and the people who possess the knowledge may also be quite different. In fact, therefore, there is an interaction between all four forms of knowledge. This is clearly demonstrated in enquiries of sociologists of science into areas of knowledge such as experimental Physics, which would appear to be highly codifiable (see Collins, 1985). There is an enormous amount of tacit knowledge in play. The know-what and know-why depend heavily on the know-how to replicate experimental results; and getting experimental results accepted depends heavily on being a recognised and legitimate actor in the know-who networks of scientists. All of this implies that the valorization of knowledge will depend upon the effective management of the interface between codified and tacit

forms of knowledge. In addition, that this interface is dynamic. As learning takes place forms of codification occur which eases the reliable transfer of the knowledge, but this then leads to new problems which people can only solve by working together to apply their experience and creativity.

In summary at this stage, therefore, we can point out several key implications for competitiveness of recent thinking on the nature of knowledge:

1. most formal measures of knowledge such as (patents and qualifications) only capture the formalised part of the 'economically active' knowledge in the economy - a point worth bearing in mind in making policy and strategic choices about investment decisions;
2. tacit knowledge resides and in social relations (work teams, innovative networks, etc) between individuals (who have experiences, creativity, etc) and therefore implementing effective social practices are just as important as buying the most up-to-date technology or the best qualified people;
3. tacit and codified knowledge continually interact as change takes place (we call this learning or innovation depending on the scale of analysis context), which implies a key focus of management is to organise the interaction between the various forms of knowledge.

3 Making knowledge pay-off

It is now necessary to move from models of knowledge to a more concrete discussion of the implications of these recent debates for policy and competitive strategy. As Lundvall (1996) notes there is a very large and important agenda of research in this area. Here we merely try to pick out two issues which seem to be critical in the establishment of a practical basis for competition in a knowledge economy: the first concerns the way in which individuals acquire skills; the second concerns the shared learning within organisations.

3.1 The triangle of learning

Education and training clearly plays a central role in a knowledge economy. But there is currently a strong current of opinion that the conventional educational is no longer adequate to prepare people for working life. Despite the spiralling demand for

qualifications by both firms and workers, there is a sense that the traditional emphasis in education systems on 'know what' and 'know why' knowledge is too far removed from practical knowledge. That formal education and training need somehow to be complemented by experiential learning to acquire 'know how' - which can only be acquired in a hands on way. In addition, there is an increasing emphasis on the interpersonal aspects of skill: the 'know who' side of knowledge (see ERT, 1995, NACFAM, 1996, SCANS 1991).

These demands on workers stem from shifts in the balance of abilities which are demanded today, shifts which are especially associated with the introduction of new technologies. Skill is actually a multidimensional concept requiring the integrated deployment of a range of abilities from physical abilities (hand-eye co-ordination, dexterity, strength) cognitive abilities (analytical and synthetic reasoning, numerical and verbal abilities) to interpersonal skills (communication, supervisory, leadership, team working, etc) (Wolff, 1995).

The knowledge economy (especially with the associated growth of new information and communication technologies) means that there are increased demands for the ability to engage in formal reasoning and manipulating symbols. This implies a shift in the composition of skills with physical skills losing place to cognitive skills. As formal education tends to concentrate upon developing cognitive skills, rather than physical skills, new technologies tend to be associated with increasing demands for more highly qualified people. Formal education has become an increasingly important signal to employers that an employee has the cognitive ability to perform well in the work environment, whilst physical attributes are likely to decline in importance.

However, cognitive abilities are not enough by themselves for a worker to work effectively. The ability to do a job depends upon an effective integration of a wide range of abilities which go beyond the immediate requirements of the technologies being used or the task in hand. For instance, in a recent synthesis of findings from Eurotecnet (1995) competencies required for work included :

- visualisation, i.e. the capacity to mentally manipulate models

- understanding of a process - how machines function and the interaction between machines and the product
- statistical deduction
- verbal, oral and visual communication
- individual responsibility for the product and the process
- the ability to make judgements
- the ability to combine business and technical issues

This list comprises a mix of both cognitive and interpersonal abilities, which relate to a willingness to take responsibility, problem solving abilities, the ability to work with others and the willingness and capacity to learn. Importantly, several of the categories emphasise synthetic abilities where abstract cognitive abilities and inter-personal abilities come together. Here we see clearly the need for a merging of codified and tacit skills, but how can this be achieved?

What is required is a difficult balancing act between the three main arenas of learning (academic, vocational and experiential) in what we might call a triangle of learning. Evidence that these areas remain poorly integrated abounds. For instance the transition to work is still one of the major periods of risk of unemployment for young adults (CEC, 1996). This is true even for graduate recruitment where many employers remain concerned by the lack of communication skills, business awareness, leadership and team working skills (Connor, 1995),

One key component of building a more effective knowledge economy (at least for younger people) therefore will be to provide ladders and bridges between vocational education, generally regarded as lower status, and academic education (OECD, 1996c). Clearly, the ambition is to 'futureproof' trainees by accompanying specific vocational education with the broader set of competences outlined above. This provides both the opportunity to 'upgrade' to an academic qualification later and a higher chance of successfully keeping up to date as technologies change by referring to first principles.

But links between education and work are also needed to complete the triangle of learning. For this reason many vocational programmes now seek to provide work-based

learning in combination with continuing general education or, at least, vocational education with a larger general component.¹ Examples include, business and education partnership aiming to ease the transition to work have also been tried such as workplace visits, work shadowing, teacher placement, mentoring of students by employees, adopt a school programmes, enterprise in school initiatives (OECD, 1992). See also Lundvall's (1996) suggestion to incorporating the notion of apprenticeship even into highly codified professional level education schemes

Most of the concrete steps towards establishing more integrated approaches to learning have been taken in respect of initial education and training. The problem of how to extend learning opportunities to experienced workers remains a more talked about than resolved challenge of the knowledge economy (not least in terms of how to finance the massive increase in demand for formal training which is implied in the move to lifelong learning. One important development in this respect is the trend towards systems of accreditation of experience (or prior learning). An example is the GNVQ structure in the UK, which provides a framework for assessing and formally recognising (and therefore legitimising) the skills which are actually in use in firms (i.e. it is based on real skills in use rather than passing written examines or formal practical tests). Therefore, GNVQs give credit where credit is due. They provide workers (and employers) with a map of the broader skill set needed to achieve a given level of competence, which is important as many real work roles are imbalanced across the different areas of skill. They also provide a structured set of upgrade paths which people can follow to raise their chances of getting a better job. Here we see a clear attempt to benchmark the existing level of experience or knowledge in the workforce, a process which will undoubtedly lead to the codification of some areas of practical knowledge but which also, because it is based on assessors judgements not formal tests, extends our ability to map the immeasurable area of tacit knowledge.

¹ The dual training systems in Austria and Germany, of course, have always offered such integration. But, dual training is, however, now often regarded as too inflexible to meet the challenge of increasing multi-skilling of jobs, the blurring of occupational distinctions and the need to be able respond to technological changes, all changes which are associated with new ICTs in the workplace. Young people are opting for academic higher education or for jobs in high technology and service sectors which do not have these well defined apprenticeship patterns.

Clearly, there is a great deal of further research, experimentation and evaluation of experience to be done in the integration of learning into work and of embedding know how and know who type competencies into education and training programmes. Some of the critical issues appear to be:

1. the need for mechanisms to ensure a balanced development (especially amongst younger people) between their needs for a long term basis of general education and cognitive and personal development and practical experiential learning in real work situations;
2. the definition of new relationships between the institutional players in order to achieve more effective integration of the different arenas learning ;
3. flexible qualification structures which cover both codified and tacit aspects of knowledge and which are understood and accepted by employers.

3.2 Codifying experience: towards the learning organisation

As we note above, much knowledge is social: it resides in the shared experiences and behaviour of groups of people acting together. For this reason, when we look at learning we have to think about the learning capacity of groups (teams, divisions, firms, organisations and even communities and countries) as well as individual learning. In terms of competitiveness the key levels of social learning to focus on are probably within the firm and in inter-firm networks. Such issues are treated elsewhere in the literature on the economic importance of knowledge transfer (one firm of learning) at these inter-firm and intra-firm levels (Cohen, 1990; Dosi, 1996, etc.) . This literature, provides strong evidence of the importance of knowledge transfer , but has less to say on the mechanisms by which knowledge is captured, distributed and applied by different social groups within the firm. For this we have to turn to the recent discussion of the ‘learning organisation’.

The learning organisation can be seen as an extension of long term debates on work organisation and industrial performance, from which it has become fairly clear that firms that put a lot of effort into organising work well tend to be more competitive. For instance, the recent US literature on ‘high performance workplaces’ has focused on establishments which are trying to commit their workers more fully to the objectives of the firm, so that more of their creativity, ingenuity, problem solving abilities and all

round energies are given to the firm. To motivate their workers in this way, firms are encouraging greater participation by the work force in decision making, providing information, extra benefits and so on. Klingís (1995) review of the research in this area suggests a positive relationship between the use of these new work practices and productivity, especially where they are used in a mutually reinforcing manner in the form of work systems (see also Osterman, 1994; Frezis et al. 1995; Johnson, Baldwin and Diverty, 1996 and, for similar annotated bibliography of high performance work practices, DOL, 1993). It is interesting to note that there is no systematic development of a model of high performance workplace, in different firms the different practices are being put together in different ways with variable, if largely positive, outcomes.

The High Performance Workplace debate indicates that this is a complex area with no single or easy solutions. However, it does indicate very strongly the value, if not necessity, of a combined approach to technological innovation, training and work re-organisation. Perhaps, the fact that firms that do well are those which integrate these three managerial disciplines are merely those that are well managed. On the other hand, good management seems to imply success in building bridges between training, work organisation and technology strategies (which in their different ways are the three main areas of knowledge acquisition in the firm).

Starting from this point, a Learning Organisation is rather more than just an organisation which invests substantial sums into training. Arguably it is an attempt to provide rationale and an integrating concept to guide the application and development of knowledge in the firm. An important feature of this debate is that it leads us to look not just at the forms of knowledge, but *who* has the knowledge and *how* they use their knowledge. In other words we have to look at the sociology of knowledge in the firm, rather than just expecting knowledge to reside in a few 'knowledge workers' such as senior executives and scientific personnel. As Nonaka notes: a learning organisation is where inventing new knowledge is not a specialised activity...it is a way of behaving in which everyone is a knowledge worker (Nonaka, 1991, p. 97).

What the Learning Organisation demands in practice, therefore, is first a wide ranging codification of the systems and procedures which the firm has to capture and mobilise

know-how and learning knowledge (Table 1). However, because this is a *Learning Organisation*, this is not a once and for all abstraction of expertise from the workers in order to embed (codify) their know-how into procedures and technological system. As we know from the discussion above, this could only be a partial and temporary success, because it will never capture all the existing tacit knowledge nor the new tacit knowledge which is created in the process of codification. Thus, the aim of such systems is to socialise workers into the practice of learning: the articulation and application of knowledge. Furthermore, by implication, the more of the workforce that can be drawn into this knowledge net the more the organisation can benefit from the experiences of the staff.

This implies a set of practical strategies for helping workers to acquire new skills such as:²

- carrying out the new tasks (90%, of company managers thought this activity was of great or some importance in employees acquiring new skills)
- being given time for coaching 78%
- organising work in teams, 60%
- supporting co-operation across departments, 59%
- tailored education and training, 57%,
- long term educational planning, 51%
- conventional classroom courses, 43%
- planned job rotation, 31%

² derived from a survey of 2000 Danish firms (Lund and Gjerding, 1996; Gjerding, 1996)

There are several key lessons which we draw at this point:

1. the fundamental point is that in the knowledge economy is organisational learning which is a social process and depends upon the application of appropriate management practices;
2. by implication, skill development does not merely take place at the individual level but amongst groups a fact which many training programme still seem to ignore;
3. knowledge creation and transfer takes place in a wide variety of ways and places within the organisation - not just in formally recognised settings such as engineering departments, labs and classrooms or amongst a few designated knowledge workers;
4. it is possible, necessary even, to devise techniques to capture and/or mobilise the vast amount of tacit knowledge which is currently under utilised in the informal routines and expertise of the workforce;

4 Conclusions: institutional and practical challenges

The paper provides a schematic introduction to the recent debate on the importance of learning and skill acquisition in the knowledge economy. It points out that the issue of learning is a cross-roads of interest not only of sociologists and economists but of policy makers and management. But because of this wide variety of interest there is considerable variation in the scale of analysis and concepts behind terms such as competence, skill, knowledge and so on. There is a severe risk of misunderstandings simply because the words are the same and the meanings differ.

The recent attempt to put some more analytical power into the debate from Lundvall, David and Foray (amongst many others) is very useful as it provides the opportunity to draw distinctions between knowledge which is measurable as indicators of knowledge (and which is the foundation of most economic analysis) and the easily overlooked, but complementary area of tacit knowledge.

The paper then goes on to show how the recognition of the key role of tacit knowledge implies the need for careful management of the social relations of learning at the individual level and in the shared knowledge which is helped by social groups. At each stage there are a number of critical implications for policy and managerial strategy - not least of which is the need to recognise and capitalise upon the interactions between

codified forms of knowledge and those that are not yet fully articulated. The two forms of knowledge are not in opposition but in a mutual tension which helps to drive forward development. If there is a single guiding line of enquiry in this area it has to be to explore further the management of this interface between the written world of codified knowledge and the social realm of know-how and know-who

Table 1 Building a Learning Organisation

Main Activities	
Systematic problem solving	- invoke the 'plan, do, check, act cycle' in order to carry out changes in a systematic way which allows consolidation of the experience afterwards; - Insist on data rather than assumptions, use statistical tools, encourage accuracy, precision and discipline in thinking; - encourage questioning of decisions.
Experimenting with new approaches	- encourage systematic, well designed and documented experimentation to test out new knowledge in both on-going programmes and one-off demonstration projects; - reward risk taking; - do follow-up evaluations using formal techniques; - analyse experiments so that tacit know how learnt by doing the project is converted into codified and transferable know why; - make sure that lessons are transferred.
Learning from experience	- assess results systematically and do post-project appraisals as a routine; - record the results in ways which accessible to all employees; - learn from past mistakes.
Learning from others	- practice benchmarking (on-going investigation, analysis and learning from industry best practices) - study practices rather than results; - be systematic, with careful examination of practices, carefully planned site visits and interviews, detailed analysis, development of recommendations and implementation; - elicit ideas from customers on product information, competitors, changing preferences, feedback on product and services - observe customers in action - develop the art of open, attentive listening
Rapid and efficient transfer of knowledge (through all means)	- written, oral and visual reports are used for summarising findings, providing checklists, describing processes and events, but cannot replace direct experience of the thing being described; - use tailored site visits and tours to introduce new policies, practices and systems. - personnel rotation are effective in transferring experience and skills, direct contact facilitates the transfer of tacit know how. - team based working to encourage sharing of know how and the generation of new knowledge - education and training are important if they provide scope for practice and application of the teaching once back on the job - support innovation by appropriate incentives such as serious evaluation and implementation of plans which are produced in training sessions

(Source: Garvin, 1993)

References

CEC (1996b) Employment in Europe, 1996, Commission of the European Communities, Luxembourg

CEC (1996a) Teaching and Learning: Towards the Learning Society, Commission of the European Communities, Luxembourg.

Choo, C. W. (1997) *The Knowing Organization*, Oxford University Press

Cohen, W. and Levinthal, D. (1990) 'Absorptive capacity: a new perspective on learning and innovation' *Administrative Science Quarterly*, 35:128-152

Collins, H. (1985) *Changing Order: Replication and Induction in Scientific Practice*, London, Sage.

Connor, H (1995) Graduates: shortage or glut? pp:33-44 in H. Metcalf (ed.) *Future Skill Demand and supply: Trends, Shortages and Gluts*, London, PSI.

Department of Labor (1995) *What's Working (and What's not)*, Office of the Chief Economist, US Department of Labor, January.

Dosi, G. (1996) The Contribution of Economic Theory to the Understanding of a Knowledge Based Economy pp 81-100 in OECD (1996) *Employment and Growth in the Knowledge-Based Economy*, Paris, OECD.

Drucker, P. (1993) *The Post-Capitalist Society*, Harper Collins, New York.

ERT (1995) *Education for Europeans: Towards the Learning Society*, Brussels, European Round Table of Industrialists.

Eurotecnet (1995) *Key/core competencies: Synthesis of Related Work Undertaken within the Eurotecnet Programme (1990-94)*, European Commission, Luxembourg.

Foray, D. and Lundvall, B (1996) *The Knowledge-Based Economy: from the Economics of Knowledge to the Learning Economy*, pp 11-32 in OECD (1996) *Employment and Growth in the Knowledge-Based Economy*, Paris, OECD

Frazis, H, Herz, D and Harrigan, M (1995) *Employer-Provided Training: Results from a New Survey*, *Monthly Labor Review*, May: 3-17.

Gjerdling, A (1996) *Organisational innovation in the Danish private business*, DRUID Working Paper 96-16, Faculty of Business, Aalborg University

Garvin, D (1993) *Building a Learning Organisation*, *Harvard Business Review*, July-August, 78-91

Johnson, J, Baldwin, J and Diverty, B (1996) *The Implications of Innovation for Human Resource Strategies*, *Futures* 28(2): 103-120.

Kling, J (1995) High performance Work Systems and Firm Performance, Monthly Labor review, May: 29-36.

Lund, R and Gjerding, A (1996) The flexible company, innovation, work organisation and human resource management, DRUID Working Paper 96-17, Faculty of Business, Aalborg University

Lundvall, 1996, The Social Dimension of the Learning Economy, DRUID Working Paper 96-1, University of Aalborg.

Lundvall, B. and Johnson, B (1994) The Learning Economy, Journal of Industrial Studies, 1(2):23-42

NACFAM (1996) US National Skills Standards Project for Advanced Manufacturing, April 1996, National Coalition of Advanced Manufacturing, US Department of Labour, Washington, April.

Nonaka, K (1991) The Knowledge Creating Company Harvard Business Review, Nov-Dec

OECD (1992) Schools and Business: A New Partnership, Paris, OECD.

OECD (1996a) Lifelong Learning for All, Meeting of the Education Committee at Ministerial Level 16-17 January, 1996, Paris, OECD

OECD (1996b) The Public Employment Service in Denmark, Finland and Italy, OECD, Paris.

Osterman, P. (1994) How Common is Workplace Transformation and Who Adopts It? Industrial and

SCANS ,(1991) What Work Requires of School, (Secretary's Commission on Achieving Necessary Skill), US Government, Washington.

Wolff, E (1995) Technology and the Demand for Skills, STI Review No. 18, Paris, OECD

Danish Research Unit for Industrial Dynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- ***The firm as a learning organisation***
- ***Competence building and inter-firm dynamics***
- ***The learning economy and the competitiveness of systems of innovation***

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-

sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

DRUID Working Papers

- 96-1 **Lundvall, Bengt-Åke:** The Social Dimension of the Learning Economy. (ISBN 87-7873-000-7)
- 96-2 **Foss, Nicolai J.:** Firms, Incomplete Contracts and Organizational Learning. (ISBN 87-7873-001-5)
- 96-3 **Dalum, Bent and Villumsen, Gert:** Are OECD Export Specialisation Patterns Sticky?' Relations to the Convergence-Divergence Debate. (ISBN 87-7873-002-3)
- 96-4 **Foss, Nicolai J:** Austrian and Post-Marshallian Economics: The Bridging Work of George Richardson. (ISBN 87-7873-003-1)
- 96-5 **Andersen, Esben S., Jensen, Anne K., Madsen, Lars and Jørgensen, Martin:** The Nelson and Winter Models Revisited: Prototypes for Computer-Based Reconstruction of Schumpeterian Competition. (ISBN 87-7873-005-8)
- 96-6 **Maskell, Peter:** Learning in the village economy of Denmark. The role of institutions and policy in sustaining competitiveness. (ISBN 87-7873-006-6)
- 96-7 **Foss, Nicolai J. & Christensen, Jens Frøslev:** A Process Approach to Corporate Coherence. (ISBN 87-7873-007-4)
- 96-8 **Foss, Nicolai J.:** Capabilities and the Theory of the Firm. (ISBN 87-7873-008-2)
- 96-9 **Foss, Kirsten:** A transaction cost perspective on the influence of standards on product development: Examples from the fruit and vegetable market. (ISBN 87-7873-009-0)
- 96-10 **Richardson, George B.:** Competition, Innovation and Increasing Returns. (ISBN 87-7873-010-4)
- 96-11 **Maskell, Peter:** Localised low-tech learning in the furniture industry. (ISBN 87-7873-011-2)
- 96-12 **Laursen, Keld:** The Impact of Technological Opportunity on the Dynamics of Trade Performance. (ISBN 87-7873-012-0)

- 96-13 **Andersen, Esben S.:** The Evolution of an Industrial Sector with a Varying Degree of Roundaboutness of Production. (ISBN 87-7873-013-9)
- 96-14 **Dalum, Bent, Laursen, Keld & Villumsen, Gert:** The Long Term Development of OECD Export Specialisation Patterns: De-specialisation and “Stickiness”. (ISBN 87-7873-014-7)
- 96-15 **Foss, Nicolai J.:** Thorstein B. Veblen: Precursor of the Competence-Based Approach to the Firm. (ISBN 87-7873-015-5)
- 96-16 **Gjerding, Allan Næs:** Organisational innovation in the Danish private business sector. (ISBN 87-7873-016-3)
- 96-17 **Lund, Reinhard & Gjerding, Allan Næs:** The flexible company Innovation, work organisation and human ressource management. (ISBN 87-7873-017-1)
- 97-1 **Foss, Nicolai J.:** The Resource-Based Perspective: An Assessment and Diagnosis of Problems. (ISBN 87-7873-019-8)
- 97-2 **Langlois, Richard N. & Foss, Nicolai J.:** Capabilities and Governance: the Rebirth of Production in the Theory of Economic Organization. (ISBN 87-7873-020-1)
- 97-3 **Ernst, Dieter:** Partners for the China Circle? The Asian Production Networks of Japanese Electronics Firms. (ISBN 87-7873-022-8)
- 97-4 **Richardson, George B.:** Economic Analysis, Public Policy and the Software Industry. (ISBN 87-7873-023-6)
- 97-5 **Borrus, Michael & Zysman, John:** You Don’t Have to Be A Giant: How The Changing Terms of Competition in Global Markets are Creating New Possibilities For Danish Companies. (ISBN 87-7873-024-4)
- 97-6 **Teubal, Morris.:** Restructuring and Embeddedness of Business Enterprises- Towards an Innovation System Perspective on Diffusion Policy. (ISBN 87-7873-025-2)
- 97-7 **Ernst, Dieter & Guerrieri, Paolo:** International Production Networks and Changing Trade Patterns in East Asia: The case of the Electronics Industry. (ISBN 87-7873-026-0)
- 97-8 **Lazarcic, Nathalie & Marengo, Luigi:** Towards a Characterisation of Assets and Knowledge Created in Technological Agreements: Some evidence from the automobile-robotics sector. (ISBN 87-7873-027-9)

- 97-9 **Ernst, Dieter.:** High-Tech Competition Puzzles. How Globalization Affects Firm Behavior and Market Structure in the Electronics Industry. (ISBN 87-7873-028-7)
- 97-10 **Foss, Nicolai J.:** Equilibrium vs Evolution in the Resource-Based Perspective: The Conflicting Legacies of Demsetz and Penrose. (ISBN 87-7873-029-5)
- 97-11 **Foss, Nicolai J.:** Incomplete Contracts and Economic Organisation: Brian Loasby and the Theory of the firm. (ISBN 87-7873-030-9)
- 97-12 **Ernst, Dieter & Lundvall, Bengt-Åke:** Information Technology in The Learning Economy – Challenges for Developing Countries. (ISBN 87-7873-031-7)
- 97-13 **Kristensen, Frank Skov.:** A study of four organisations in different competitive environments. (ISBN 87-7873-032-5)
- 97-14 **Drejer, Ina, Kristensen, Frank Skov & Laursen, Keld:** Studies of Clusters as a Basis for Industrial and Technology Policy in the Danish Economy. (ISBN 87-7873-033-3)
- 97-15 **Laursen, Keld & Drejer, Ina.:** Do Inter-sectoral Linkages Matter for International Export Specialisation? (ISBN 87-7873-034-1)
- 97-16 **Lundvall, Bengt-Åke & Kristensen, Frank Skov.:** Organisational change, innovation and human ressource Development as a response to increased competition. (ISBN 87-7873-036-8)
- 98-1 **Præst, Mette.:** An Empirical Model of Firm Behaviour: A dynamic Approach to Competence Accumulation and Strategic Behaviour. (ISBN 87-7873-037-6)
- 98-2 **Ducatel, Ken.:** Learning and skills in the Knowledge Economy. ISBN 87-7873-038-4)

Information for subscribers.

Subscription price for 1997 is 600 DKR (about 20 papers). The rate for single issues is 40 DKR. It is possible to make a commitment to an exchange of papers from related departments or research teams. All correspondence concerning the DRUID Working Papers should be send to.

Pernille Wittrup, Fibigerstræde 4
DK-9220 Aalborg OE
Tel. 45 96 35 82 65
Fax. 45 98 15 60 13
E-mail: druid-wp@business.auc.dk