J Knowl Econ (2012) 3:389–405
DOI 10.1007/s13132-011-0060-9

Modes of Innovation and Differentiated Responses to Globalisation—A Case Study of Innovation Modes in the Agder Region, Norway

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Received: 22 September 2010 / Accepted: 28 September 2011 /
Published online: 25 October 2011

Abstract The main argument of this paper is that firms and industries are dominated by different innovation modes and that they therefore respond differently to challenges of globalisation. The paper differentiates between three modes: science, technology and innovation (STI), doing, using and interacting (DUI) application mode and the DUI technological mode. These innovation modes are based on different dominant knowledge bases, modes of learning and external knowledge. What is the implication of these differences with regard to competing in a global economy? Our empirical research shows that firms innovating according to the DUI application mode are in a position of negative lock-in due to severe competition from low-cost countries. The DUI technological mode firms are globally competitive due to a strong regional technological base built upon broad collaboration and a mixed innovation strategy. The STI firms are often part of international or national corporations, with a constant threat of being relocated to another country if they are not globally competitive.

Keywords Globalisation · Innovation modes · Knowledge sources · Regional innovation systems · Regional policy

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Introduction: The Challenges of Globalisation

The contemporary economy is described as a globalising learning economy [16]. The economy is characterised by outsourcing and offshoring of production activities but also of research and development (R&D) and innovation. Many firms are increasingly involved in global value chains and knowledge networks. Firms also experience increased international competition on various products and services, which challenges the economy of many countries and regions.

Norway has mostly benefited from the more global economy. The nation has experienced increased demand for its raw materials from China and other fast-growing economies, while Norwegian firms hardly produce any of the cheap consumer goods from these economies [20]. Nevertheless, Norway still experiences challenges from a more globalised economy. As in many other high-cost countries, the answer to the 'global challenge' is to strengthen creativity and innovation activity in industry (St. meld. nr. 25 [18]). The practical innovation policy in Norway has increasingly been regionalised in the sense that regional actors have been given more responsibility for developing, performing and financing innovation policy tools [12]. The idea is that innovation programmes developed regionally will be better adapted to specific regional characteristics, needs and challenges than national ones, and as such be more efficient in developing global competitive firms and regional clusters.

The need for fine-tuning of innovation policy to regional circumstances is also recommended in the regional innovation literature. No one best practice innovation policy approach that can be applied to any type of region is seen to exist [19]. Furthermore, the literature emphasises the need to construct regional advantage as one way to compete in the global economy, and the literature simultaneously maintains that regional advantage can be constructed by a proactive public–private partnership [4]. This demands, however, a fine-tuning of policy instruments, in which in particular four elements need to be considered. The policy should target the dominant innovation mode and knowledge base of regional industries. A basic division is between the science, technology and innovation (STI) mode and the doing, using and interacting (DUI) mode [13], which need different types of institutional and policy support. Other factors considered in fine-tuning of policy instruments are the working of the regional innovation system, how to increase the related variety and knowledge spillovers in the regional industry and how to link regional industry and knowledge organisations to national and international knowledge sources [4].

The approach based on innovation modes departs from the traditional sector approach, which is based on division of industries in different sectors. This article analyses learning and innovation processes in a sample of firms in the Agder region in Norway, and how firms individually and collectively meet the challenges from the more global economy. The sample of firms is found in four different industries in Agder: the information and communications technology (ICT) industry, the oil and gas equipment supplies industry, the process industry and (parts of) the cultural industry. However, the firms are categorised into three different groups according to their dominant mode of innovation. The article thus analyses (1) the dominant forms of learning and modes of innovation in the sample of industries in Agder and (2)

their geography of knowledge sources in innovation activity, (3) how different types of firms are influenced by the global economy and (4) how firms act to meet the global competition.

The remainder of the article includes four main parts. The next theoretical part addresses the globalisation debate and defines and discusses the two main modes of innovation of STI and DUI. The third part presents the empirical data and how the data have been categorised. The fourth part analyses the different modes of innovation, knowledge flow and globalisation trends in the sample of firms. The concluding part summarises the study and discusses how the firms in Agder can meet the global challenges.

Theoretical Framework: Globalisation and Different Forms of Learning and Innovation

The globalisation of economic activities has increased in the last two decades. This is seen in the fact that the production network of a specific product or service increasingly has become a geographically extended sequence of activities adding up to the final product of service [10]. Transnational corporations (TNCs) are lead firms that orchestrate complex global production networks that span different territories [23]. TNCs often hold resources to relocate activities around the world to utilise geographical differences of production factors. TNCs' decision to invest, or not invest, in a particular geographical location can decide much of the economic development of specific areas [21]

The globalisation has large implications for firm strategies as it has increased the competitive pressure on firms. Firms may respond to this challenge by lowering production costs or by differentiating their products and activities from those of competitors. Both responses also have implications for how firms can utilise local production factors. The idea is that 'global competition can be won by relying more heavily on local capacity, expertise, and competence' ([21] p.10). An important source of competitiveness for a specific geographic area is, thus, to strengthen local production factors, such as the education and training system and local firm collaboration. Specific location factors may also lead TNCs to invest in the area or relocate activity to the area.

The response by firms and local areas to the challenge from globalisation may differ between firms and geographical areas. We will address this subject by analysing how firms organise innovation activities internally and how they bring in external knowledge in innovation processes. Thus, two main types of mechanisms for the advancement of knowledge and technology can be distinguished, and these are linked to two forms of innovation systems. One refers to the traditional industrial districts where the focus is on experience-based learning (DUI) and skilled workers [2]. The other refers to national systems of research (STI) which focus more on national policy and knowledge organisations [15]. The DUI mode of innovation is mostly based on informal processes of learning and experienced-based know-how, while the STI mode is more based on the production and use of codified, scientific and technical knowledge. At the level of the whole economy, the main tension between these two modes therefore lies in their different weight on formal processes

of R&D in order to produce explicit and codified knowledge, versus focus on learning from informal interaction within and between organisations resulting in competence building often with tacit elements [13].

The two main innovation modes of STI and DUI are thus related to different forms of learning and technological development. The different forms of learning are a result of their different dominating knowledge bases which will be decisive for type of knowledge used, how knowledge flows and for the exact geography of knowledge creation and innovation in the two modes. Regions are dominated by industries that rely on different innovation modes, which influence the interaction and innovation patterns of firms and individuals in specific regions. The STI and DUI modes of innovation may thus function as analytical tools in order to capture and highlight the different forms of learning in specific industries and regions and how firms may respond to the challenge from the globalisation.

The STI Innovation Mode

The STI mode is mostly based on an analytical knowledge base that is characterised by the production and use of codified scientific and technical knowledge [3]. The motivation for knowledge generation is the need of new knowledge that can give detailed understanding of isolated phenomena or the inner details or mechanisms in a system [14]. The innovation process is characterised by developing and transforming scientific knowledge.

The STI mode gives high priority to the production of know-why (knowledge of scientific principles explaining how things work in certain ways) and specialised know what (knowledge of scientifically based facts). 'Know what' is often a prerequisite for operating in a science-based learning mode [13]. The innovation process in industries dominated by an analytical knowledge base is often organised through defined R&D projects carried out in R&D departments often in collaboration with external actors. Learning is based on interaction with the knowledge infrastructure and on the use of new scientific, codified knowledge.

The STI mode uses and further develops explicit and global know-why and is, in general, more dependent on global knowledge and interaction than on regional, tacit knowledge in order to promote innovation. However, locally embedded tacit knowledge is also of importance, as for example R&D departments of large firms need to combine know-why insights with know-how when carrying out experiments and interpreting results [13]. Specific R&D projects can be triggered by practical problems encountered with new products, processes and user needs.

Knowledge flow and innovation collaboration in the STI mode are carried out between people belonging to the same epistemic communities ([1] pp. 75–76). These communities represent informal and self-organising groups of people. Members of a community share the same understanding and norms which regulate and ease the flow of information and knowledge between them. Epistemic communities consist of persons sharing the same type of knowledge, for example, people working in the same scientific field who exchange mainly codified knowledge. The collaboration between people is based on cognitive and institutional proximity since the actors represent the same knowledge base and share the same norms, values and rules of

the game regulating the collaboration [6]. These characteristics make it possible for members of epistemic communities to collaborate over distance.

The result of the "STI type" of innovation processes is new, codified knowledge. Codification is important as the results are both based on and can be used as building blocks for further research. The innovation can take the form of a publication, a licence or a patent [9], as well as spin-offs from existing firms (or the knowledge infrastructure). The STI form of learning, even if it starts from a local problem, will use global knowledge all the way through, and will potentially end up as global knowledge ([13], p. 683).

The DUI Innovation Mode

The DUI mode relies on informal processes of learning and experience-based know-how [13]. Firms' activities build mostly on practical skills, and learning occurs mainly in the form of applied research and development and as learning-by-doing, using and interacting. As cited from Jensen et al. [13], it is still the case that "much of practice in most fields remains only partially understood, and much of engineering design practice involves solutions to problems that professional engineers have learned 'work' without any particularly sophisticated understanding of why" ([17] p. 458). Employees face ongoing challenges that need a solution through know-how (knowledge related to how things work in specific ways) and know who (knowledge of who knows what) as much of the relevant knowledge resides in persons.

Knowledge is mostly gained through experiences at the workplace and through finding practical solutions based on accessible practical and tacit knowledge, which is often highly localised. The learning may be an unintended result of interaction between people representing different departments in the firm, or between people in the firm and external actors such as customers and suppliers or other agents along the firms' supply chain. Supply chains are the networks of organisations that are involved in different ways to produce value in the form of products and services in the hands of the ultimate consumer ([7] p. 17). A firm's interaction and coordination with actors in the supply chain may lead to experience-based learning which can lead to innovation and competitive strength in the market.

Much of the learning and knowledge development in the DUI mode is a by-product of the firm's daily activities and through the use of experience-based knowledge. Learning often happens in communities of practice [22] that consists of groups of people working with the same tasks (assignments) such as ICT professionals, accountants or people working with marketing that discuss how practical problems can be solved. The knowledge that is created and shared in communities of practice is often hard to codify. Geographical proximity eases the collaboration within such groups, and it stimulates social proximity [6].

The combination of the two modes of innovation seems to be the most efficient strategy for firms. Firms that have used the STI mode intensively may benefit from paying more attention to the DUI mode and vice versa [13]. To further elaborate the combination of innovation modes, we distinguish between application development and technological platform development [5]. The former is what we perceive as the archetypal DUI mode of innovation. *Application* development is typically user–producer-based innovation carried out when developing and adapting a concrete

product or service for a dedicated customer. This development takes place in-house or in contact with suppliers and customers as described above.

Technological platform development typically takes place as applied research projects in cooperation with external R&D organisations. This represents the STI mode of innovation but based on synthetic knowledge [5]. Technological platform development includes developing the technologies and core competence to be used when developing specific products, services and solutions. This is technology that is more general and serves as a common platform for different specific and concrete technologies. We denote this type of innovation as DUI, technological platform development in Table 1.

Industries based on synthetic knowledge are active users and adopters of existing technologies in order to solve concrete problems through learning-by-doing-and-using. Continuous incremental learning makes "the DUI industries" competent buyers that can put pressure on suppliers of technology with regard to improvements and new technical solutions [14]. External relations with the knowledge infrastructure exist in particular as regards technological development. The results are mostly incremental process innovations in the form of patents, technical solutions and prototypes [9] that can be taken directly into use.

Table 1 summarises important aspects of the three modes of innovation. The main argument is that learning and knowledge generation are carried out differently in the different modes.

Empirical Data and Context

The data for analysing firms' innovation mode are generated from the Agder region. Agder is the southernmost part of Norway. It consists of two counties, Aust-Agder and Vest-Agder, with a total of 280,000 inhabitants in 2008. The population is concentrated on the central coastline of Agder; 55% is found in the four city municipalities between Kristiansand and Arendal.

Agder has comparatively more jobs in manufacturing industries than the average for Norway,[1] and the stronghold in Agder is the three manufacturing sectors analysed in this article. The industrial policy in the two counties also has a special emphasis on culture industries in the fourth industry analysed in this article.

Data Generation

The empirical study of innovation processes and forms of learning in the four regional industries in Agder builds mainly on a web-based survey to firms in these industries. We also use informant interviews in 12 oil and gas equipment supplier firms when interpreting some of the results from the firm survey. The main reason for choosing these four regional industries is that they are regarded as important industries by policy makers in the region and that they are target areas for a research programme initiated by the Norwegian Research Council and co-financed by the two

[1] Agder had 13.5% of its employees in manufacturing industries in 2006 compared with 9.6% in Norway (Statistics Norway).

Table 1 An\alytical framework: characteristics of the modes of innovation

Innovation mode	Dominant knowledge base	Modes of learning	Important external knowledge flows	Geography of innovation	Typical innovation result
STI	Analytical. Know-why and know-what	In a defined R&D project	Cooperation with knowledge organisations and use of codified knowledge	Globally (in epistemic communities)	Product innovation and radical innovation
DUI, application development	Synthetic. Know-how and know who	In daily work and in projects for individual customers	Along the value chain	Locally (in communities of practice) and globally (in value chains)	Process innovation and incremental innovation
DUI, technological platform development	Synthetic	In a defined, applied R&D project	Cooperation with applied knowledge organisations	Most often locally	Development of the general level for specific technologies and core competence of the company

counties in Agder. The data presented in this article was from a survey carried out during the autumn of 2007 and the start of 2008. The questionnaire is quite extensive, and it includes questions regarding basic information about the firms; firms' core competence and learning; firms' innovation activity, R&D and patenting; idea and knowledge sources for innovation; regional factors stimulating and hampering innovation; and regional cooperation and networks.

The questionnaire was firm sent to 197 firms. These include all 41 firms participating in the regional network Norwegian Offshore and Drilling Engineering at the time of the survey, all 12 process firms that are members of the Eyde network and all 72 firms seen to be part of the regional ICT industry.[2] This selection procedure ensured that nearly all oil and gas equipment suppliers, process firms and hardware and software ICT firms in Agder were registered. The cultural industry is more heterogeneous. It also consists of many individual enterprises and is difficult to overview. The survey concentrated on a few, supposedly innovative sectors of the cultural industry, i.e. architecture, design, film and design-intensive manufacturing. Based on the telephone catalogue, web sites and inquiries to municipalities, a list of 62 firms in these industries was prepared.

The managers in small firms and the technical directors, etc. in larger firms were asked to answer the questionnaire. The last reminder consisted of telephone calls to contact persons in the largest firms, and the sample includes almost every firm with more than ten employees. The general response rate is about 51% after several rounds of reminding. The process industry had a higher response rate with nearly 67%, but since there are so few firms in this industry, the overall response rate is not much altered.

It is difficult to find statistical figures for the number of jobs in the four sectors as these do not always correspond with the two-digit NACE sectors (Nomenclature generale des Activites economiques dans les Communautes europeennes (NACE) refers to the industrial classification used by Eurostat) that are available on the county level from Statistics Norway. However, calculations indicate clearly that the sample of ICT firms, equipment suppliers and process firms in the survey includes a substantial share of the jobs in these sectors in Agder, and the sample should then give a good picture of the forms of learning and innovation in these industries in Agder.[3] The culture industry in the survey includes a few small industrial sectors where the number of jobs is not available in the official statistics (Table 2).

Characteristics of the Firms

The surveyed industrial sectors have some specific characteristics to be aware of when analysing the learning and innovation processes. The process firms (smelteries, etc.) are clearly the oldest and largest ones and are all part of larger corporations

[2] The firms in the ICT industry were selected according to information from a regional organisation (Coventure) working to support firms and networking in this industry.

[3] The chemical manufacturing industry and metal production (NACE 24 and 27) had about 2,300 jobs in Agder in 2007 (according to Statistics Norway), while the process industry firms in the sample have more than 1,900 jobs. Manufacturing of machinery and equipment (NACE 29) included about 3,100 jobs in Agder in 2007, and the equipment suppliers in the sample have nearly 2,500 jobs. As regards the ICT industry, the sectors office machinery and equipment, electrical machinery and apparatus, radio, television and communication equipment and apparatus, and computer and related activities (NACE 30, 31, 32 and 72) include 2,100 jobs at Agder, and the sample of ICT firms in the survey includes 750 jobs.

Table 2 Size of the survey sample

Industrial sector	Number of firms	Response rate	Number of jobs
ICT firms	36	50.0	742
Suppliers of equipment for the oil and gas industry	21	51.2	2,488
Process firms (smelteries, etc.)	8	66.7	1,936
Culture firms (architects, designers, film companies, design-intensive manufacturing firms)	31	50.0	290
Sum	96	51.3	5,456

Source: The VRI survey

(Table 3). These are production units that largely employ skilled workers. The firms produce mainly standardised products in large quantities, but they also, to some extent, adapt products to individual customers. The equipment suppliers are also quite old and large, although they include a mix of old and new, small and larger firms. These are more often engineering firms that produce small batches or one-off products adapted to individual customers. Nearly half of the equipment suppliers are part of larger corporations.

The two other sectors include much smaller firms, although three of the ICT firms in the sample have about 100 employees. The ICT firms are often software producers with a high share of employees with higher education. The culture firms in the sample (such as architects, designers and film producers) also have high shares of higher educated staff. These are mainly small firms, locally owned, and also characterised by a high degree of customised products and services.

Categorisation of Firms

The sample of firms in the survey is divided into four categories based on the firms' answers. The first category is the non-innovative firms, while the next three categories are firms dominated by the STI mode of innovation and the two DUI modes in Table 1. The non-innovative category consists of eight firms without R&D projects that had not introduced any innovations at the market in the last 3 years. The rest of the companies in the sample were regarded as innovative.

Table 3 Basic information of the surveyed firms

Industrial sector	Average age (in 2008)	Average number of jobs in 2007	Share of firms where more than 50% of the employees have higher education	Share of firms that are part of a larger corporation
ICT firms	9	21	86	32
Equipment suppliers	23	118	68	46
Process firms	41	242	0	100
Culture firms	16	9	66	8

Source: The VRI survey

The firms in the STI category were identified as firms with R&D departments and that were engaged in R&D projects both in-house and in cooperation with external knowledge organisations. Thirteen firms fulfilled all these three criteria.

Firms that did not fulfil the criteria of the STI mode of innovation, but regarded cooperation with universities, university colleges and research institutions as very important or important, were characterised as DUI firms with technological platforms. Seventeen firms fulfilled these two criteria. The remaining 58 firms were regarded as DUI application firms. These are innovative, but do not fulfil the criteria decided for STI firms or DUI technological firms.

Innovation and Knowledge Sources in Agder

Table 4 shows the distribution of firms in the different modes of innovation. The majority of firms are DUI application firms, and a small share of the firms in the sample is non-innovative. The non-innovative group is excluded in the following analysis.

There are significant differences with regard to learning and information flow between the three other groups of companies. Nearly 27% of the firms innovate according to the STI and the DUI technological mode of innovation. These are the most innovative firms in the region. This implies that there are 30 companies in the sample that are innovative and leading the technological development, while a larger group of companies are not so innovative. The companies that innovate according to the STI and the DUI technological mode are ICT firms, equipment suppliers and process firms, while nearly all cultural companies are within the DUI application or within the non-innovative category.

A further investigation of the equipment supplier industry reveals that firms that develop their own product which they sell under their own brand names most often perform technological platform development [11]. The component suppliers, on the other hand, are generally more traditional DUI firms with less strategic knowledge upgrading and innovation activity.

The difference between the STI and the DUI technological firms is that the latter cooperate more with demanding clients, and that they use many different information sources in their innovation process. The STI companies use universities

Table 4 Categorisation of firms in different modes of innovation

Category		Non-innovative firms	STI	DUI technological	DUI application
Number for firms		8	13	17	58
Percent		7.3%	11.9%	15.6%	65.1%
Industry	ICT	–	7	7	22
	Oil and gas	–	1	9	14
	Process	–	5	0	2
	Culture	–	0	1	33

Source: The VRI survey

Table 5 Percentages of firms that state that different sources of information for innovation have been very important in the last 3 years

	Sources within the firm	Clients	Conferences, meetings, journals	Trade fairs/ exhibitions	Suppliers of components, parts	Other entities in the enterprise	Suppliers of machinery, equipment, software	Univ. and higher educ. inst.	Other specialised firms	Competitors	Research institutes	Consultants
STI	92.3	69.2	16.7	8.3	0	16.7	0	23.1	0	7.7	30.8	7.7
DUI application	82.0	42.0	20.0	16.7	14.0	17.0	16.0	0	10.2	8.0	0	6.0
DUI technological	76.5	82.4	47.1	31.2	41.2	17.6	29.4	35.3	17.6	18.8	23.5	11.8
Total	82.5	55.0	25.3	18.4	17.7	17.1	16.7	11.2	10.3	10.1	10.0	7.5

Source: The VRI survey

Table 6 The location of important knowledge sources for firms' innovation activity

	Own region (community/ neighbour community)	Other places in Agder	Rest of Norway	Europe	Rest of the world	Total
STI	9.3	5.0	29.2	32.9	23.6	100.0
DUI application	12.7	14.7	37.6	16.0	19.0	100.0
DUI technological	16.4	12.5	35.9	16.0	19.1	100.0
Total	13.2	12.4	35.6	19.0	19.8	100.0

Source: The VRI survey

and research institutes more than the DUI technological firms, and they are more globally oriented in their search for information and knowledge than the other companies. The STI and the DUI technological firms compete more in the global market than the DUI application firms. The DUI technological firms collaborate much more with demanding clients and suppliers than the others do, and much of the collaboration is concentrated to the Agder region.

Sources within the firm and clients are the most important sources of information for innovation among the surveyed firms (Table 5). However, the importance attached to these sources differs between firms dominated by different innovation modes. Almost all STI firms report that sources within the enterprise are very important, and more than two thirds report that clients are very important, followed by research institutes and universities and higher education institutions. The DUI application firms report several other sources (besides those within the enterprise and clients); however, the share of firms mentioning these sources is relatively low. The DUI technological firms relate to yet other external sources. Nearly half of these firms' perceived conferences, meetings and journals as very important, followed by suppliers of components, universities, trade fairs and suppliers of machinery. This suggests that DUI technological firms are able to use a broad set of external information sources in their innovation efforts, both along the value chain, in the knowledge infrastructure, and the more informal meeting places. The DUI technological firms seem to be able to use knowledge sources that are typical for both the STI mode and DUI modes of innovation to some extent.

There are large differences between the innovation modes with regard to the *location* of important knowledge sources for firms' innovation activity. The STI firms mostly search outside their own region and Agder for knowledge sources

Table 7 Percentage of firms that collaborate very often with other actors in Agder

	Clients	Suppliers	Other firms in same branch	Consultants	Univ./HEIs	Research institutes
STI	7.7	7.7	0	7.7	23.1	15.4
DUI application	32.0	20.0	12.0	18.8	6.1	2.0
DUI technological	64.7	35.3	29.4	17.6	17.6	5.9
Total	35.0	21.2	13.8	16.7	11.4	5.1

Source: The VRI survey

(Table 6). More than half of the firms search for knowledge in Europe or in the rest of the world, which indicates that firms dominated by the STI mode of innovation depend on global knowledge sources for their development of 'know-why'. The DUI technological firms have the highest share reporting that their own region houses important knowledge sources for innovation. However, the important sources are often found elsewhere in Norway, suggesting that national knowledge sources (both local/regional and the rest of Norway) are of importance for these firms. The DUI application group of firms has nearly the same geography of knowledge sources as the DUI technological firms.

The survey also enquired into how often firms take part in more formal collaborations with different regional actors. The share of firms engaging in local collaboration differs markedly between firms that are dominated by different modes of innovation (Table 7). The STI firms report least regional collaboration, besides collaboration with universities, higher education institutions and research institutes. Tables 6 and 7 indicate that STI firms enter into few regional collaboration projects and that this collaboration mostly includes the regional knowledge infrastructure. DUI application firms, on the other hand, collaborate to some extent with clients, suppliers and consultants, but hardly with the knowledge infrastructure. In the DUI technology group, two thirds of the firms report to collaborate very often with clients, and a relatively large share also report to have collaboration projects with suppliers and other firms in the same branch, suggesting that important parts of the value chain are found locally. These firms are also to some degree embedded in a regional system of innovation as some of the firms also report collaboration with the knowledge infrastructure.

The STI firms are clearly the most international ones among firms in the survey. This is demonstrated in Table 8, which shows that no STI firms found 'strong competition' in Agder, and few found such competition in the Norwegian market in 2007. The STI firms differ in this respect from the DUI firms in the low percentage of STI firms that report about competition on the regional and national levels. As much as one third of the STI firms reports, however, about strong competition on the international market.

DUI application firms, on the other hand, have relatively large shares of firms reporting strong competition both locally/nationally and internationally. The component producers in the Agder oil and gas industry, which most often are DUI application firms, report increasing competition from low-cost countries [11]. The firms produce mostly for local customers. They produce prototypes and the first versions of a new component or product. When the products are standardised, the

Table 8 Percentage of firms reporting 'strong competition' in 2007

Markets' innovation mode	With other firms in Agder	On the Norwegian market	On the international market
STI	0	7.7	33.3
DUI application	26.0	28.0	25.5
DUI technological	17.6	23.5	35.3
Total	20.0	23.8	28.9

Source: The VRI survey

Table 9 The share of labour recruited from Agder in the last 3 years

	Labour with certificate of apprenticeship					Labour with higher education				
	<25%	25–49%	50–75%	>75%	Total	<25%	25–49%	50–75%	>75%	Total
STI	18.2	0	9.1	72.7	100	0	7.7	23.1	69.2	100
DUI application	19.2	19.2	7.7	53.8	100	6.5	10.9	17.4	43.5	100
DUI technological	0	0	8.3	91.7	100	0	12.5	18.8	68.8	100
Total	14.3	10.2	8.2	67.3	100	4.0	10.7	18.7	53.3	100

Source: The VRI survey

local component producers, however, report increasing competition from producers in low-cost countries. DUI technological firms perceive the competition locally to be slightly less than DUI application firms; however, a larger share of these firms regards competition on the international market to be strong (35.3% versus 25.5%).

An important aspect in analysing the importance of the Agder region for the surveyed firms is to what extent they actually find necessary human capital locally. The survey distinguished between two types of human capital: newly recruited labour with apprenticeship and labour with higher education. As much as 92% of the DUI technological firms report that more than 75% of their manpower with certificate of apprenticeship is recruited from Agder (Table 9). Also, the STI firms report high shares of such manpower recruited regionally. The DUI application firms have, to a larger degree, recruited human capital with apprenticeship from other places than Agder.

Human capital with higher education is also recruited mostly locally and first of all among the DUI technological firms and the STI firms. Table 9 indicates, however, that firms also recruit manpower with higher education from other places, which is most marked for the DUI application firms.[4]

Conclusion

The starting point in this article is based on firms' and industries' different modes of innovation and that the firms dominated by different modes of innovation may meet different challenges from globalisation. The approach departs from the view that industries in a region may be quite different with regard to their way of innovating, including which types of knowledge inputs firms in different industries need for their innovation activity and where the important sources of knowledge are found.

The article distinguishes between three main modes of innovation. The first one is the science, technology and innovation (STI) mode, characterised by innovation in

[4] The DUI application category includes many cultural firms (Table 3) that need to recruit architects, designers and many other higher educated and skilled workers outside Agder as there is no education for such professions in Agder.

specific R&D projects and by the use of mainly scientific knowledge. The second one is the doing, using, interacting (DUI) mode which includes application development. This is characterised by incremental product and process innovation by the use of mainly experience-based knowledge in the firms and cooperation with customers. The third category combines the first two innovation modes in performing technological platform development which includes applied research and development to upgrade the technological platform and core knowledge of firms. Most of the firms in the Agder sample are characterised as DUI application mode which means that these firms only perform incremental innovation.

Firms dominated by the STI mode of innovation find their knowledge sources for innovation mostly within the enterprise, from their clients and through the knowledge infrastructure. These sources are mainly located outside Agder, that is nationally and especially globally where these firms also meet the strongest competition. These results are in line with the theoretical propositions regarding the geography of innovation in STI firms. Agder is, however, important for formal innovation collaboration, especially with the knowledge infrastructure, and for the recruitment of qualified labour.

Firms dominated by the DUI application mode of innovation also emphasise knowledge sources within the enterprise and at clients as important for innovation, as well as more informal meeting places such as conferences and trade fairs. These sources are mostly found at the regional and national levels; however, also some international knowledge exchange exists. Formal collaboration is mostly with actors along the value chain and with consultants. Regional recruitment of employees is important, however less so for firms in this group as for firms dominated by the other innovation modes.

Firms characterised by the DUI technological mode of innovation have the broadest set of knowledge sources and the broadest set of collaborators, which suggests that these firms are using a more mixed innovation strategy. These firms are regionally embedded with strong dependence on regional knowledge sources and human capital. However, the strongest competition is found on the international market, suggesting that these firms have gained a competitive strength based on regional assets.

Based on these findings: How is the three types of firms influenced by the global economy? And how can the firms meet the challenges from globalisation? The most important challenge in Agder is met by the large share of firms that only carry out application development. These firms focus on incremental product and process innovations. Many of the firms meet price competition from low-cost countries and can enter into negative lock-in situations in cases of external changes in technologies and markets in their industrial sectors. One solution in this type of firms is to acknowledge their vulnerable position and to develop strategies in order to strengthen their position. Important elements in such a strategy could be to upgrade these firms to carry out more systematic R&D activities, i.e. that they perform technological development and develop their core competence. One way to achieve such upgrading in the case of component suppliers is to develop more sparring relations and interactive learning with their customers that most often are local firms that develop and market their own products. The component suppliers cannot compete on cost and must therefore upgrade to supply larger parts of their

customers' value chain, such as contribute to product development, engineering, more completed components, etc. [11]. The suppliers could then avoid some of the competition that only includes price.

The strategy of developing technological platforms probably demands increased formal competence in the firms that may also demand a strengthening of the regional innovation system. Today, these firms do not use sources of knowledge from universities, other higher education institutions or R&D institutes. Thus, there is a need to increase the connectivity in the regional innovation system, and in particular between the DUI application type of firms and higher education institutions, applied social research institutions and applied technological research institutes. The firms need to raise their absorptive capacity, which is their ability to identify and make more use of external competence [8]. This capacity is closely linked to the human capital in the firms. Agder thus needs to strengthen its "DUI-based innovation system" including a broad set of actors that influence learning and innovation in the region. This may include, for example, collaboration to develop study programmes at the university which are adapted to the needs of the firms, and to perform applied research in cooperation with regional knowledge organisations.

The STI firms meet another type of challenges. These firms are often part of international or national corporations which, for example, are the case with all the process firms in the sample (cf. Table 3). Among firms in the sample, the STI firms also clearly find least knowledge locally (cf. Table 6). Both external ownership and lack of local knowledge sourcing demonstrate that these firms may have comparatively few local connections. Thus, the STI firms may be in danger of being moved to other areas with, for example, lower labour costs or more dynamic industrial environments. A possible strategy from the perspective of the region to meet such a challenge is to strengthen also the "STI-based innovation system" in Agder. This means to raise the R&D capacity in first of all the University of Agder and to strengthen the innovation cooperation between the STI firms and the university. However, we must recognise that Agder is a fairly small region with a rather 'thin' regional innovation system. It is thus important to discuss what type of competence should be the specialities of the knowledge infrastructure in Agder seen in a larger geographical division of labour including national and international knowledge organisations.

The DUI technological firms meet still another challenge. These firms have a strong regional base through cooperation and they are globally competitive. For the time being, they are successful and can be used as good practice for other companies in the region. However, the firms still must develop strategies for future changes. One element in such a strategy could be to connect more closely to the regional university and regional applied research institutes in order to exchange knowledge, codify knowledge and continue to develop their technological platform. These firms are the local customers to some of the DUI application firms, for example the component suppliers. This illustrates that although different types of firms may meet quite diverse challenges from globalisation, a coordinated response from network of firms or regional policy makers *may* be appropriate, which also demands an absorptive capacity among firms and other regional actors.

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