Innovation Systems and Economic Development

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June 2011

1. Introduction

The innovation system concept was developed in the 1980's (Freeman 1982/2004, Lundvall 1985; Freeman 1987; Freeman and Lundvall 1988; Freeman 1988; Freeman 1988: Nelson 1988). In this paper we start by some notes on how the concept emerged. In the rest of the paper we present what regard as progress in understanding it and we do so while relating it to economic development, and, finally, on how it might be further developed in the future.

2. Innovation system: A new combination?

To the best of our knowledge the NSI-concept took form in a dialogue between Freeman and members of the IKE-group in Aalborg in the very beginning of the 1980s. A common ground for our discussion was the need to root the concept in 'the production structure'. Freeman cherished the concept of innovation system because he saw it as useful for less developed countries that wanted to catch up. In this context he found inspiration from Friedrich List (1841) who saw the active role of the state in building infrastructure and investing in competence building as a prerequisite for Germany's catching up with England. List published his ideas with reference to 'the National System of Political Economy' (Freeman 1982/2004).

Simultaneously, Esben Sloth Andersen, member of the IKE-group linked the analysis of innovation to the French structuralist tradition inspired by Francois Perroux and at the time dominated by scholars such as Christian Palloix and Destannes de Bernis. They introduced concepts such as 'industrialising industries' and they used the concept 'national system of production' to frame their analysis. Andersen made important contributions to overcome the mechanical character of their theoretical schemes by introducing elements from the literature on economic development (Hirschman, Stewart and Myrdal). Already around 1980 you can find references in Aalborg

writings to 'the innovative capability of national systems of production' and from here to 'national systems of innovation' the step was quite small.

This common and simultaneous interest in finding the roots of innovation in the production system was of fundamental importance for how Freeman and Aalborg scholars defined the national innovation systems. This is reflected in Freeman's book on Japan's innovation system (Freeman 1987). The main emphasis is not on the organisation of the science system - it is rather on the organisation of work within and networking between firms in Japan. It is also reflected in the book on small countries and innovation that Freeman and Lundvall edited together (Freeman and Lundvall 1988). The chapter by Andersen and Lundvall (1988) linking the innovation perspective simultaneously to economic structure and to the interaction between producers and users illustrates the point.

3. Innovation Drivers and Modes of innovation

Recently there has been a plethora of concepts defining innovation according to *specific 'drivers'*(see for instance OECD's innovation strategy - OECD 2010). Categories such as 'cost-driven', 'demand-driven, 'user-driven' and 'employee-driven' innovations have been proposed. This new vocabulary may be seen as an attempt to broaden the understanding of the innovation process and to indicate that other factors than science need to be taken into account. This certainly reflects a legitimate concern. Nonetheless I find the classification misleading for two reasons.

First, it tends to neglect that the most important driver of innovation, at least in the private sector, is the aim to make money in competition with others. New technology and the emergence of new user needs may be seen as opening up new opportunities for innovation but basically the innovation process is *driven by competition*. At the phase of 'invention' the competition among inventors and research teams may be combined with 'pure curiosity' or with an urge to engage in creative activities at the level of individuals or collectives.

Second it is true for *almost all* innovations processes that the chance for success is enhanced when producers take user needs into account, for instance through interacting with and learning from users. It is also true that the chance of success for *almost all* innovations increases when there is

involvement of competent employees in the process. This is the second reason why it is misleading to define specific classes of innovation as respectively 'user-driven' or 'employee-driven'.[1]

There is a different way to broaden the understanding of the innovation process and it distinguishes between innovation processes at the level of the firm on the basis of the 'learning mode'. We see some innovations as being outcomes of processes where codified knowledge plays a major role (STI-mode refers to the Science, Technology, Innovation chain) and others that come out of processes dominated by experience based learning and with strong elements of tacit knowledge (DUI-mode refers to learning by Doing, Using and Interacting).

In a series of recent papers based upon a unique combination of survey and register data for Danish firms we have demonstrated that firms that engage in R&D without establishing organizational forms that promote learning and with weak customer interaction are much less innovative than firms that are strong both in terms to STI- and DUI-learning (Jensen, Johnson, Lorenz and Lundvall 2007).[2] And, the other way around the firms that develop the characteristics of a learning organisation and interact with users but do not engage in R&D or collaborate with academic institutions are significantly less innovative than those that combine the two modes.

Table 1 refers to the outcome of an analysis of survey and register data for almost 700 Danish firms and it presents different variables related to the propensity to introduce new products or services. We use sector, size and form of ownership as control variables but the focus is upon a variable indicating *the mode of innovation* in the firm. We distinguish between firms that are strong in science-based learning, firms strong in organizational learning, firms that are strong in both respects and we use those firms that are weak in both respects as benchmark category. To construct this variable we pursue a cluster analysis grouping the firms in the four categories.

[1] This does not rule out that under specific conditions and in specific types of technologies it is more frequent that respectively users and employees innovate. Von Hippel has written extensively on 'user-innovation' and Shulin Gu has introduced the concept 'blue-collar innovation' referring to innovations that are based directly upon ideas developed by employees.

[2] The data in table 1 are from Jensen, Johnson, Lorenz and Lundvall (2007).

Table 1: The probability that firms develop a new product or a new service

Variables	Odds ratio estimate	Coefficient estimate	Odds ratio estimate	Coefficient estimate
STI Cluster	3.529	1.2611**	2.355	0.8564**
DUI Cluster	2.487	0.9109**	2.218	0.7967**
DUI/STI Cluster	7.843	2.0596**	5.064	1.6222**
Business services			1.433	0.3599
Construction			0.491	-0.7120*
Manuf. (high tech)			1.805	0.5905*
Manuf.(low and med. tech)			1.250	0.2229
Other services			0.747	-0.2923
100 and more employees			1.757	0.5635*
50-99 employees			0.862	-0.1481
Danish group			0.859	-0.1524
Single firm			0.521	-0.6526*
Customised product			1.378	0.3203
Pseudo R^2	0.1247	0.1247	0.1775	0.1775
N	*692*	*692*	*692*	*692*

** = significant at the .01 level

* = significant at the .05 level

As indicators of strong science-based learning we use the R&D expenditure, presence of employees with academic degree in natural science or technology and collaboration with scientists in universities or other science organizations. As indicator of experience-based learning we take the use of certain organizational practices normally connected with learning organizations such as ‘interdisciplinary workgroups’ and ‘integration of functions’ together with ‘closer interaction with customers’ – to signal learning by interacting and a focus on user needs.

We use firms with weak efforts to support science-based and experience-based learning as benchmark and the 'odds ratio' estimate indicates how much higher the propensity to innovate is among firms strong in respectively one or both of the modes of learning. The results reported in table 2 show that firms that combine the two modes are much more prone to innovate than the rest. It shows that the effect remains strong also after introducing control variables related to size and sector.

The above analysis shows that some firms operate more on the basis of science-based and codified knowledge than others. But it also indicates that such firms may have much to gain from establishing the characteristics of a learning organisation. Learning organisation firms without R&D-efforts may become more innovative by establishing links to the science based knowledge. Most important, it demonstrates why we need to define innovation systems in such a way that they encompass institutions that contribute to both modes of learning.

The performance of any innovation system will reflect how DUI-processes are combined with STI-processes within the system. While science becomes increasingly important for a widening set of economic activities and while the wide use of information and communication technology speeds up the flow of information at a global scale the DUI-mode sets limits for innovation as well as for the absorption and actual use of new technologies.

How do innovation systems in less developed countries differ from those of rich countries? Judith Sutz and Rodrigo Arocena (2000) refer to the Latin American experience and show that there are important differences both when it comes to DUI-processes and STI-processes. On the STI-side it is easy to show that resources allocated to R&D are much smaller in Latin American countries (1995 it was less than 1% of GNP in the seven countries they list). Less obvious but even more significantly they find that 'the quality of interaction' in the national systems is much less developed in Latin America:

"In Latin America it is a relatively easy task to create organisations to foster innovation, but it is quite difficult to make them function as bridges between people."

To pursue the analysis of innovation systems in less developed countries in both these dimensions is a major challenge. This implies taking a closer look at them as 'national learning systems'.

4. National innovation systems or national learning systems?

Several authors including Viotti (2002) and Matthews (1999) have argued against the use of the concept *innovation* system in the context of less developed countries. Viotti argues in favour of using the concept 'national learning systems'. In less developed countries incremental innovation, diffusion and learning may take place but not innovation (stricto senso). He then goes on to make a distinction between Active and Passive learning systems using Korea as an example og an active systems and Brazil as an example of a passive system.

While Viotti's comparative analysis is interesting and useful, his argument is valid only if we operate with a narrow definition of the innovation process and the innovation system. Much of the early work on innovation systems was developed in connection with small countries such as Sweden, Norway, Denmark and Finland (Freeman and Lundvall 1987, Lundvall 1988). These countries have in common with developing countries that they prosper not because their firms develop unique new innovations for the world market but because of a highly developed capacity to absorb and use new technology developed elsewhere (see also Fagerberg, Mowery and Verspagen 2008). Following Viotti these countries would have learning systems but not innovation systems – perhaps we would end up with 'innovation systems' strict senso only in the US, Japan, the UK, France and Germany?

Viotti finds the use of 'innovation process' as covering both original development, diffusion and use of new technology too vague. The reason that we disagree on this is that there is a widely shared assumption that innovation contributes to economic growth. Where new ideas originate is much less important for economic performance than where they are diffused and used. As Chris Freeman puts it: Despite similarly large investments in R&D by various industrialized and semi-industrialized countries starting in the 1950's and 60's "evidence accumulated that the rate of technical change and of economic growth depended more on efficient diffusion than on being first in the world with radical innovations and as much on social innovations as on technical innovations" (Freeman, 1995, p. 10).

The intention of the original innovation system concepts was to link innovation to economic performance and to the potential for 'catching-up' among less developed countries. This will reflect innovative and imitative activities that take place in the *whole* population of firms. Having a long tail of slow adopters and a few world leading firms may be less attractive than having many firms that are quick adopters without any world leaders. Big countries such as Brasil, India and China may for different reasons have aspirations to become world leaders in specific technologies - for

instance in order to avoid technological dependence when it comes to what the US may define as 'strategic technologies' but for most countries this is not at the very heart of policies mobilising innovation to promote competitiveness and growth.

But at the same time we agree completely with Viotti, Matthews and others that a fundamental step toward understanding innovation and innovation system is linked to understanding learning processes. The sub-title of the 1992-book (Lundvall 1992) - 'towards a theory of innovation and interactive learning' – gives a very clear signal in this direction. To begin with the focus was upon the interaction between users and producers of new products. More recently we have applied this perspective to what goes on inside firms and not least to work organisation.

5. From user-producer interaction to the role of the home market

In the beginning of the 1980s and inspired by the collaboration with Christopher Freeman members of the IKE-group developed empirical and analytical work on the role of users in the process of innovation. Our version of the innovation system concept was rooted in an understanding of how users and producers interact in connection with the development of new products (Lundvall 1985; Lundvall 1988). The innovation system may be seen as constituted by 'relationships' between agents operating at different stages in value chains. In Lundvall (1985) this perspective was applied not only to inter-firm relationships but also to the interaction *within* the science system where applied science was seen both as a user of 'fundamental science' and as a producer addressing users in industry.

The analysis of the interaction between users and producers had a critical side and constructive side. On the critical side it was used to explain why 'pure markets' with arm's length and anonymous relationships would not support (product) innovation. It also explained why the reality where product innovation is frequent is incompatible with both standard neoclassical analysis and transaction cost theory. Finally it showed that the only possible explanation why capitalist economies did perform well in terms of innovation was that most markets were 'organised markets' characterised by 'untraded interdependencies' and long term relationships.

On the constructive side we used the analysis to explain why innovation processes are localised and why it is meaningful to assume that innovation systems are local, regional or national. It was demonstrated that proximity in terms of geography (and/or in language and culture) may compensate for the uncertainty that characterizes the innovation process. In parallel colleagues in

Aalborg including Andersen, Dalum and Willumsen (1981) and Fagerberg (1992) used data on international trade demonstrate the important role of the home market as a test bed for new products. This was another important step toward the understanding of *national* innovation systems.

Today it is highly relevant for less developed countries to think about how they can use their home market to initiate innovations. Such countries may be poor in terms of capabilities and resources but they are rich in terms of unsolved problems and unfilled needs. The product life cycle theory of international trade (Vernon 1966) assumed that rich countries are privileged when it comes to innovation because they can use their advanced home market as test bed to develop new products later to become export products addressing the rest of the world. It is only much later in the product life cycle when there has been a standardisation of process technology that developing countries successfully can take up the production of the new product.

Recent theoretical developments that refer to 'below the radar' or 'bottom of the pyramid' innovations turn this argument around and argue that innovations may from the very beginning be oriented toward the needs of poor people or less developed regions and countries (Clark et al 2009). China has with success developed telecommunication hardware and software for its provincial low income domestic users (Gu et al 2009). Another example is the development of a cheap Indian automobile. Such less expensive solutions may at a later stage become export products addressing users in other parts of the world with low income per capita.

In order to design such strategies it is crucial to understand both the role of the home market and the formation of user-producer relationships including the building of trust and communication between producers and users.wetherefore see a potential link from the work on those topics in the middle of the 1980s to China's current efforts to promote 'endogenous innovation' through public procurement (Gu and Lundvall 2006).

6. The resource curse and the innovation system

Another area where the user-producer perspective is crucial for understanding development issues is in connection with innovation around raw-material based activities. There has recently been a literature on 'the resource curse' (Sachs and Warner 1995). The assumption is that rich access to raw materials may hamper the effort the effort to develop industrial activities that are necessary for sustained economic growth. There are certainly many examples in the current world in Africa and

in the Middle East where national economies do combine easy access to oil or other raw materials with stagnation in almost all other economic activities.

But it is equally obvious that economic development can take a specialisation in raw materials as a starting point for establishing paths of sustained economic growth. For instance all the Nordic Countries (Denmark, Finland, Iceland, Norway and Sweden) started their industrialisation on this basis and they ended up among the 10 richest countries in the world. Crucial for their transformation was the building of industries that delivered technologies used by the primary sectors, the building of industries refining the raw materials and building the knowledge institutions to the support the resulting 'clusters'.

Recently Allan Dahl Andersen in his Ph.D. thesis (2011) made a study of the successful construction of the ethanol-industrial innovation system in Brazil showing that a similar process had taken place there over the last couple of decades. A crucial element both in the historical examples in the Nordic countries and in the case of Brazil was that building competence on both the user and the producer-side was combined with the formation of user-producer linkages. Andersen points with reference to Arocena and Sutz (2000) to the successful establishment of 'interactive learning spaces' as fundamental for the success.

Regarding the resource curse he concludes that when you take a learning perspective there is no a priori hierarchy of industries. Instead, primary, secondary and tertiary sectors co-evolve in processes of learning and structural change. Such a perspective entails a dynamic perception of natural resources which implies that they via linkages can stimulate processes of learning, capability building and development. Natural resource based industries often stimulate learning qua their role as recipient industries and participants in interactive learning spaces. Hence, 'it is not natural resources that make countries poor, but 'weak' innovation systems' – a weak competence base and barriers to linkage building are the main culprits.

In the current era the unique growth of China has a major impact upon the rest of the world. For developing countries it represents a mixed blessing. On the one hand it stimulates the demand for raw materials, raising prices and incomes in poor countries. On the other hand the strong competitiveness of China's manufacturing industries tends to squeeze out attempts to develop industries. In this situation it is an acute challenge for many developing countries to find ways build industrial capacity around the natural resources they have. That might require strategic initiatives in trade policy as well as explicit agreements with China on sharing industrial capabilities. But any

successful transformation requires the building of domestic competence and the creation of interactive learning spaces.

7. People work and learn differently in different national innovation systems

While the original intention was to develop an understanding of innovation systems as rooted in production, to begin with, production structure was seen mainly as constituted by user-producer interfaces where interactive learning could take place. At the national level it implied a hypothesis that international specialisation in production and trade would match the specialisation in terms of knowledge and competences and vice versa that the learning processes would tend to deepen specialisation since there is 'learning-by-doing' and 'learning by using'.

It was only later that we extended the analysis to take into account the interaction in connection with 'organisational learning' at the workplace which is a central element of the DUI-mode of learning. In the DISKO-project on the Danish innovation system from 1995-1999 we made a major effort to understand how innovation is rooted in organisational learning (Lundvall 2002). Here one clear result was that at the level of the firm there is a strong correlation between having 'learning organisation characteristics' and being active in terms of product innovation.

Recently this line of work linking innovation to national patterns of work organisation has been further developed at the scale of Europe. Lorenz and Valeyre (2005) and Arundel et al (2007) develop an EU-wide mapping of the adoption of different types of work organisation. There is a great potential in extending the perspective to capture the transformation of innovation systems in less developed countries and regions. In general 'innovation theory', with few exceptions such as the work by Freeman on Japan's innovation system (Freeman 1987), has neglected the role of workers. The recent work on 'employee-driven' innovation may be seen as a reaction to this neglect.

The innovation process has been seen as reflecting mainly the activities of entrepreneurs, bankers, managers, scientists and engineers. The neglect of the role of the employees may reflect the elitist perspective of Schumpeter as well as the overstatement of the role of science in the innovation process. On the other hand the interest for 'innovation' among labour economists and work-life experts has been limited. Either it has been focused upon workers fare in terms of health, working conditions or democratic participation or it has been on how employers should organise work in order to get workplaces that were both efficient and flexible.

Lorenz and Valeyre (2005) developed an EU-wide mapping of the adoption of different types of work organisation and Arundel et al (2007) linked this mapping to national innovation performance. Drawing on the results of the Third European Survey on Working Conditions,[3] cluster analysis is used to identify four different systems of work organisation: the discretionary learning (DL), lean, taylorist and traditional forms. The two most important dimensions used to distinguish between them are respectively problem-solving and learning on the job, on the one hand, and the degree of freedom that the worker has to organise his work activities, on the other. Discretionary learning involves complex problem-solving and freedom to choose or change one's work methods and pace of work. A typical example would be managers, experts or skilled workers with great autonomy.

The principal difference between the discretionary learning and the lean clusters is the high levels of discretion or autonomy in work exercised by employees grouped in the former. Over 85 percent of the employees grouped in the DL cluster affirm that they have control over their work pace and work methods whereas only slightly over 50 percent of the employees grouped in the lean cluster affirm this. Another difference is that such core 'lean' or 'high performance' work practices as team work, job rotation, and the use of quality norms are at average, or below average, levels in the DL cluster, whereas they are considerably above average in the lean cluster. Task complexity is higher in the DL cluster than it is in the lean cluster. Workers in automobile factories where modern management techniques are applied (Toyotism rather than Fordism) would typically fall in the lean category.

Discretionary learning thus refers to work settings where a lot of responsibility is allocated to the employee who is expected to solve problems on his or her own. Business service jobs are typical examples where employees continuously are confronted with new and complex problems. Although some of the tasks take place in a team, teamwork is not seen as imposing narrow constraints on the work. Rather, team-work may involve brain-storming by professional experts as much as collectively solving narrowly defined problems.

Lean production also involves problem solving and learning but here the problems appear to be more narrowly defined and the space of possible solutions less wide. The work is more constrained,

[3] The Third European Survey of Working Conditions on which the mapping is based was directed to approximately 1500 active persons in each country with the exception of Luxembourg with only 500 respondents. The total survey population is 21703 persons, of which 17910 are salaried employees. The analysis presented here is based on the responses of the 8081 salaried employees working in establishments with at least 10 persons in both industry and services, but excluding agriculture and fishing; public administration and social security; education; health and social work; and private domestic employees.

notably by constraints linked to the use of numerical production targets or performance targets and this points to a more structured or bureaucratic style of organisational learning that corresponds rather closely to the characteristics of the Japanese or 'lean production' model.

Table 2: National Differences in Forms of Work Organisation

	Discretionary learning	**Lean production**	**Taylorist organisation**	**Traditional organisation**
Austria	47.5	21.5	13.1	18.0
Belgium	38.9	25.1	13.9	22.1
Denmark	60.0	21.9	6.8	11.3
Finland	47.8	27.6	12.5	12.1
France	38.0	33.3	11.1	17.7
Germany	44.3	19.6	14.3	21.9
Greece	18.7	25.6	28.0	27.7
Italy	30.0	23.6	20.9	25.4
Ireland	24.0	37.8	20.7	17.6
Luxembourg	42.8	25.4	11.9	20.0
Netherlands	64.0	17.2	5.3	13.5
Portugal	26.1	28.1	23.0	22.8
Spain	20.1	38.8	18.5	22.5
Sweden	52.6	18.5	7.1	21.7
United Kingdom	34.8	40.6	10.9	13.7
EU-15	39.1	28.2	13.6	19.1

Source: Third Working Condition survey. European Foundation for the Improvement of Living and Working Conditions

The other two clusters are both characterised by lower levels of learning and problem-solving. Taylorism offers the employee very limited access to learning and little autonomy when it comes to organise daily work. This is a kind of work widely used in textile factories and electronics factories in the South. In the traditional cluster task complexity is the lowest among the four types of work organisation, while constraints on work are relatively low. This category groups traditional forms of work organisation where methods are for the most part informal and non-codified. This kind of

work may be found in small shops and in paid domestic work. In developing countries we would assume that most informal sector activities belong to this category.

Table 2 shows that DL-forms of work organisation are most widely diffused in the Netherlands, the Nordic countries and to a lesser extent in Germany and Austria, while they are little diffused in Ireland and the southern European nations. The lean model is most in evidence in the UK, Ireland, and Spain and to a lesser extent in France, while it is little developed in the Nordic countries or in Germany, Austria and the Netherlands. The taylorist forms are more present in Portugal, Spain, Greece and Italy, while the traditional forms are similarly more in evidence in these four southern European nations as well as in Germany, Belgium and Luxembourg.[4]

Table 2 shows that people working in different national systems of innovation and competence building *have very different access* to learning by doing. It also shows that in Southern Europe big proportion of the workforce work in either 'Simple' or Taylorist organizations. The richer the country the bigger is the proportion of workers employed in jobs with discretionary learning characteristics. But it is also important to note that countries at similar income levels – Germany and the UK for instance – have quite different distributions of workers between the four forms. While the proportion of workers operating in the lean production is more than 40% in the UK, it is less than 20% Germany. How people work and learn differs across national systems of innovation not only because of levels of income but also because of other systemic features.

The data presented above indicate that even within Europe the international differences in how people work and learn at the workplace are dramatic. This is of course much more so when we take a global view. The transformation of working life that has already taken place in the North mirrors changes taking place in the South. The fact that there are few taylorist jobs left in the small Nordic countries reflects that they have been exposed to a growing international competition from countries such as China and that they have high minimum wages. We see it as a *major challenge for the future to analyse both economic development and underdevelopment as a transformation of working life and to link this transformation to the understanding of innovation processes.*

[4] In Lorenz and Valeyre (2005) logit regression analysis is used in order to control for differences in sector, occupation and establishment size when estimating the impact of nation on the likelihood of employees being grouped in the various forms of work organisation. The results show statistically significant 'national effect' also when controlling for the structural variables, thus pointing to considerable latitude in how work is organised for the same occupation or within the same industrial sector.

A traditional view might be one that assumes that 'industrialisation' is a key to economic development and that within a few generations industrialisation transforms many jobs in agriculture from being 'simple jobs' to becoming 'taylorist jobs'. This might give rise to quite brutal forms of learning enforcing more discipline while actually reducing 'discretion'. But we may also see a strong growth in simple jobs related to the informal sector and in services in urban areas as a sign of underdevelopment. If we assume that innovation and organisational learning are two sides of the same coin this way of studying national systems of innovation offers new valuable insights.

8. Working life and innovation

In Arundel et al (2007) we explore the link between the organisation of work and innovation by developing national aggregate indicators for the EU member states of organisational forms and innovation modes (how firms innovate). The innovation mode indicators are calculated using the results of the third Community Innovation Survey (CIS-3) for innovation activities between 1998 and 2000.

The analysis draws on a taxonomy developed by Arundel and Hollanders (2005), in collaboration with Paul Crowley of Eurostat, in order to classify all innovative CIS respondent firms into three mutually exclusive innovation modes that capture different methods of innovating, plus a fourth group for non-innovators.[5] The classification method uses two main criteria: the level of novelty of the firm's innovations, and the creative effort that the firm expends on in-house innovative activities. The three innovation modes are as follows:

Lead innovators: For these firms, creative in-house innovative activities form an important part of the firm's strategy. All firms have introduced at least one product or process innovation developed at least partly in-house, perform R&D at least on an occasional basis, and have introduced a new-to-

[5] Data are available for all EU member nations in 2000 with the exception of Ireland. The original Arundel, Hollanders, and Crowley classification makes a further distinction between lead innovators that make continuous use of R&D and are active on national or international markets and lead innovators that make only occasional use of R&D and/or are only active on local or regional markets. Since our interest is the relation between forms of work organization and the capacity for creative in-house development of novel products or processes regardless of R&D expenditures or the scope of markets, we have merged these two categories into a single 'lead innovator' group. For full details on the methodology for innovation modes, see Annex B of the Trend Chart document 'EXIS: An Exploratory Approach to Innovation Scoreboards http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/EXIS.pdf).

market innovation. These firms are also likely sources of innovations that are later adopted or imitated by other firms.

Technology modifiers: These firms primarily innovate through modifying technology developed by other firms or institutions. None of them perform R&D on either an occasional or continuous basis. Many firms that are essentially process innovators that innovate through in-house production engineering will fall within this group.

Technology adopters: These firms do not develop innovations in-house, with all innovations acquired from external sources. An example is the purchase of new production machinery.

The analysis shows that in nations where work is organised to support high levels of discretion in solving complex problems firms tend to be more active in terms of innovations developed through their in house creative efforts. In countries where learning and problem-solving on the job are more constrained, and little discretion is left to the employee, firms tend to engage in a supplier-dominated innovation strategy. Their technological renewal depends more on the absorption of innovations developed elsewhere. These patterns remain when we divide the economies into manufacturing and services.

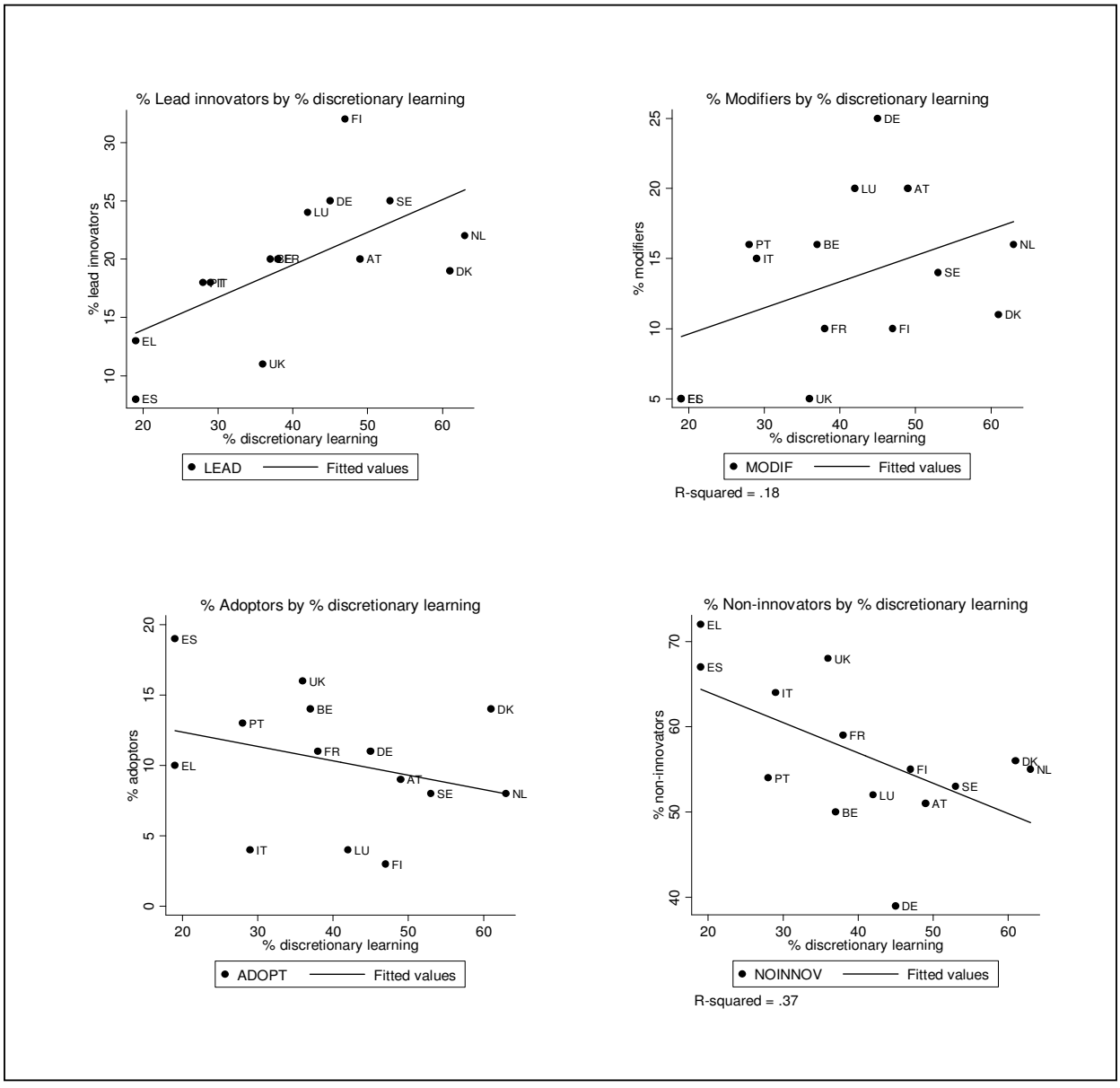
Work organisation could influence innovation performance through two main mechanisms[6]. First, forms of work organisation that stimulate interaction among agents with a diverse set of experiences and competences could be more creative, leading to the development of original ideas for new products and processes. Second, work organisational forms that delegate responsibility for problem solving to a wide range of employees could be more successful both in upgrading the competences of workers and in transforming new ideas into new products and processes.

Figure 1 presents the results of this exercise for the discretionary learning (DL) form of work organisation. The main result is that there is a positive correlation between discretionary learning and the frequency of the two innovation modes for which the levels of novelty and creative in-house effort are the highest, the lead innovators and modifiers, while there is a negative correlation

[6] We ignore here the effect of organisational forms that provide financial or other incentives to employees to innovate.

between discretionary learning and the frequency of non-innovators. Furthermore the strongest positive correlation is between lead innovators and discretionary learning, with an R^2 of 0.39.[7]

Figure 1: Correlations between innovation modes and discretionary learning, all sectors



[7] The correlations between the frequency of discretionary learning and the frequencies of lead innovators and non-innovators are significant at the .05 level.

These and the other results in Arundel et al (2006) provide support for the view that there are systemic links between the way work is organised in a nation and the distribution of different innovation modes. More specifically, the positive correlation between discretionary learning and the frequency of lead innovators provides support for the hypothesis developed in the qualitative literature that the forms of work organisation characteristic of operating adhocracies support the exploration of new knowledge that is needed for creative, in-house innovative activities that can lead to the development of new-to-market innovations and possibly radical innovations.

Although our data can only show correlations rather than causality and are aggregated at the national level, they support the view that the way work is organised is highly nation-specific and that it co-evolves with an equally highly nation-specific distribution of different modes of innovation.

A first major finding is that in nations where work is organised to support high levels of discretion in solving complex problems, firms tend to be more active in terms of innovations developed through their own in-house creative efforts. Second, the results indicate that learning and interaction within organisations and at workplaces are at least as important for innovation performance as learning through interactions with external agents. Therefore, in order to understand national systems of innovation it is necessary to bring the organisation of work into the analysis. A third implication is that indicators for innovation need to do more than capture material inputs such as R&D expenditures and human capital inputs such as the quality of the available pool of skills based on the number of years of education. Indicators also need to capture how these material and human resources are used and whether or not the work environment promotes the further development of the knowledge and skills of employees.

Does this matter for developing countries? The focus upon the workplace in developing countries has been mainly upon the poor working conditions and this is of course a legitimate concern. But as firms in countries such as China, Brasil and India move toward the front in terms of developing innovations on their own (cf. The emphasis upon endogenous innovation in China) old style hierarchical modes of organising work may increasingly become barriers for the kind of intraorganisational interaction that is necessary to become a lead innovator.

9. Welfare and inequality in the context of innovation systems

A promising line of research is to link the analysis of learning at the workplace to Amartya Sen's (1999) perspective on welfare, inequality and economic development. Sen presents a capability-based approach to welfare where development is seen as an expansion of the substantive freedoms that people enjoy. Substantive freedoms are defined as the capabilities people have to live the kind of lives they have reason to value. They include things like being able to avoid starvation and undernourishment, diseases and premature mortality. It also includes the freedoms of being literate, able to participate in public life and in political processes, having ability and possibility to work and to influence one's work conditions, having entrepreneurial freedom and possibilities to take economic decisions of different kinds. Enhancement of freedoms like these is seen as both the ends and means of development.

While Sen's approach is definitely compatible with a system of innovation approach, it is noteworthy that learning and innovation capabilities generally have not been emphasized in his capability-based approach to development. Extending capabilities may be the result of changing the setting in which the agent operates. Seen in a dynamic perspective it is especially relevant if the setting gives access to and stimulates a renewal and upgrading of the competence of agents.

The learning capability is the most dynamic of the human capabilities and it is conditioned by national institutions including the prevailing forms of work organisation (see table 2 above for Europe). It has an instrumental role in extending capabilities - learning to use a computer makes it meaningful to get access to one - but it might also, under certain conditions, be seen as having substantive value. 'The hunger for knowledge' as insatiable - it is actually growing with learning experiences. When learning takes place in such a way that it enhances the capability of individuals and collectives to utilize and co-exist with their environment, it contributes directly to human well-being.

To indicate the general direction of the proposed shift in perspective on economic development Sen (1983) quotes Karl Marx who refers to 'replacing the domination of circumstances and chance over individuals by the domination of individuals over chance and circumstances'. We would argue that one of the most important means to move in this direction is to develop 'workplaces' that offer both discretion and learning.

10. Degree of inequality in access to organizational learning in Europe

According to Sen an egalitarian income distribution might not be the most important dimension of social equality and welfare. It is not what we can buy or own that constitutes welfare but rather what we can do. Therefore we see the uneven access to 'competence-building' as the most important dimension of inequality. The 'learning divide' as it has been used by Arocena and Sutz (2000) is not only a divide between regions and nations – a similar divide can be found within national systems between different categories of people.

Here we focus the attention upon the quality of work as a core human activity. We see it not only as a source of income giving access first to 'entitlements' and second to 'capabilities. It also offers those who work uneven access to upgrading their capabilities. The distance

Table 3: National Differences in Organisational Models (percent of employees by organisational class)

	Discretionary learning	**Share of managers in discretionary learning**	**Share of workers in discretionary learning**	**Learning Inequality index***
North				
Netherlands	64,0	81.6	51.1	37.3
Denmark	60,0	85.0	56.2	35.9
Sweden	52,6	76.4	38.2	50.3
Finland	47,8	62.0	38.5	37.9
Austria	47,5	74.1	44.6	39.9
Centre				
Germany	44,3	65.4	36.8	43.8
Luxemb.	42,8	70.3	33.1	52.9
Belgium	38,9	65.7	30.8	53.1
France	38,0	66.5	25.4	61.9
West				
UK	34,8	58.9	20.1	65.9
Ireland	24,0	46.7	16.4	64.9
South				
Italy	30,0	63.7	20.8	67.3
Portugal	26,1	59.0	18.2	69.2
Spain	20,1	52.4	19.1	63.5
Greece	18,7	40.4	17.0	57.9

Source: Lundvall, Rasmussen and Lorenz (2008)
* The index is constructed by dividing the share of 'workers' engaged in discretionary learning by the share of 'managers' engaged in discretionary learning and subtracting the resulting percentage from 100. If the share of workers and managers were the same, the index would equal 0, and if the share of workers was 0 the index would equal 100.

This may be far away from what is going on in a less developed economy where the majority of people will be working very hard indeed and sometimes under bad and even life-threatening

conditions. But even here there is a 'division of labour' offering quite different conditions both in terms of 'discretion' and in terms of 'learning'.

Economic development may be seen as a process where an increasing proportion of the population move out of hard and boring labour into more interesting jobs that offer upgrading of skills. The data referred to above on organizational models of learning in different European countries makes it possible also to develop a more dynamic and adequate indicator of inequality.

In table 3 we present an indicator for the social distribution of workplace learning opportunities. We distinguish between 'workers' and 'managers' and we compare their access to discretionary learning in different national systems.[8] Table 2 shows that everywhere employees at the high end of the professional hierarchy have more easy access to jobs involving discretionary learning.

But it is also noteworthy that the data indicate that the inequality in access to learning is quite different in different countries. In the Nordic countries and Netherlands the inequality in the distribution of learning opportunities is moderate while it is very substantial in the less developed south. For instance, the proportion of the management category engaged in discretionary learning in Portugal is almost as high as in Finland (62% in Finland and 59% in Portugal), but the proportion of workers engaged in discretionary learning is much lower in Portugal (18.2% versus 38.2%).

Table 4 indicates that the way work is organised has a direct impact upon the well-being of workers. The table shows the percentage distribution of employees in each organisational class according to their degree of job satisfaction. On average discretionary learning promotes job satisfaction while taylorism is the worst alternative. The difference between simple production and lean production is negligible. This shows that while having a job may be a positive value in itself, how happy you are with being employed will reflect how work is organised in terms of learning opportunities and autonomy. Discretionary learning is attractive since it gives the employee opportunities to learn with some freedom. That simple production is valued more highly than taylorism may reflect that simple production includes many activities where workers interact directly with customers while taylorism gives the least opportunity for interaction with others: Often the worker is closely linked

[8] The class of managers includes not only top and middle management but also professionals and technicians (ISCO major groups 1, 2 and 3) The worker category includes clerks, service and sales workers as well as craft, plant and machine operators and unskilled occupations (ISCO major groups 4 through 9).

to a machine. In general we see the results as confirming that workers value interactive learning, while absence of learning and loss of autonomy is the worst possible combination.

Table 4: Organisational Forms and Levels of Job Satisfaction – EU 15 (Percentage of employees in each organisational class)

	Discretionary learning	**Lean production**	**Taylorism**	**Simple production**
Highly satisfied	34.2	20.2	13.3	22.3
Largely satisfied	55.9	57.9	55.8	57.1
Largely unsatisfied	7.7	16.6	23.8	14.4
Highly unsatisfied	2.2	5.3	7.1	6.2

Source: Lorenz, Lundvall and Valeyre, 2004.

11. Inequality in learning and income inequality

Sen argues against using income inequality when it comes to assess well-being and the degree of inequality. It is therefore interesting to find out to what degree international differences inequality in access to learning give a similar or different picture than what we would get by comparing income inequality. In table 5 we have compared the two forms of inequality for the year 2000 for the EU 15. The date on income inequality emanate from a paper by Brandolini and Smeeding (2007) on Inequality Patterns and refer to the Gini coefficient with respect to disposable income.

Table 5: Comparing Income Inequality with Organisational Learning Inequality

	Income inequality Gini Coefficient	**Ranking Income inequality**	**Inequality in 0rganisational learning**	**Ranking Inequality in 0rganisational learning**
Austria	0.257	11	39.9	12
Belgium	0.279	7	53.1	8
Denmark	0.225	15	35.9	15
Finland	0.246	12	37.9	13
France	0.278	8	61.9	6
Germany	0.275	9	43.8	11
Greece	0.334	4-5	57.9	7
Italy	0.334	4-5	67.3	2
Ireland	0.313	6	64.9	4
Luxembourg	0.260	10	52.9	9
Netherlands	0.231	14	37.3	14
Portugal	0.363	1	69.2	1
Spain	0.336	3	63.5	5
Sweden	0.252	12	50.3	10
United Kingdom	0.343	2	65.9	3

Sources: Brandolini and Schmeeding 2007 p. 31 and the last column of Table 3.

The most striking result is that the countries with the highest degree of income inequality (UK and Portugal) are also the ones most unequal in terms of access to discretionary learning and that those countries (Denmark and Netherlands) that have the most equal income distribution also offer the most egalitarian access to jobs with discretionary learning.

This pattern shows that income distribution is more equal in countries where workers are given and take on more responsibility at the workplace. While income distribution may be of less relevance for individual welfare the system effect from income distribution on the degree of broad participation in processes of work may be important.

The data set – and its relevance for developing countries

The research is based on the results of the third European survey on Working Conditions undertaken by the European Foundation for the Improvement of Living and Working Conditions[9]. The survey was carried out in each of the 15 member states of the European Union in March 2000. The survey questionnaire was directed to approximately 1500 active persons in each country with the exception of Luxembourg with only 500 respondents. The total survey population is 21703 persons, of which 17910 are salaried employees. The survey methodology is based on a multi-stage random sampling method called 'random walk' involving face-to-face interviews undertaken at the respondent's principal residence. The analysis of forms of work organisation developed here is based on the responses of the 8081 salaried employees working in establishments with at least 10 persons in both industry and services, but excluding agriculture and fishing; public administration and social security; education; health and social work; and private domestic employees.

In developing countries it is often difficult to get reliable data on work organisation and learning via surveys addressed to firms and a realistic strategy is often to rely less on statistical analysis and more on case studies. It is an interesting question if addressing citizens instead of firms and ask them about their work could produce reliable statistical material. The success of such a strategy may depend on having access to registers that make it possible to draw representative samples. On the other the relatively low costs of labour might make it possible to use labour intensive methods such as face to face interviews.

10. Challenges for innovation system research

To understand how learning takes place within organizations as well as in the interaction between organizations is a key to understand how systems of innovation work. While it is important to study national characteristics in terms of organisations that pursue R&D (STI), it is equally important to understand national characteristics in terms of how firms interact with customers and to what degree different firms give employees access to competence-building in connection with on-going economic activities (DUI).

[9] The initial findings of the survey are presented in a European Foundation report by D. Merllié and P. Paoli [2001].

Almost from the beginning, innovation system research has taken two different perspectives, a narrow one, equalling innovation to science and technology and a broader encompassing learning, innovation and competence building at different levels of aggregation (Lundvall 2007). Narrow definitions of the national innovation system are of limited relevance when it comes to understand the problems of less developed economies. Actually they are misleading when it comes to inform innovation policy strategy everywhere.

Finally we see a great potential in linking Sen's analysis of individual 'capabilities' to the analysis of innovation systems. In our view the most important of all capabilities is the capability to learn. This capability is fundamental for all the other capabilities and it is the one that will shape the dynamics of welfare. To put it crudely economic development is about enhancing capability and opportunity to learn at all levels.

It is a major challenge to understand how modes of innovation and innovation performance relate to the degree of inequality in a society both in the North and in the South. In a neo-liberal discourse inequality is seen as a factor that promotes entrepreneurship and initiative. In a learning economy discourse it might be seen as something that makes it more difficult to build social capital and trust that is the basis for interactive learning. While STI-learning may prosper also in an unequal society, it might be more difficult to engage employees in organisational learning and other forms of DUI-learning.

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