PILOT
NEWSLETTER
- 2 -

The PILOT project is funded within the European Commission's Key Action Improving the Socio-economic Knowledge Base.

Content

Editorial

Dear readers,

We are happy to present the second issue of the PILOT-NEWSletter. The four articles below give you an overview of the work done in the year of the research project.

David Jacobson gives a general introduction highlighting some aspects of innovation in low-tech industries. The following articles present first results of the work done in three of the PILOT project's research strands. Staffan Laestadius starts with a report on the conceptual work package 1. Johan Hauknes reports on the statistical work package 2. Focal point of this issue of the PILOT-NEWSletter are the company studies conducted during the last months. The article by Klaus Schmierl & Tobias Kämpf summarise results of the first round of case studies. Whereas they provide the broad view on the work done in work package 3 so far, Kevin Heanue is digging deeper. He concludes this volume with a detailed case study of an Irish furniture company.

I hope you will enjoy this issue!

Gerd Bender

PILOT – NEWSletter -2-

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Aspects of Innovation in Low Tech Industries

by David Jacobson[1]

Introduction

There has been an over-emphasis in both academic and policy contexts on the differences between so-called 'high-tech' and 'low-tech' industries. While it is clear that new sectors or sub-sectors do grow rapidly on the basis of the application of new technologies, these new technologies frequently diffuse to 'old' sectors and sub-sectors. In some cases the old, traditional, industries grow more rapidly, or more consistently, over a longer period, than the new sectors. In addition, while not the results of research and development (R&D), there are innovations in low-tech industries that, where they occur, enhance the competitiveness of those industries on international markets. An internationally competitive traditional sector may contribute more to a small economy's prosperity than a new sector that burns brightly but briefly, transferring any innovations to more advanced, larger economies closer to core markets. The aim of this paper is to explore some of these issues.

Measuring the Level of Technology

The standard OECD classification of industries, in terms of level of technology, is based mainly on R&D data. The *Frascati Manual*, developed in the early 1960s, provided – and still provides, in its sixth edition (OECD, 2002) – a basis for collecting and comparing data on R&D. This led to the classification of manufacturing sectors according to R&D intensity (the percentage of total revenue allocated to R&D) (OECD 1986). There was originally a three-position taxonomy: high-, medium- and low-tech industries. High-tech industries were those (such as ICT and pharmaceuticals) spending more than 4 percent of turnover on R&D, medium-tech those (such as vehicles and chemicals) spending less than 4 but more than 1 percent of turnover on R&D, and low-tech those (such as textiles and food) spending less than 1 percent of turnover on R&D. The contribution of high-tech, even to the most advanced economies, is small. Fig. 1 shows that even in the USA, the high-tech share of manufacturing added value is less than 16 percent. Manufacturing in the USA accounts for less than 20 percent of GDP. The net result is that high-tech contributes less than three percent of GDP, and even less in the EU and Japan.

In response to some of the inadequacies of the three-position model, it was replaced by a four-position model (OECD, 1994):

High-tech: R&D/Turnover	> 5%
medium high-tech	5% - 3%
medium low-tech	3% - 0.9%
low-tech	< 0.9%

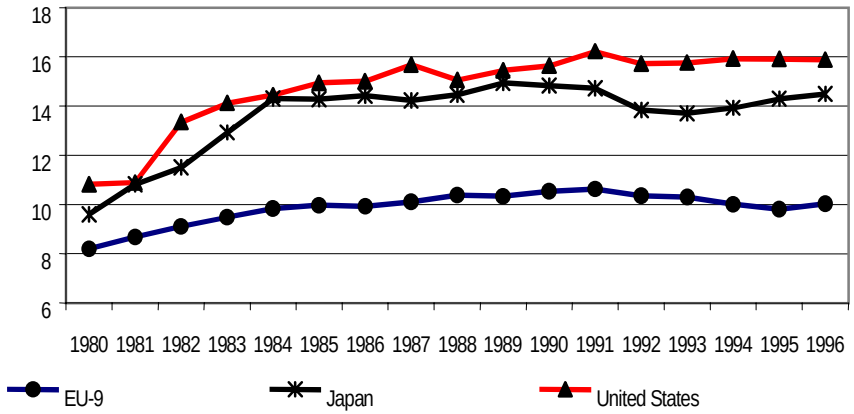
Nevertheless, even with this new classification, even if new EU members are included, and even if more recent years are examined, the shapes of the graphs remain roughly the same, more or less flat

[1] This paper is based on Hirsch-Kreinsen, et al (2003).

since the mid-1980s. Employment in high-tech is actually declining.

Innovation is much more than R&D. But even what must be included in R&D is debatable. Design, for example, aspects of which are explicitly excluded by the *Frascati Manual*, is a fundamental part of the development of a product. The original OECD discussion of the classification was careful to point out that direct R&D is but one indicator of knowledge content. However, in practice, the classification has without this qualification had enormous influence, especially on policy. The EU and its member countries, for example, have turned the aggregate R&D/GDP ratio into a quantitative target for science and technology policy as a whole. This is open to two important objections. First, R&D is by no means the only measure of knowledge-creating activities. Second, it ignores the fact that the knowledge that is relevant to an industry may be distributed across many sectors or agents: thus a low-R&D industry may well be a major user of knowledge generated elsewhere.

Fig. 1: High-tech industries' share of value added for total manufacturing. 1980-1996.



Knowledge and Level of Technology

Knowledge-intensive, and science-based, have become almost interchangeable epithets in describing industries. This encourages the perception that advanced, science-based industries, and in particular information and communication technologies (ICT) and biotechnology industries (BTI), are the only ones that incorporate knowledge, in any serious sense. The focus shifts, as a result, to the need for high levels of education, training and skill acquisition for these industries but not for any others. Among the ironic consequences of this kind of perception by both policy makers and the media, is the recent radical downturn in applicants to third level computer courses in Ireland. Seeing a recession in the computer industry, and the associated reduction in employment in that sector, students, encouraged by their parents, have opted for other courses in colleges and universities. They have turned to arts, humanities and business studies. This is based on a false premise that the only industry in which

computers skills are required, is the computer industry.

There are other consequences of this focus on science-based knowledge. First, it supports the emphasis on R&D – and particularly research – as the basis for industrial growth and economic prosperity. Many firms are innovative without having any formal R&D expenditure, if we understand innovation in the broadest sense as 'the processes by which firms master and get into practice product designs and manufacturing processes that are new to them, whether or not they are new to the universe, or even to the nation' (Nelson 1992). R&D is only one aspect of the system of innovation which can also be defined broadly, 'as a set of actors such as firms, other organisations, and institutions that interact in the generation, diffusion and use of new – and economically useful – knowledge in the production process' (Fischer 2001). Such knowledge also includes knowledge about new or altered products, about ways of organising, as well as about production processes themselves. Accepting a system of innovation approach implies a rejection of the simple form of the OECD definition; 'a too narrow focus on R&D overlooks the importance of other types of innovative efforts in the business sectors and, thus, the innovative performance of low-tech sectors in the economy' (Fischer 2001). This contrast is frequently not realised. An example is a report of the Irish Science Technology and Innovation Advisory Council (1995); even though the report – *Making Knowledge Work for Us* – espouses the national system of innovation as a basis for the development of policy, its main focus is on science and advanced technology, to be achieved through increasing R&D.

A second, related, consequence of the focus on science-based knowledge is a view that formal, codified knowledge is most important for the 'knowledge economy'. Formal and codified can be contrasted with informal and tacit, where the latter implies that the knowledge is derived from experience rather than formal study, and is passed on through interpersonal interaction in the work process, rather than through specific training or education. (For a more detailed definition, see Lam 2000.) Codified knowledge is associated with high-tech, and tacit with low-tech. The reality is much more complex than this. Low and medium tech (LMT) industries in fact do use codified knowledge, employ engineers – and in some cases even undertake R&D. In general, however, this use of educated, trained and skilled people, sophisticated machinery, and advanced knowledge about organising, about logistics and about design, is all relegated because of low levels of R&D. Thus firms like IKEA, Habitat, Benetton and Zara, are in the low-tech category despite their innovativeness.

This not to say that tacit knowledge is unimportant in LMTs. The importance of tacit knowledge, moreover, is closely related to the systems perspective, and to the evolutionary economic theory that underlies it. Most tacit knowledge is obtained through learning-by-doing. It is often based on work practices (routines) and rules that are not necessarily person-

bound; they are rather norms accepted collectively by the employees or the community in question. This leads directly to the collective dimension of knowledge. Collectiveness concerns knowledge stored in the rules, procedures, routines and shared norms of work processes, problem-solving activities and patterns of interaction among individuals. In this sense, the collective side of knowledge is rather to be found between than within individuals. It can be more or less than the sum of the individuals' knowledge, depending on the mechanisms that translate individual into collective knowledge (cf. Lam 2000). The arguments by Teece (2002) are similar and link this to competitiveness: the ability to translate (individual) resources to (firm) capabilities is what constitutes firms' competitiveness. Tacitness of knowledge is not the only defining characteristic of low-tech activities, but it is clear that this concept points us towards important problems in knowledge creation and learning. Moreover, there is nothing in this discussion that excludes tacit knowledge from low-tech activities in high-tech firms.

In addition to codified and tacit knowledge, for the purposes of the present research we use the term 'practical' knowledge. This is similar to tacit knowledge in that it is gained through the specific work experience. Practical knowledge, however, also includes some codified knowledge, in the sense of informal, written rules that may replace formal instruction manuals. So practical knowledge is tacit knowledge plus elements of informal codified knowledge.

Another problem in the definition of knowledge is the difference between knowledge and competence – with a science focus emphasising the former. A recent study on the dynamics and characteristics of firms' relations to external repositories of knowledge (Hales 2001), demonstrates that a distinction between knowledge as furnished by external repositories or 'knowledge bases' and the productive competence[2] underpinning firm-level innovation and behaviour is essential for understanding the 'learning processes' of innovating firms. Rather than 'knowledge intensity', this implies that the relevant driver is 'competence intensity'. Although formulated somewhat differently this perspective is present in several discourses on knowledge formation and creation of firm capabilities. Cohen and Levinthal (1990) for example use the concept 'absorptive capacity' and Teece et al. (1997) and Zollo & Winter (2002) use 'dynamic capability' to address these issues. The competences and capacities are not necessarily R&D-based, and may involve many non-technological dimensions.

Organisations with high levels of competence do not necessarily have high levels of knowledge, and vice versa. Firms with high levels of R&D are clearly knowledge intensive. They may not be competitive in their industries and may therefore

[2] Hales (2001) defines competence broadly as something that determines a firm's competitiveness. It includes people, and capital and equipment; characteristics that qualify a firm to be in an industry, or those that enable it to lead or innovate; and competences are seen both as resources and assets.

have low competence intensity. Firms that have a core competence in simple assembly functions may not be knowledge intensive but, if they are competitive in their industry, they are by definition competence intensive. In the extension of this family of arguments we face the complexity of knowledge formation in agglomerations, in networks, and in supply chains. The dynamics and synergies within these structures and collaborative relations are far from easy to capture and locate to specific actors/industries.

Networks, Industrial Agglomerations, Clusters

Despite this lack of specifiability, among the clearest examples of groups of low-tech firms that became competitive and sustained that competitiveness over long periods, are the industrial districts of the Third Italy. Most of the industrial districts are in traditional sectors like clothing, textiles, footwear, furniture and ceramic tiles. There has clearly been something about the combination of place, culture and proximity that has contributed to the success of these industrial districts. Other agglomerations, like that in Silicon Valley, are high-tech; successful agglomerations are not synonymous with low-tech. The literature on clusters and industrial districts is now vast and too well-known to require summary here.[3]

It is worth pointing out, however, that there is a close relationship between the literature on industrial districts and work on learning and innovation. Systems of innovation theories, for example, attributing a critical role to technological, organisational and institutional learning in the process of innovation, stress that learning is an interactive and socially embedded process (Lundvall 1992; Fischer 2001). Industrial districts, in which inter-firm co-operation is facilitated by spatial proximity, provide support for the idea that spatial proximity is important in promoting interactive learning, innovation and the development of competitive advantage. Lorenzen (2002) takes this idea further, providing theoretical arguments for ascribed trust being at the heart of the way in which a kind of shared understanding develops in networks of firms. Some of this can be codified, especially in relation to 'hard' information such as business data on revenue and profits. This does not particularly require proximity. In addition, even exchange of 'complex, tacit, and "embodied" information' – though requiring trust, and 'frequent face-to-face interactions', and though helped to some extent by proximity – is 'not severely inhibited by geographical distance'. However, to derive benefit from high levels of social trust, sharing in local culture, being part of a community and its rich social capital, does require close proximity. The 'social learning processes that create social codebooks... are constrained by geography', Lorenzen argues, and 'hence "cultures" arise locally – for example in industrial clusters'. All these are highly tacit, the costs of their development appear nowhere (and certainly not under R&D expenditure), and yet they contribute substantially to the innovativeness of what Lorenzen calls industrial clusters. His contribution to the development of

[3] See, for example, Jacobson et al (2002) and Jacobson & Mottiar (1999).

theory in this area provides a basis for relating the social and cultural to the economic, in a way particularly relevant to LMT industries.

Organisational proximity is of a non-material and non-market nature (Burmeister & Colletis-Wahl 1997), and it 'presupposes the existence of shared knowledge and representations of the environment within which the firm exists' (Hudson 1999) Through interactions in intra-industry relations, co-operation and collective learning processes, organisational proximity creates a capacity to assemble fragmented information, tacit knowledge and other non-material and non-standardised resources. Information originating outside the network is received in a qualitatively better way, due to organisational proximity among the actors. The existence of organisational proximity – formal and/or informal networks – enhances absorptive capacity. Organisational proximity is viewed as a prerequisite for collective learning processes, and for co-operation among different organisations in the creation of new resources and innovation. While organisational proximity is a necessary condition for creating innovations and resources through processes of collective learning, it is also simultaneously a product of the process of collective learning.

Heanue & Jacobson (2002) provide empirical evidence of organisational proximity in the case of a dispersed network of three firms in the furniture industry in Ireland. They show that these firms share values, meanings, understandings and tacit knowledge and a common set of institutions through which these features are produced. The most important mediating institution in this case was the Irish industrial development agency, Enterprise Ireland. The individual involvement of each of the firms over time in various industry initiatives with Enterprise Ireland not only contributed to the development of a shared 'worldview', but it also enabled the firms and institution together to identify suitable partners for the current network.

The empirical focus of this work was a geographically dispersed formal network. In contrast, Dahl & Pedersen (2003) examine the case of regionally clustered informal networks. The theoretical context of their work is the recent importance attached to the role of informal networks in the development of regional clusters. In particular, informal contact between employees in different firms is argued to be one of the main carriers of knowledge between firms in a cluster. They empirically examine the role of informal contacts in a specific cluster. The analysis, based on a questionnaire sent to a sample of engineers in a regional cluster of wireless communication firms in Northern Denmark, shows that the engineers acquire and share valuable knowledge through informal networks. The authors argue that this shows that informal contacts are important channels of knowledge diffusion. Again it must be emphasised that firms gaining from this diffusion of knowledge do so without any specific R&D effort; in this case the firm gains without any explicit effort at all. Clustering and knowledge exchange of these types appear to be a pervasive feature of LMT industries (Isaksen 2001),

and it is this that links the innovation and growth potential of LMT industries to important regional issues in Europe.

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Elaborating a conceptual framework – work package 1 in year 1

by Staffan Laestadius, KTH

The main objective of work package 1 (WP1) in the first project year was to shape the conceptual framework for the 'empirical' work packages 2, 3, 4, and 5, ensuring that the consortium shares a common understanding and stable perspective. At the kick-off meeting in Dortmund on February 12-13, 2003 seven problems on the research agenda were preliminarily identified:

The taxonomy problem, the 15 year old classification problem (high-tech, low-tech etc).[4]

The knowledge formation problem, i.e. the problem whether the high/low-tech discussion depends on a too simplistic model for knowledge formation in industrial and technical activity neglecting phenomena such as tacitness, acquisition and absorption as well as design.

The new economy illusion, i.e. the fact that the high-tech discourse to a large extent has developed during a long upswing period since the mid 70s, now followed by a shake out among several high-tech firms.

The strengths of parts of the old economy, i.e. the fact that there are surprisingly many industries – including services – which normally are identified as non high-tech but nevertheless have been rapidly growing during the last decades.

The difficulty to use a traditional innovation concept. This concerns at least three aspects. (a) The relative decline of raw labour and the increase of cognitive dimensions in human labour opens for a situation with dramatic increase of 'innovative' work (cf. biotech and telecom firms). How to handle that? (b) About three-quarter of economic activity in industrial countries are classified as services. It is far from obvious how innovations can be identified within these activities. (c) The design problem; it may be argued that the design dimension has been neglected in the S&T biased innovation discourse.

The *temporal character of innovations* in the 'new' economy. That is, the problem whether the life time for innovations is declining in information society (new digital devices every year and substituting new software for well functioning old ones) and the general problem of creative destruction.

The acquisition problem, that is, the penetration of new technologies into old industries and technologies.

It was suggested that participants during the first eight months of the WP1 work should select these – and related – research questions and prepare papers to a proposed seminar.

This seminar, the 'PILOT Workshop on concepts, theory, taxonomies and data' was held at Royal Institute of Technol-

[4] The OECD classified manufacturing sectors according to R&D intensity: Low-tech industries (and companies) spend less than 0.9% of the turnover for R&D and medium low-tech industries less than 3%; OECD (1994), *Science and Technology Policy – Review and Outlook*, Paris.

ogy, Stockholm on September 26-27, 2003. The workshop was open for participants outside the PILOT project too. 18 persons attended the sessions or parts thereof. One of the main topics was a discussion of the state-of-the-art paper.[5] All together ten papers were presented and discussed at the seminar – all of which were related to either WP1 or WP2 and many of them directly related to the problems specified in Dortmund:

Low-tech industries and the knowledge economy: state of the art and research challenges (Hirsch-Kreinsen, Jacobson, Laestadius & Smith).
This 50p report reviews the literature and state of the art in research of relevance to the 'low-tech discourse'. The high-tech race is analysed as is the role of science in industry and technology and a more broad approach to knowledge formation in industry and technology.

Distributed knowledge bases in low-tech industries (Smith)
The paper discusses the fact that low-tech industries to a large extent synthesise – or are the means to add/create value to/of knowledge generated elsewhere in the economy (see Hauknes in this issue).

Knowledge and innovation in low-tech – some preliminary hypotheses (Bender & Hirsch-Kreinsen)
Based on early case study experiences within the PILOT work package 3 this paper questions some of the common wisdoms among 'low-tech researchers'.

Networks of firms as knowledge system – concepts and transformation (Bardi, Garibaldo & Freddi).
The consequences for network dynamics by the disappearing of the Italian industrial district is discussed in this paper.

Receptive capacity of established industries as a limiting factor in the economy's rate of innovation (Robertson, Pol & Carrol)
The role of low-tech firms as (dynamic) suppliers and customers for the high-tech firms is discussed in this paper (see Hauknes in this issue).

The behaviour matrix: a method for assessing the impact of knowledge acquisition in SME:s (Shelby)
This paper develops the concepts adopter and adapter as regards acquisition of technology among low-tech firms.

Measuring the right thing – the problem with S&T-based indicators and taxonomies (Laestadius)
This paper discusses the role of indicators and taxonomies for industrial policy and analyses some of the arguments for a new taxonomy.

Evolution of networks around software multinationals in Ireland (Jacobson).
This paper discusses the low tech character and lacking dynamics of the world leading high-tech exporting country, Ireland.

From product oriented business towards service oriented business concepts – impacts on innovation in traditional low-tech industries (Hyvönen, Palmberg & Loikkanen)
This paper addresses service sector problems.

[5] This report is available on www.pilot-project.org/publications/publications.html.

Economic development in Europe 1980-2000 – a statistical low-tech overview (Hauknes)
Based on preliminary statistics this paper indicates the strength of the old sectors/ industries in recent growth (see Hauknes in this issue).

The final discussion of the workshop dealt with two topics: further work in WP1 (and WP2) and the theoretical and methodological input for WP3 to be delivered at a work package meeting in Munich the following week. That input included:

1. A concept to map knowledge formation processes focusing on
(a) The *knowledge base:* activities, (what are they in fact doing); techniques (an activity may be built upon synthesizing a set of different techniques); knowledge (what kind of knowledge, tacitness, practical, science based); sources (institutions, organizations, professions, embodied in machinery).
(b) The *network character* of knowledge formation processes (formal, informal, regional, knowledge relations).
(c) The *acquisition/reception* processes (purchasing, large installations, learning by using/doing, disembodied and embodied knowledge, relations to knowledge providers).

2. An advice to capture the dynamics of the creation of capabilities, including modes of innovation (how is novelty generated, how are processes and products being changed), entrepreneurship and business ideas, and the creation of (dynamic) capabilities (in a wide sense, i.e. outside the traditional understanding of innovation).

One of the core problems in the 'low-tech discourse' – the measurement problem – was the theme for the WP1 input to the Bologna project meeting on November 28-29. Based on a discussion on the origin of the innovation concept the paper argues that an advanced knowledge based economy where industrial activities have been dramatically reduced will face problems to identify what activities to classify as innovative. It is far from obvious that a broadening of the innovation concept in the Oslo Manual[6] will provide the useful data and information.

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[6] OECD (1997), Proposed guidelines for collecting and interpreting technological innovation data. Paris

Macro level analysis – work package 2 in year 1

by Johan Hauknes, STEP Group

The Stockholm workshop mentioned in Staffan Laestadius' article was organised as a joint discussion forum for WP1 and WP2, and it was generally agreed to keep the work in these two work packages integrated. The main reason for this is that beyond the statistical analysis of growth patterns in Europe, the work in WP2 will benefit substantially from being developed in close collaboration with the theoretical perspectives and developments of WP1, and vice versa. We have therefore decided to reorganise the schedule of WP1 and WP2 work package meetings, to allow for two joint workshops in the remaining project period.

The activities of WP2 in the first year has been focussed at four areas:

(1) Contributions to the state-of-the-art paper *Low-Tech Industries and the Knowledge Economy: State of the Art and Research*

(2) The acquisition and preparation of international data sets allowing analysis of national and European patterns of economic development during the last decades. As part of this a preliminary version of a data inventory has been prepared, describing main aspects of internationally comparable data sets, prepared by different international organisations and agencies. We have chosen to focus primarily the OECD STAN data base, supplementing with data from the OECD National Accounts data base where valuable. These data give us a broad structural decomposition of member economies over a long time period. Other sources are UNIDO data on economic structure and production; the Penn World Table (aka. Summers & Heston data), version 6.1 (October 2002), prepared by the Center for International Comparisons at the University of Pennsylvania; and EUROSTAT data, primarily as regards access to and exploitation of the Community Innovation Survey. Additionally we need access to other European economic and social statistics and micro data integrated by EUROSTAT. Access to these data falls under Community Regulation 831/2002, *Community Statistics, concerning access to confidential data for scientific purposes*, cf. OJ L133, 7-9 (18.5.2002). EUROSTAT has recently informed us that the implementation of Reg. 831/2002 has been seriously delayed, with access not before Autumn this year.

(3) Preparation of three discussion papers for the PILOT project (see below).

(4) The preparation of a first statistical survey of growth and structural change in manufacturing industries in Europe in the 1980s and 1990s.

The Discussion papers

(a) Paul Robertson et al, Receptive capacity of established industries as a limiting factor in the economy's rate of innovation

Although scholars and policy makers have widely acknowledged the importance of so-called high-technology in-

dustries as drivers of economic change, they have paid insufficient attention to the interaction between high-tech sectors and the remainder of the economy in developed countries. The paper argues that any constructive view of economic change must recognise the importance of the diffusion of innovative products and processes to the economy as a whole through the role that firms in established sectors play as customers and suppliers for high-tech firms. It is important to insure that these firms' 'Receptive Capacity' is as high as possible.

To demonstrate their point, the authors first use 'old' growth theory to develop a model of economic change and then show how this model ties in with 'new' growth theory by providing a convincing justification for investment in R&D and other innovative activities. They argue that innovation is a complex process and that policies to encourage economic growth need to reflect this. In particular, the health of more mature 'Recipient' sectors of the economy deserves as much attention as do the interests of the newer 'Enabling' sectors that are often the loci of major innovations. In the absence of backward linkages from the Recipient sectors that comprise the vast bulk of modern economies to the innovative Enabling sectors, there would be little incentive for investment in R&D.

In contrast to Schumpeter and Rostow, but consistent with the arguments of Dahmén, Carlsson and Eliasson, the authors contend that, from the standpoint of economic growth, the development paths of innovative sectors in mature economies cannot meaningfully be discussed independently of the development paths of established (Recipient) sectors. Thus, from a policy perspective, it may cause serious harm if emphasis is placed on encouraging innovative sectors at the expense of established ones. Except perhaps in the case of defence products, the ability of innovative firms to survive and prosper depends on the extent to which they are able to fit into the context of established industries that dominate mature economies.

The fates of Enabling and Recipient industries are frequently mutually reinforcing. While Enabling sectors provide pecuniary externalities and an ability to develop improved and more attractive products for Recipient industries, the recipients provide the markets that innovative firms need to take advantage of economies of scale and amortise their R&D expenses. Creative updating and replacement is often a necessary complement to creative destruction.

As for the policy implications of the argument we should note that the rate of knowledge generation and hence the rate of innovation in an economy depends heavily on the expected level of profits from the R&D activity required. This, in turn, is a function of the expected size of the market for the fruits of new knowledge. It is well-known that the diffusion of new technologies can be prolonged, particularly in the case of systemic innovations such as electrification, the spread of the private automobile, and more recently, the use of computers for business and personal purposes. One important

way of inducing the generation of knowledge and innovation, therefore, is to speed up the rate of diffusion. This is especially true when the rate of technological change is seen to be high and the time periods needed for amortisation of R&D expenses are correspondingly short. As a result, serious thought should be given to finding ways of increasing the receptive capacity of firms in established industries – to boosting their access to the intellectual, physical, and financial resources needed to adopt innovations quickly.

(b) Keith Smith, What is the 'knowledge economy'? Knowledge-intensive industries and distributed knowledge bases

The economics of innovation has always focused on learning, just as public policies for science, technology and innovation have always been aimed primarily at creating and diffusing knowledge. In recent years such policies have attracted increased attention as a result of claims that knowledge-intensive industries are now at the core of growth, and that we are now entering a new type of knowledge-driven economy or even a completely new form of knowledge society. But what do we mean by knowledge, and what does it mean to speak of a knowledge-intensive industry or a knowledge-based economy?

The paper firstly examines what various authors mean by the concept of a knowledge economy or learning economy. Four broad approaches are outlined and assessed. The belief that knowledge is quantitatively and qualitatively more important as an input to production. The idea that knowledge is in some way more important as a product than it has been hitherto – that we are seeing the rise of new forms of activity based on the trading of knowledge products. The view that codified knowledge (as opposed to tacit, person-incorporated skills) is in some ways more significant as a component of economically-relevant knowledge bases. And the idea that the ICT revolution implies a fundamentally new role for knowledge in economic processes. The conclusion is that some of these claims are unsustainable, while others represent real trends. Yet none have either the conceptual or empirical substance to justify claims that we are entering a new type of 'knowledge economy'. This leaves open the question of how and why knowledge is important at the present time.

Secondly, the paper explores the use of knowledge across sectors of the economy that are not normally regarded as high-tech. In exploring this issue, the paper first uses Community Innovation Survey data to describe some empirical dimensions of knowledge creation in Europe, and then turns to concepts and a methodology for mapping the knowledge base of an economic activity. The aim is to generate a more nuanced understanding of the meaning of 'knowledge intensity' in production. The paper argues that it is important to turn from direct indicators of knowledge intensity in production, to an approach based on what the paper terms distributed knowledge bases that have a more systemic and institutionally diffuse location. Knowledge for many key activities is distributed among agents, institutions and knowledge fields, and the problem is to understand the embodied

and disembodied knowledge flows between them. Empirical examples of such knowledge bases are described, in the offshore oil and gas sector and the food processing industries. The paper concludes by discussing how such distributed knowledge bases might affect our conceptions of the knowledge economy, and links this to current policy challenges.

(c) Johan Hauknes, Innovation and economic behaviour. Need for a new approach?

This paper addresses two interrelated questions: (a) what has been learnt about the contents and characteristics of innovation – of new economic activities in commercial firms – in the last decade? And (b) how does the OECD/EUROSTAT Innovation Manual (Oslo Manual) framework address these issues? The discussion is based on the objectives of the Oslo Manual in its two previous editions and on the rationale behind its initial development during the 1990s. The paper is focussed on the conceptual foundation of the Manual and the relevance of this foundation for the purposes it has been designed to address.

A crucial point for any attempt to organise sustained efforts into mapping innovation and innovation performance must be to ensure that this conceptual basis is in line with the results and implications of recent socio-economic research on innovation and its impacts. This raises questions first of all of the validity of concepts and principles organising data collection and analysis across industrial sectors and different market structures, and secondly of the proxy character of technological product and process innovations for mapping innovation dynamics at firm level across sectors and markets. The answers to questions as these are intimately linked to the objectives of the data collection – what analytical questions, policy issues and indicator problems are addressed. In revising the OECD/EUROSTAT Innovation Manual we have to ensure a reflexive and unbiased conceptual framework for innovation mapping, providing a ground for relevant both research and policy analysis and allow generation of comparable and realistic innovation statistics. Questions as these have implications for how the revision process is planned and what issues are to be addressed in this process.

The Oslo Manual – a core part of the Frascati family of S&T statistics and indicator manuals, has now passed its tenth anniversary. At start of its development it was a highly innovative and explorative initiative, attempting to cover an essentially white part of the map of the economic S&T landscape. Just as the Frascati Manual contributed to refocused and improved science and research policies in industrialised countries during the 1960s, the Oslo Manual gave a strong impetus to the development of innovation policies in the 1990s. In the intervening years the Oslo Manual has proven its value and merit manifold – the initiative and the orientation it was given in 1991-92 was both right and important. However, at the time it was also a highly explorative initiative – hence, a core part of the aim of launching the Oslo Manual was to start a learning process, with a continual feedback between data collection and statistics generation on the one hand and on the other hand analysis of the data gen-

erated, experiences in the use of the associated indicators and wider socio-economic research on innovation constraints, processes, capabilities and impacts, as well as policy use and requirements. So, a vital question at this juncture in time is what have we learnt in the intervening ten years about innovation activities and their impact, how have the requirements to innovation statistics and related analysis changed, what do we know of innovation as a competitive tool for companies today and that was not included as part of the basis for the Innovation Manual. In the light of all this; what does present innovation data really tell us – and does it really provide answers to the questions that still lies at the core of the Oslo Manual?

The statistical survey

Low tech industries in European growth performance: A statistical overview over main indicators for European Manufacturing industries 1980-1996

The purpose of the statistical analysis is to outline major patterns of recent economic growth in Europe and elucidate how various industries and sectors contribute to this process. In classifying national and European level specialisation patterns, we will use the criteria of various OECD taxonomies to identify high-, medium- and low-tech industries, as well as distinguishing resource- and knowledge-intensive industries to characterise major patterns of structural change at the national level. An overview and analysis based on international comparable data will compare growth performance between Member States and within the Triad comprising the European Economic Area, US and Japan. This analysis will be based on OECD data – mainly on the OECD STAN, ANBERD and National Accounts databases – and on EUROSTAT data – primarily data from the New Cronos database. A preliminary report was produced for the PILOT consortium during the last months

This report comprises the first statistical overview of main indicators and data taken from internationally comparable OECD data. We use these data her to characterise aspects of the economic development in Europe during the two decades since 1980. Indicators have been constructed both on the level of individual countries, with an emphasis on the PILOT partner countries, and where available at the European level to facilitate a comparison within the triad between Europe, US and Japan. In line with the limitation that was imposed on the PILOT project, we have limited this analysis to manufacturing industries.[7] In line with the PILOT work plan, the report is based directly on the OECD taxonomy. At this stage we take this taxonomy and the associated industrial classification as given and utilise it as the basis for grouping industries and sectors in presenting the indicators chosen in this report.

The major objective of the report is to present in a concise form trends and di-

[7] For a European statistical survey of service industries and related data issues, see Hauknes (1996): *Innovation in the service economy*, Preissl (1997): *Services ın Europe: Patterns of Growth And Development*, and Hauknes (1998): *Services in innovation – Innovation in services*.

rect contributions to growth in manufacturing in the triad. The report is meant to provide some empirical and analytical inputs into the discussions about the next step of the PILOT project, as regards the design and execution of more disaggregated studies of innovation and growth performance of low-tech industries behind the general economic trends and the observed growth contributions. After a short presentation of relevant data sources to PILOT and of the data sources used in this report we focus on a comparison of European[8] developments with those of the triad. We show how the manufacturing sector (NACE[9] 15-37 industries) developed in the period 1980-1996 compared to the rest of the economy. Then, we concentrate on the description of trends within manufacturing industries in the triad based on *six key indicators*. These are:

1. Shares of total value added in manufacturing.

2. Shares of total employment in manufacturing.

3. Labour productivity (i.e. the ratio of constant price value added to employees engaged in a group of industries).

4. Distribution of R&D expenditures (i.e. R&D expenditures for a group of industries (low tech) as a percentage of R&D expenditures for total industries).

5. Investment shares in manufacturing (i.e. gross fixed capital formation (GFCF) in a group of industries as a percentage of GFCF for total manufacturing).

6. Export specialisation (i.e. a country's exports for a group of industries as a proportion of total manufacturing exports divided by OECD exports of the same industry as a proportion of total manu facturing exports).

At last we study trends in the industrial distribution of value added in the manufacturing sector. This allows us to get a first picture of the rapidity – or slowness – of structural change at national level at the sectoral aggregation level that is available in OECD statistics. The purpose of this analysis is twofold; firstly to identify for each partner country the dominant sectors of manufacturing, and secondly to get an indication of the changes in these distributions over a moderately long time period (1990-2000).

A recent OECD study showed that growth disparities across the OECD economies have widened in the 1990s compared with the previous decade. While USA and some smaller countries (Australia, Ireland and Netherlands in particular) saw an acceleration in growth, others, mainly large continental European countries and Japan, saw a slow down in the pace of growth. Decomposition of GDP per capita growth shows that both labour productivity and employment rates are key variables in explaining these divergent

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[8] In this study we focused on EU-9 area – that is, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, and UK for better industry and period coverage – and on the countries participating in PILOT-project for which there are data available.

[9] NACE stands for *Nomenclature Générale des Activités Economiques dans l´Union Européenne* which is based on the UN International Standard Industrial Classification of all Economic Activities

patterns.[10] Growth in labour productivity can partially be explained by the enhancement of 'human capital' amongst those in employment, but also by the exclusion of the low-skilled from work. Labour productivity and formal skills of labour force in low tech should, therefore, be an important area also in PILOT research.

In contrast, the study presented here reveals a remarkable *stability* in the structure of manufacturing value added and employment all over the triad. Trends in labour productivity as well as trends in physical investment and export specialisation patterns in low-tech industries vary considerably between countries and between the economic regions in the triad.

Simple regression analysis of these indicator data suggest that differences in labour productivity is a good explanatory variable of export specialisation differences in high-tech, but not in low-tech industries. This issue must be econometrically researched more carefully to go beyond the suggestive indication presented here. This is part of the further obligations of work package 2 for the next year. Finally, we wish to stress the need and importance of studying trends in industrial development at a more disaggregated level than the one pursued here and in combining this analysis with aggregated data on innovation activities and performance in relevant industries. This is another point on the WP2 research agenda for the next months.

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„Low-tech companies" – some preliminary remarks on production, knowledge and innovation in low-tech industries

by Klaus Schmierl, Tobias Kämpf, ISF Munich

In this article we present first results of the company case studies conducted during the first year of the PILOT project (i.e. Work Package 3: Investigation of knowledge generation and utilization in selected low-tech firms).

WP3 research design

Basic hypothesis of the PILOT project is that low-tech and medium low-tech industries are highly relevant for growth and employment in the European economies (Hirsch-Kreinsen 2000; Hirsch-Kreinsen et al. 2003; Smith 2003a). This hypothesis stands in contrast to the widely held conviction, that it is most and

foremost high-tech-industries that are the main engine of economic growth and, hence, social welfare.

This basic hypothesis will be tested through conceptual and quantitative research (done mainly in WP1 and WP2)[11] as well as qualitative work based on extensive case studies. WP3 is a major work package for the latter. The focus here is on innovation processes, organisational strategies, management processes and human resource policy of a selection of about forty firms in the participating countries (plus Lithuania). Particular emphasis will be put on mapping the companies' knowledge bases.

It goes without saying that in a project as big and multi-disciplinary as PILOT particular attention has to be paid to ensure comparability of the individual research results. The methodology the research team implemented to guarantee this is described in the following subsections.[12]

[11] See PILOT-NEWSletter No. 1 for an overview of the research design.

[12] The detailed work programme was discussed and fixed during three PILOT meetings in Dortmund (12-13 Feb, 2003), Oviedo (23-24 May), and Munich (3-4 Oct).

Selection of sectors

The field of low-tech industries and medium low-tech industries is extremely wide and heterogeneous. Hence, one of the first methodological tasks of the PILOT team was to come to a reasonable understanding on the sectors on which the empirical research should focus. The selection was based on results of a statistical evaluation as part of WP1 and WP2 (STEP 2003; Hauknes 2003; Laestadius 2003). We decided that each project partner will conduct half of his or her case studies in a sector which will be the same for all partners. This common sector is *Manufacture of fabricated metal products, except machinery and equipment* (NACE DJ.28). The other half of the case studies is determined nationally on the basis of a range of pre-selected sector, namely

- food, beverages & tobacco (NACE Subsection DA), or
- textiles, apparel & leather (NACE Subsections DB and DC), or
- wood products (NACE subsection DD) & furniture (NACE DN.36), or
- paper, paper products & printing (NACE subsection DE).

Main criterion for the final selection was a sector's importance in the state or region in terms of growth and/or employment.

As for the qualification of a company as a PILOT case we determined three criteria. It has to be

- *innovative* (regarding products and/or processes),
- economically *successful* and of a
- critical *minimum size* (preferably more than 50 employees).

Furthermore, at least one of the selected companies/plants should have close links with a high-tech partner (e.g. supplier, customer, consultant).

Research instruments

One main research method of the case studies are interviews with representatives of the companies (managers, staff, works councils etc.). A common half-standardised *interview guideline* was de-

veloped. It is structured into the nine thematic clusters shown in following table and a whole set of exemplary questions for each of them which are then adapted to the individual researchers needs (in terms of content and language).

Thematic clusters of the interview guideline

- Knowledge base
- Ways to generate and use knowledge
- Patterns of innovation
- Interchange with high-tech partners
- Other cooperation regarding innovation
- Influence of market conditions on innovative behaviour
- Recent organisational change
- Workforce policy / industrial relations

In addition to the guideline a *standardised questionnaire* is employed in each company, to gain the most important quantitative data (e.g. turnover, number of employees, sum spent for R&D).

The first case studies

After each partner had conducted a first pilot case study we had a work package meeting in Munich to discuss results. Purpose of this first round of empirical field work was not just to collect data, but also to test the two instruments. In general they have proved useful and applicable.

An overview of the first companies investigated is given in the following tables. They cover a wide range of different economic low-tech and medium low-tech sectors reaching from a 'classical' low-tech mass producing furniture company to a manufacturer of ship propellers and a producer of finest paper for a niche market. The differences in size of the selected companies too reflect the heterogeneity of the low-tech industries in Europe. Finally the sample embraces family owned firms as well as subsidiaries of multinational corporations.

First findings

Because of the low number of cases examined so far, the following examination will be rather descriptive than explanatory.

The production processes

We start off with the firms' production processes. There are two questions guiding the analysis: *What* are low-tech companies doing (activities)? And *how* do they do it (techniques/technologies)?

The production process of most of the investigated companies can be characterised as rather complex. Mostly quite sophisticated forms of line production with a high level of automation are employed. Therefore, the use of latest automation technologies is required. Not surprisingly CNC machinery is here in many cases common. A striking example for this is the case of the Finnish ship propeller manufacturer. They employs the world's biggest robot grinding line.

Advanced ICT and CAD technologies play an important role in nearly all of the

cases. Business Software systems such as SAP R3 seem to grow more important for some of the firms.

Nevertheless, the sample also contains companies with more labour-intensive work processes and/or simple standard machinery. An outstanding case is here the German producer of quality paper, one of their paper machines is more than 100 years old.

Hence, the least you can say is that the broad term 'low-tech' covers an extremely wide range in terms of both organisation and technology of production reaching from highly sophisticated technology and processes to standard machinery and simple manufacturing. Such a co-existence of different modes of production can even be seen within a single plant. It happens that some segments of the production process are characterised by complexity and very modern machinery, while others are rather simple, less modern and much more labour-intensive. An example is the Italian car wheel manufacturer, whose production process is segmented into apparently uncritical phases (e.g. mould production, prototype production, heat treatment) and critical ones (casting, design, feasibility studies).

It may be useful to analytically differentiate within a low-tech company's production process between relatively uncritical *routine phases* and knowledge-

Fig. 2: First Case studies

PILOT project partner	Royal Institute of Technology Stockholm	Step Group Oslo	Technical Research Centre of Finland, Helsinki	Technical Research Centre of Finland, Helsinki	University of Dortmund	University of Oviedo
Country of the case study	Sweden	Norway	Finland	Lithuania	Germany	Spain
Sector	Fabricated metal products	Fabricated metal products	Fabricated metal products	Fabricated metal products	Wood products & furniture	Fabricated metal products
Main activities	Manufacturer of hand tools	Producer of sockets, plugs and switches	Manufacturer of ship propellers	Metal working – e.g. for buildings	Manufacturer of furniture (swivel chairs)	Manufacturer of railway parts
Employees (rounded)	360	250	40	50	500	150
Turnover in Mill. € (rounded)	33	440	4	1,5	100	18

and communication-intensive *critical phases*. Then one can test the hypothesis that it is the critical segments which are more important for a firm to be successful and competitive. Following this line would also help to map actors and resources (knowledge, skills, experience and others) inside and outside the company which are vital for its success.

Whether a segment of the production process is critical or not is not just a technological questions but varies depending on the product, process requirements and in particular on the business strategy and the markets. Packaging and delivery for instance are unproblematic processes in most of the company cases but the most critical segments for some others (such as the German furniture firm and the Austrian producer of industrial textiles). Unsurprisingly, this has consequences for e.g. rationalisation and investment as well as innovation strategies.

PILOT project partner	Austrian Institute of Economic Research, Vienna	Catholic University of Lublin	Dublin City University	Institute for Labour Foundation, Bologna	Institute for Social Research Munich	Jagiellonian University of Krakow
Country of the case study	Austria	Poland	Ireland	Italy	Germany	Poland
Sector	Textiles, apparel and leather	Food, beverages & tobacco	Wood products & furniture	Fabricated metal products	Paper, paper products & printing	Paper, paper products & printing
Main activities	Producer of industrial textiles	Manufacturer of frozen fruit and vegetable	Producer of living room, dining room and bedroom furniture	Manufacturer of car-wheels	Producer of finest paper	Printing house
Employees (rounded)	500	220	60	360	100	120
Turnover in Mill. € (rounded)	70	5	3	40	20	4

To sum this part up, one may say that the case studies so far reveal a broad variety in terms of productions processes. They show that little or no investment in intramural R&D does by no means indicate simple production processes and little usage of modern technologies (cf. Schmierl 2000a, 2000b). It goes without saying that all of the companies use computers, some of them work with highly sophisticated machinery to run very complex processes. So what they actually do is not low-tech at all. On the other hand we find examples that seem to approve a simplistic under-

standing of low-tech industries. But even in these cases it sometimes showed that literally next door the work and the machines looked much different.

There are two basic findings of the first round of case studies which will be elaborated further in the ongoing research.

- As far as production processes are concerned there is no such thing as 'the low-tech company' (or 'the low-sector') but – as in the case of high-tech companies – a very broad variety in terms of organisational as well as technological characteristics.
- Production processes of low-tech companies are – as in the case of high-tech companies – not necessarily homogeneous but may be composed of organisationally as well as technologically different segments. To cope with this complexity might be one key to success.

The knowledge base

No sound person would ever claim that knowledge plays no important role in low-tech industries. But the fact that such companies are by definition not engaged in the development of scientific knowledge is conducive to the emergence of two prejudices. Namely that (1) scientific knowledge is irrelevant for them and (2) that their production and business processes are somehow simple and that, therefore, one needs not to know very much to do it. Statement (1) is in many cases simply wrong but as only a few of the first case studies focused on this we will name just a few examples and will come back to the point in more detail in a later issue of the PILOT-NEWSletter.

The simplicity thesis (2) stands in strict opposition to one of the hypotheses of the PILOT project that a low-tech company may indeed turn out to be highly knowledge-intensive when you give up the bias on scientific knowledge. If you take this as a conceptual starting point the problem becomes much more complex. Then one can ask what kinds and forms of knowledge are relevant for a company's business, where they are located, how they can be combined, and how they are integrated to form permanently reproduced capabilities (for a conceptual discussion on capabilities see Hauknes 2003). A first step to answer questions like these is to reconstruct the specific *knowledge base* as a major part of the company case studies.

Again quite unsurprisingly, the case studies show that the knowledge bases of low-tech companies can be described as *polymorph*. When it comes to production and product design various forms of knowledge are used in one or more of the investigated firms – knowledge embodied in machinery, practical knowledge of blue-collar workers, technical knowledge of skilled workers and engineers, scientific knowledge generated elsewhere to mention just a few.

The latter is perhaps most evident in the case of the Finnish manufacturer of ship propellers. They are able to combine practical knowledge in very traditional propeller design and casting techniques with sophisticated theoretical knowledge in hydrodynamics and CAD-based mathematical modelling. The Swedish

tool producer collaborates with a scientific institute for ergonomics in order to improve product-design. Nevertheless, there is evidence that in general direct interchange with scientific establishments plays a less important role in low-tech sector than in high-tech sectors. But it is also true that low-tech companies sometimes need to have and in fact have capabilities to adopt and integrate scientific knowledge into their internal processes. This is one of the reasons why most of the firms employ engineers or even scientists.

But the development of capabilities to integrate distributed knowledge is an important point not only in the case of scientific knowledge. The case studies show that a great variety of sources of knowledge in the bandwidth between exclusively internal and exclusively external sources is utilised. Though of course not all on the same level, nearly all of the investigated companies employ external sources of knowledge and expertise such as scientific institutes, business associations, customers, suppliers etc.

This does not necessarily mean collaboration. One way all of the firms named as an important first step to obtain relevant knowledge was screening the market and the activities of competitors e.g. via internet, trade journals or service agencies. Some of the firms do this on a regular and systematic base to win new insights which are often a point of departure for targeted activities to improve own products and/or processes.[13] This strategy is particularly important for the smaller firms in the sample because they consider themselves to be too weak to be a trend-setter and, hence, obliged to follow trends invented by bigger competitors. Another important sources of knowledge is of course the personnel. Here again, the picture is not uniform.

In some firms the staff is highly qualified and work is organized in a way that advantages utilisation of this 'intramural' knowledge and competence. This is also supported by training schemes organized within and sometimes also outside of the company. But not all of the relevant knowledge can be acquired and maintained this way. In some of the cases such as the German paper manufacturer and the Swedish tool company interviewees highlighted the importance that the blue collar workers have a 'feeling' for the processes and machinery. That is, tacit knowledge you gain by doing something again and again. This is not necessarily individual knowledge but sometimes knowledge of a collective of mates. Hence, the management has an interest to keep the workers in the company.

On the other hand there are cases with mainly semi-skilled or unskilled labour and no one expects the workers to be creative. This was particularly striking in one of the furniture cases. This firm's production process is stable enough to allow them the use of a lot of unqualified leased work regularly to balance seasonal

[13] This kind of imitation and spreading of new inventions is discussed in neo-institutionalism as one type of institutional isomorphism (DiMaggio and Powell 1983).

fluctuation of demand. This case is in nearly every respect a contrast to the ones just mentioned. With one exception: this furniture company too is highly successful and innovative. The reason for this is that at the core of their business model is design and the ability to bring very high numbers of units to the market in a very short time. The knowledge you need to be able do this is not located at the shop floor but in design, planning and logistics.

- In modern society knowledge creation increasingly requires the capability to use and stimulate knowledge bases 'distributed across a range of technologies, actors and industries' (Smith 2003b, p.15). So-called low-tech industries are no exception of this rule.
- There is some evidence from the case studies that at least for some low-tech companies this capability to link up with and utilise external sources of knowledge is one of the major conditions for success.
- Qualification of the personnel is no criterion to differentiate low-tech firms from others. There is no evidence so far that qualification is more or less important in low-tech and medium low tech sectors than in other sectors. All we can see so far is that less qualified staff is in itself no obstacle to economic success in the 'emerging knowledge society'.

Innovation

Managers of every single one of the companies we investigated underlined the importance of steady innovation not only for success but even for mere survival of their firm. But what sort of innovations is brought forward in a low-tech company and what are the most important drivers or sources of innovation? (Cf. Hirsch-Kreinsen et al. 2003; Boly et al. 2000 and Palmberg 2001 for a more general overview).

Types and modes of innovation

The selected firms are innovative in terms of both product and process innovation (cf. Palmberg et al. 1999 for a definition). As one may expect incremental modes of innovation are predominant for both types. Though some of the companies underwent major process changes recently in connection with the purchase of new machinery 'jumps' like this happen rather seldom. More typical in terms of process innovation are continued improvements of quality and speed of production or the implementation of electronic linkages with major customers or suppliers. Sometimes product innovation too is a means to improve process performance. The major product innovation was in one case a re-design of one of the firm's main products to reduce assembling effort.

One mode of innovation which is relevant for many of the firms under investigation seems to get round the process-product distinction in a way. Namely activities in branding, logistics and design. In the case of the German swivel chair producer e.g. far most of the product innovations are changes of design like a newly shaped back or maybe just the colour of the wheels. Such seemingly marginal changes of the product do not make much of a difference for the processes at

the company itself. But they can induce major changes upstream in the production chain that is, for suppliers. For the chair company a design innovation is always a potential innovation in logistics. And the indicator which separates incremental from radical innovations is for the firm's Head of Product Development that the latter requires a reorganisation of the production chain.

For most of the companies the 'standard' product innovation is re-design according to (anticipated) customer needs. Sometimes this means just fashionable modifications of the appearance. This applies not only to the furniture companies or the paper producer in the sample. The Swedish hand-tools manufacturer too created a tool series with (just) a new look –called cool tools – for the US market. And also for the Norwegian producer of plugs, sockets and switches is innovative design a marketing feature.

It is too early for generalisation but the examples just given might be indicators for a specific mode of innovation in low-tech industries which is highly demand oriented. And which forces the companies to develop (a) relations in production that are extremely flexible and (b) to establish a distributed knowledge base which enables them to cope with the complex problems which arise from this.

Sources and drivers of innovation

The case studies disclose three main drivers of innovation, market demand, new technological solutions which allow to increase productivity and regulatory requirements.

Customer requirements caused some of the firms in the sample to invest very high sums in new technology. For example the Spanish railway manufacturer was pushed by risen quality requirements of clients to introduce a very complex and expensive microscope monitor system able to produce pictures of metal structures.

Rationalisation is the other main driver of innovation. The Polish printing house e.g. recently invested heavily in more productive machinery. The Irish producer of furniture installed automation systems to improve the flow of goods through the factory in order to enhance the efficiency of the production process.

In some of the investigated companies recent major process innovations were made to meet heightened ecological standards and environmental laws. The German paper producer implemented a modern water treatment system, which allowed to reduce costs and the input of resources. The Irish furniture producer installed a waste management and disposal system. The new machinery blows saw-dust into a silo and then feeds a burner automatically which provides heat for the shop and for the process (cf. Heanue in this issue).

It should be mentioned that investment in such 'environmental innovations' is considered to be good marketing too because it helps to create and/or maintain the positive image of a responsible producer.

There are at least two general conclusions which can be drawn from the case studies so far.

- The ability to innovate – both product and process innovation – is a key success factor for low-tech companies too.
- Innovation processes in a (medium) low-tech company are almost by definition not based on in-house R&D. But this does neither mean that there is no innovation at all nor does it mean that innovation here is exclusively demand driven.

Prospects and future challenges

What we produced with the first round of company case studies was mainly evidence for the complexity of the field which is covered by the term low-tech. This is one of the reasons why most of the tentative theses presented here are rather descriptive than explanatory. To develop their analytic strength and fertility is one of the topics of future research.

Discussions within the national research teams as well as within the consortium on our instruments and findings had been a prerequisite to develop a common approach. This allows us now to focus the ongoing research not only on the WHAT but also on the HOW and WHY of everyday business in general and innovation in particular.

This will be complemented on the one hand by ongoing reflection on modes of knowledge formation and economic development (WP1) and on the other hand by extensive investigation of 'enduring linkages between actors in low-tech industries' (WP4) which already started.

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An Irish Furniture Case Study

by Kevin Heanue

Introduction

The company chosen is in what has been identified in previous studies as a form of industrial district (Mottiar 1997; Jacobson & Mottiar 1999) – the wooden furniture industry in County Monaghan. It is among the top 15 firms in the industry in terms of employment. With a history of furniture production on its site going back to 1947, the company in its present form has existed since 1967. The company has consistently been to the fore in the Irish furniture industry. In 1990 it was identified by IDA Ireland as one of the more competitive furniture companies, and one to support. At that time, it employed 52 people and had a total output of €2.54m and was exporting 25 percent of its products. In 2002, it exported 90 percent of its output: 80 percent to England and 10 percent to Northern Ireland. The remainder of its output is sold on the Irish market where it is rated fifth among Irish brands in the middle market cabinet furniture segment.

The company currently employs 62 people (from a peak of 78 in 1997). Seven of these are not directly involved in production. Joint Managing Director A is an accountant by profession. He is responsible for management, administration, marketing, sales, R&D and finances. He was previously a Chairman of the National Furniture Manufacturers Association. Joint Managing Director B is responsible for the Machine Shop and the Veneer Plant.

The company has a plethora of suppliers from whom they receive board materials, veneers, components, glass, glues, handles, hinges, lacquers etc. The suppliers are located in Asia, Africa and Europe. The company does not consider geographic proximity to be important in relation to suppliers. However, closeness in terms of 'organisational proximity' or trust-based and reciprocal relationships with the suppliers is extremely important.

The majority of customers are located in England. In terms of furniture tastes, trends etc., the company views the English market in reality as a home market; it is an export market for revenue purposes only. The reliance on the English market is seen as a weakness. Most of the designs are purely for the English market - they are 'classic' English designs, based on English measurements/proportions, with English characteristics; it would be difficult to sell them on the continental market. The company is investigating the idea of exporting to Italy, and is exploring this option with a representative at present.

With the assistance of Enterprise Ireland, the company has instituted a World Class Manufacturing (WCM) Programme. The WCM consultant is still kept on a retainer for one day every week. After putting WCM in place, the company went from a net profit of five or six percent to almost 17 percent.

Production Process

The company produces furniture for dining rooms, living rooms and bedrooms[14] (NACE 3614 – 'Other furniture'). The company produces three main ranges of furniture, mahogany, cherry and oak. Within those three ranges, there are 232 individual pieces of furniture. The cherry range is targeted both at an upper and middle market segment, whereas the oak and mahogany ranges are focused on middle market buyers. Within these generic ranges, the style of the furniture is either classic English or classic French[15]. They have one modern styled range – the Manhattan range – which is made in beech panel material and solid wood, which they view as most susceptible to competition. On a self-evaluation exercise, Joint Managing Director A rated the products at seven on a ten-point quality scale.

The company does not make specials or one-off pieces but standard products sold to retail stores. The production process is best characterised as medium volume production (20 to 1,000 pieces) and is organised in a line. The company's general competitive strategy is 1) quality-leadership, 2) customer-orientation and 3) concentration on core competences.

The production process is organised into five sections: veneer plant, machine shop, assembly shop, finishing shop and dispatch. Each of these sections has a supervisor. Board material of various thickness, either chipboard or MDF (medium density fibreboard), is veneered in the veneer plant. The veneers are pressed on to the board using high pressure and intense heat. The panels are then processed through the machine shop, passing through a variety of com-

[14] For dining and living rooms, the specific products are dining tables and chairs, display cabinets, occasional furniture, home entertainment and home office. For bedrooms, the specific products are chests, vanity units, dressing tables and mirrors, wardrobes and beds.

[15] The classic French style encompasses two sub ranges – the Corrib Bedroom Range, which is made in oak, was introduced in 2003 and the Avoca Bedroom Range and the Avoca Range, which is made in cherry, was introduced in 2001.

puter-controlled machinery, including overhead routers. Other automated processes include panel edging and dowelling.

In the assembly shop, a team of operatives assemble each piece of furniture by hand prior to proceeding to the polish room. The assembly operation is quite simple. The only jointing technique used is dowels; therefore assembling the furniture is similar to assembling 'Lego'. Between the machine shop and the assembly shop, there is a buffer stock of various panel and solid wood components, out of which any of the firm's products can be assembled. The maintenance of adequate levels of this buffer stock is the key to the company's flexibility to fulfil composite orders (one or two of a variety of products) in a relatively short lead-time of 4 to 6 weeks. No complete articles of furniture are assembled, unless there is an order for them.

The polishing shop contains a relatively recently installed continuously moving conveyor system. After a water-based stain is applied to the piece of furniture it is dried briefly in an oven, then placed on the conveyor system which brings the piece of furniture to alternative sealing, drying, sanding, lacquering, drying, sanding, quality control and dispatch stations. A patina highlight is applied to each piece of furniture prior to polishing giving the product a renaissance style finish. The lustre on each piece of the company's brand of furniture is the result of several applications of lacquer with hand sanding between each application. A system of continuous quality control checks operates throughout the different stages of production. Every piece of furniture leaving the factory carries a label bearing the initials of three checkers.

Generation & Use Of Knowledge

The company does engage in formal R&D. Uniquely, among Irish furniture firms, it has a dedicated prototyping unit (this consists of one craftsman who is employed three days a week, just to develop and assemble prototypes).

The company relies heavily on embodied knowledge in the form of investment in CNC machinery and other plant and equipment. Two recent examples are investments in the waste management and disposal system that also provides heat for the factory in general and the finishing plant in particular, and the new continuously moving finishing line. It is clear from the interviews, that there is no great repository of tacit or practical knowledge in the production personnel; most of the production workers are semi-skilled. Rather mischievously, I asked the question whether if all of the production staff was fired tomorrow, and another workforce hired, how long would it take for the factory to be back running at the same efficiency? The answer was three months or less. Crucially, however, this depended on the supervisory staff remaining in place. Therefore, individual practical knowledge at supervisory level or shared routines in organisational terms appear to be important.

The company extensively uses and interacts with 'external repositories of knowledge'. The involvement with Enterprise Ireland in the implementation of World Class Manufacturing programme is one

example. A second example is the impetus that came from the Environmental Protection Agency, to install a waste management and disposal system.

In addition to its relationships these institutional actors, the company also has a relatively structured interactive process for product innovation/development. This process integrates external knowledge from customers, sales representatives and competitors with internal design and production competence. Notwithstanding this, much of the knowledge input involved in design is of a practical or tacit nature and emanates from senior management in the company.

Innovation / Modes Of Innovation

Product Innovation

The furniture market in general is very fashion oriented. The company, however, does not see itself as a trendsetter. In fact, they argue strongly that no Irish furniture company, due to their small size, can be a trendsetter. In effect, the company follows the trends. Their main source of information on trend setting products is attendance at furniture manufacturers' shows in France, Spain and Italy. The aim of these market research trips is to identify the general trends. This overall concept is used, but the furniture is customised or adjusted for the company's brand; remade according to the company's own dimensions etc. In this sense, the company sees itself as operating in a niche market.

Product innovations are best described as incremental innovations. The process by which they come about can best be described as interactive process with a structure in place to coordinate the inputs from various actors:

Senior personnel from the company attend furniture manufacturers shows, to get ideas and generate/develop a concept. Then, a meeting is called with sales people and the concept is outlined to them. Depending on their reaction, the next step is the production of prototypes. For the next step in the process, the company invites several retailers in England that they are particularly friendly with to the factory for a critical preview of the prototypes. Depending on the reaction of these customers, it may have to return to the drawing board and rethink the concept/design/prototype. After this, the same or a new group of customers are invited back to the factory again for a critical preview and to see what their reaction and comments are to the new amended prototypes. The ultimate aim of the process is to design something that is acceptable for them to manufacture and for the retailers to sell. The whole process – from developing the concept to putting it on the shop floor takes about eight or nine months.

The company does not employ a full-time designer. However, a designer who is very good at customising has been working on a part-time or occasional basis with the company for 15 years. By 'customising', the company is really describing incremental innovations to the product concept. In the interview, the process was described as follows.

The visual input to a furniture design is very important. You can give four people the materials and drawings for the same

table, and they will come up with four different looking pieces of furniture. In other words, there is a subjective element to design that may be hard to define – this is what they call customising. What shape will the top of the table be? What decoration, if any, should be around the top of the table? This type of knowledge obviously has a large tacit or practical dimension. In addition, the company is looking for products that have relatively long life cycles. When asked how you know what products are going to have a long life cycle, Joint Managing Director A replied, 'experience'.

Process Innovations

Over the past three or four years, the company has been installing systems that improve the flow of goods through the factory. The most recent process innovation in this vein was the trolley system for the finishing line. This system was bought in the United States. At the same time, and complementing this innovation in the finishing system, the company installed a new extraction plant for the factory. This plant gathers all the sawdust waste, which is then blown into a silo. There is an automatic feeder from the silo to a burner. This burner in turn, not only provides heat for the factory in general, but also for the drying ovens for the finishing plant.

Once a piece of furniture leaves the assembly shop to be finished/polished, the product is put on a trolley which is on a conveyor system that moves continuously, passing through a variety of spray booths, ovens, sanding and denibbing stations, sealing, ovens, lacquering, ovens, sanding, quality control and dispatch. Production operatives carry out all of these processes. The speed of the line can be altered. At the time of the factory visit, a piece of furniture was arriving at dispatch every 5 minutes.

Some of the company's competitors in Monaghan put in alternative systems to finish entire panels – the panel is lacquered and the furniture is assembled afterwards. This system did not suit the company, because they produce a traditional type of furniture with more intricate shapes, and finish it fully assembled. In other words, the finishing plant is more suitable for the market that the company is in; therefore, in this context product design was a big influence on process innovation. Joint Managing Director A stated that the new finishing system and extraction unit, improved production capacity and reduced labour requirements to such an extent that the cost (IR £500,000), which was all internally financed by the company, has been recouped.

The company from which the trolley system was bought sent over an engineer to oversee the installation of the system. The factory was closed for a week and the existing workforce was used to install it. There was no special training for the operation of the system – it is a logistics system, not a methodology – nor are any special skills needed for maintenance.

The installation of the continuously moving finishing system was, however, a big change for the operatives. It is estimated that it took about six months for the system to be accepted. To facilitate acceptance of the new system, a production

bonus was inaugurated at the same time. At the moment this is not in operation – sales levels do not justify it – but it can go as high as 12.5 percent throughout the factory.

This system also means that the company is the only furniture factory in Ireland that is able to successfully use water-based lacquers, because the system allows force drying of the lacquers. The turbulent air and heat in the ovens dries the water-based lacquers in 20 minutes or less, after which it is ready for sanding. Another important benefit is that they now also satisfy EPA regulations on emissions and waste management systems, because water-based lacquers have more solids. The implication of this is less waste. For solvent-based lacquers, 72 percent of solvent constitutes emissions that need to be dealt with. For water-based applications, 56 percent of spray is water; no toxic emissions are released into the atmosphere.

Influence Of Market Conditions On Innovative Behaviour

Since 1990, the company has changed its range of furniture three times. The impetus for product innovation was described as follows by Joint Managing Director A. 'A product has a certain life cycle; growth, peak and decline. [The company] aims to achieve somewhere between 12.5 and 15 percent growth each year. In order to do that, the product range needs to be refreshed otherwise the furniture starts looking tired. For example, we are making the mahogany range since 1990, but it is tweaked every year... However, you can only do this for so long before a more fundamental change is needed.'

It is the company's strategy to develop furniture that has a relatively long life cycle. This was explained by Joint Managing Director A to mean a range that will last for six to seven years. This is in contrast to fashion furniture, for which new pieces are made every autumn or spring. When pressed as to what determines that a product will last six to seven years, or how you know what a product has to have to last this length of time, the answer was 'experience'. The analogy was made with classical music – it is still popular and an audience exists for it, because it has a certain appeal, quality. The suggestion was made that, in particular, the French style furniture that the company now makes, will still sell in twenty years time.

Thus, the furniture the company makes is not fashion-oriented. For the market that they are in, and for the size of the company that they are, the market is big enough to sustain them producing long cycle furniture because most companies are in the fashion market. The market for their furniture is not as price sensitive either.

The company sees itself as competing in a global market; direct competitors are the Chinese, Taiwanese, Malaysians, Philippines, etc. Furniture comes to Europe in container loads from all over the world. When asked how the company competes with this, the answer was 'customer relations, service, value for money'. By service, is meant the ability

to respond, in a relatively short lead-time, to composite orders from retailers that include a variety of products. The advantage this gives the company was explained thus.

If UK retailers go to Asia or Eastern Europe to source furniture, they probably have to pay by a letter of credit or some other instrument, up front, for a container(s) load of furniture. This is because Eastern European or Asian manufacturers deal in bigger quantities e.g. 200 units of a product. This stock then has to be warehoused in the UK by the retailer (another cost). If there are problems with the furniture, the retailer has already paid for it, so there may be problems with replacements etc.

In contrast, when dealing with the company, UK retailers only have to carry a showroom display, which occupies 100 to 200 square foot in showroom. Individual customers buy from the display (the shop does not hold any stock) and the order is sent to the company. As the customers pay a deposit on the furniture, cash flow for the retailer is better. The retailer gets the furniture delivered to its warehouse within four to six weeks (as the products are made to order – the company does not hold any stock of assembled products) by the company's own fleet of trucks. Therefore, the company sees its particular strength in being able to offer customers the smaller amount of stock they want, thereby reducing the retailers' inventory costs, at little or no cash lay-out, thus improving financial turnover.

Workforce; Industrial Relations

The company, similar to many other furniture firms in the Monaghan region, finds it difficult to recruit a local production workforce. The reason is that local workers do not want to work in factories anymore, and those that do want to work in the sector are, according to the interviewees, not suitable and prone to discipline problems. At present, half of the production personnel in the company are Lithuanian or Romanian. Due to the lack of suitable local labour, the company reported that if not for these foreign workers, they would not be in business at all. Most of the furniture factories in the Monaghan area are now employing a certain percentage of foreign workers.

The production personnel are not craftsmen; at best they are semi-skilled. The main reason that they are recruited is because they have a positive attitude to work – they are tidy, clean and have an element of pride in what they do. In contrast, the supervisors are tradesmen. However, the main quality sought in these middle managers is ability to motivate and oversee the operatives. The implementation of World Class Manufacturing (see above) means that there are procedures for the supervisors to follow and they need to be able to devise approaches to meeting targets, if they are not being met.

The reliance on semi-skilled operatives was not always the case. The company used to employ 12 cabinetmakers. However, it was found that these craftsmen were actually the source of production problems. If they were operating inefficiently, then it was irrelevant how efficient the rest of the factory was – e.g.

machine shop and finishing shop. If the craftsmen were not making the furniture, then there was a problem for the whole factory. After a discipline problem, when six of the cabinetmakers had not turned up for work on a Monday morning after a holiday break, dismissal procedures were instigated against the craftsmen and they were all subsequently dismissed. After this, the hiring of foreign workers began.

Most of the foreign workers have a background in the industry before they come to Ireland. In particular, the company tries to recruit people who have worked in joineries or other wood working trades. The company works closely with a factory in Romania and recruits staff from them for the polishing shop. A lot of recruits for the finishing shop are women. It was commented that it is widely recognised in the furniture industry, especially on the continent, that women have a far better attitude to doing mundane jobs such as sanding, denibbing and checking quality.

Relevant Policy

When first asked what policies impacted on the company, the reply from Joint Managing Director A was that he was not aware of any policies that impacted on the company. However, after probing it was acknowledged that there were at least two main areas that impact directly on the company. One is and immigration policy. As half of the production personnel are either Lithuanian or Romanian, the cost of work permits and the associated bureaucracy involved in employing these workers is a concern for the company.

The other one is industrial policy. The company has been involved with Enterprise Ireland (EI), on several initiatives. Enterprise Ireland provided assistance with a WCM Programme and at the instigation of the EI, the company has also gone to trade shows, and trade missions in relation to outsourcing components in Poland and Romania. In the opinion of Joint Managing Director A, the personnel in Enterprise Ireland are excellent; they are very proactive. In general terms, policy within Enterprise Ireland is now on trying to strengthen the company, rather than necessarily being focused, as it used to be, on employment creation.

In the opinion of Joint Managing Director A, the company gets a good reception from Enterprise Ireland because of their track record, and success in implementing any strategy and achieving any targets which they set out to do. In terms of the furniture industry in general, however, their ability to influence policy makers is relatively weak. This is because the Irish furniture industry is still very unprofessional in many ways. Ireland is one of the few countries that has a weak/non-existent furniture manufacturers association. It was suggested that the main use members of the National Furniture Manufacturers Association make of the organisation is to complain about the activities of the Environmental Protection Agency towards furniture firms, and about the cost of insurance. Apart from this, Joint Managing Director A described most Irish furniture firms as apathetic in their approach to the industry.

Discussion: Implications for PILOT Project Themes

The usefulness of the notion low-tech is called into question by this case study. The firm uses state of the art organisational tools – World Class Manufacturing – utilises cutting edge waste disposal, management and recycling technology, operates a highly mechanised and in some instances automated production process based on state of the art manufacturing technology and manages supply chains that are not in close proximity.

At production level at least, there appears to be an increase in the use of embodied knowledge (in the form of machinery) and a reduction in the reliance on tacit and practical knowledge; there has in particular been a reduction in the use of skilled craftsmen. At supervisor or middle management level, practical knowledge and an understanding of shared organisational routines are considered important. At senior management level, practical design, marketing and product engineering knowledge is combined with explicit systems integration knowledge. Many of the key product decisions are based on 'experience' – that is, tacit or practical knowledge.

Overall, the form of work organisation contains many different elements but can generally be described as post-Fordist. The overall competitive strategy of the company could be described as flexible production – it can fulfil composite orders, containing any mixture of its 232 products in a relatively short lead-time. There is an element of Just-in-Time to this process as furniture is only assembled in the company in direct response to an order. The key to this capability is the maintenance of the buffer stock of components between the machine shop and assembly shop, at the correct levels. To facilitate the buffer stock, however, the raw materials/stores inventory must be managed optimally and the veneer plant and machine shop operations must be integrated.

Alongside this, the introduction of a continuously moving finishing line has Fordist connotations; the pace of the work being brought to the various operations in the finishing shop is controlled mechanically, not by the workers or supervisors. In addition, there is a strict division of labour into standardised repetitive tasks in the finishing shop between sprayers, sanders, quality control etc. More generally, the apparent deskilling of much of the operative workforce suggests a conscious move away from more qualitative modes of work organisation.

In this sense, the picture that emerges so far from the case study echoes the sentiments of Dicken (2003, p.119) 'the claim that we are shifting from one hegemonic (Fordist) system to another hegemonic (post-Fordist) system is far too sweeping and simplistic to capture the complex reality of a world based upon increased flexibility of production and organisation'.

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