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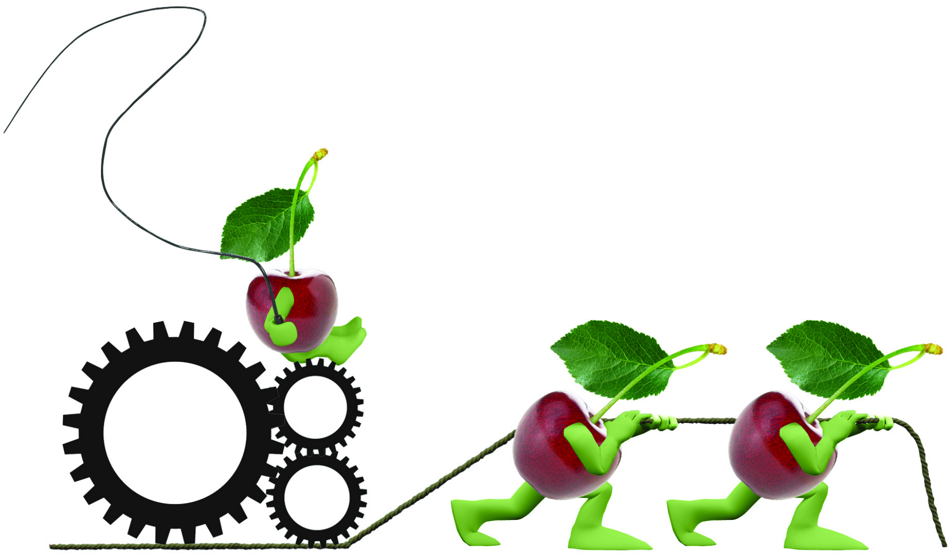

SCIENCE, TECHNOLOGY AND BUSINESS; MARKET OR INTERACTIVE COORDINATION?

SCIENCE, TECHNOLOGY AND BUSINESS — MARKET OR INTERACTIVE COORDINATION?

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Abstract

Recent decades have witnessed a growing interest in the importance of science and technology for business development and how they affect the positions of individual companies and their economic performance. Over the years the discussion involved R&D people and general managers from industry, researchers and administrative managers from universities and policy people from governments. The crucial issue is about the present state of the technology-business interface and the general connections among scientific research, development of technologies and economic development in terms of the performance of business units. This is interesting for us as our research group has extensive experience in innovation research in an industrial setting.

Keywords: technical knowledge, human resources, R&D sector, international orientation, interactive coordination

Introduction

Recent decades have witnessed a growing interest in the importance of science and technology for business development and how they affect the positions of individual companies and their economic performance. This was also one of the themes in the European Forum: "Marketing of Scientific and Rese-arch Organizations" in Warsaw in November 2011. Over the years the discussion involved R&D people and general managers from industry, researchers and administrative managers from universities and policy people from governments. The crucial issue is about the present state of the technology-business inter-face and the general connections among scientific research, development of technologies and economic development in terms of the performance of business units. This is interesting for us as our research group has extensive experience in innovation research in an industrial setting[1]

The basic issue-interaction between producers and users of technical knowledge

There are at least four different issues related to the basic issue of how the interaction between producers and users of technical knowledge should be organized.

First is that there seems to be an increased need for direct contact between the end users and the producers of knowledge. It is not enough anymore to work through research "middlemen", i.e. industry research institutes or similar research organizations directed toward broad problem areas. One important reason for this might be that knowledge exchange in general has changed. Earlier it was mainly broad and focused on general knowledge regarding certain technologies. Now it has become much more spe-cific and precise knowledge that is exchanged that can be directly used in an application.

Second is the developments within the research community-the academic world. This world has become so fragmented and specialized that it is difficult for an outsider to orientate within it and even worse to try to gain an overview even if the problem area has been well specified. This increased specialization has also made the international dimension more important for both users and producers. Advanced users have to be in contact with quite a number of research institutes all over the world if they want to stay current. The same is true for the academic side. In order to be an efficient research institute there is a need to have contacts with other advanced research institutes on an international scale, both1 to be informed about contemporary research and to be able to use complementarities in resources and knowledge in the research.

A third related issue is the role of the single university in relation to the country in which it is located. Should it define its role in any special way in relation to, for example, users in its own country? Does it have a special responsibility for knowledge development among the users in that country? Here we see a clear trend of universities becoming more international-at least within Europe. Furthermore, it has become increasingly difficult to define the origin of business users; what should be the definition of a local company (should it be in terms of owners, location of production, number of employees in the country or?). A consequence is that neither companies nor the research institutes will have any special advanta-ges by being domestic in relation to other domestic counterparts except for geographic proximity. From a language point of view the differences are also quite small as most research information and knowledge is communicated in English. The research community's and the companies' orientations have become increasingly internationalized. Every actor within the research community-whether they are producing or using knowledge-will have to do it in relation to an international context. The existence of an inter-national structure has also changed the national structures. Domestic or regional universities have not become less important, but they have to act and behave as members of a larger community where one important task is to bridge over to other competent international knowledge centers.

Fourth need for competent counterparts in the process of technical development in companies has become a critical issue. Development often appears on the borderline between different knowledge bodies, and cooperation in a relationship between two different units can thus be innovative. Another factor is that, in order to convince anyone to try to invest in a new solution (innovation), there is a clear advantage with an established relationship. A general problem seems to be that there are companies and research institutes that have not realized this and therefore are surprised when others do not react positively to new technical suggestions. Another issue is that, despite the fact that relationships (probably) always have been important, the increased specialization has made them even more critical.

These four issues give a picture of some of the consequences of the changed interaction between the classical producers of knowledge (the academic world) and some of the most important users (the business world). The basic issue is: How should the relationship between knowledge producers and knowledge users be organized to function in an efficient way for both sides? This is obviously a classic question that has been discussed for a long time and in relation to different settings. Two of them will be presented in the next section.

The relationship among Science, Technology and Business

There are two particular very broad and connected areas that have received a lot of attention. One is the relationship between investments in science and its effects in terms of economic development. There has been a tremendous interest, especially from politicians, in attempts to create economic growth within countries or regions with the help of science[2]. Through large investments in science-for example in terms of large national programs or science parks-the ambition has been to create growth poles. Up to now the results have not been very rewarding.

The second area focused on and discussed could be depicted as "innovations". In both companies and in the political sphere so much hope is connected to this word. This is directly concerned with com-pany operations and the possibilities of, and the problems with developing and launching new products or services. Shorter product life cycles have made issues like "time to market" increasingly more important. This problem is not easy to solve, especially when the success rate of new products (at least when they are of a more radical character) is perceived to be quite low. The combination of feelings of necessity to increase the speed and frequency of product development and difficulties in getting the expected results is, consequently, seen as a dilemma by many managers.

Both of these issues point to the need for an interplay among science, technology and business, as well as indicating that we do not know very much (enough) about this interplay. If there are certain changes taking place in the basic conditions for this interplay, which seems to be one of the consequences of the four earlier identified issues, this could be seen as a minor problem as we do not know what it previously looked like. The main question is still how the interplay functions. However, the changes might help us as they may work as windows through which we can learn more about the basic interplay.

The relationship among science, production and economic development has traditionally been described and analyzed using the "linear model", where investments in science were believed to more or less automatically transfer over into technological solutions that in turn will yield economic develop-ment. Over recent decades this model has been questioned by almost all researchers dealing with these issues. Still, there is a lack of alternatives that has been well formulated or accepted in a broader way. Here

I will discuss the relationship between production and use of knowledge using results from research dealing with production and use of industrial products. I will use an established model, making a distinction among actors, activities and resources[3]. Differentiating among these three creates the oppor-tunity to identify different, and sometimes contradictory, factors. The three are certainly related to each other; it is actors who are using resources to perform activities, but they have also different features and follow different change patterns; thereby it can be rewarding to analyze them separately.

The ambition is to use this model to identify patterns in the interplay as seen from three reference po-ints identified from the three "layers" above. The first one is a scientific/knowledge reference point where we look at what is happening in terms of knowledge creation. The second is a substantive/technological reference point based on the materialized technologies. The third is a commercial/business reference point and from here the economic use of new knowledge can be covered.

The discussion will be tentative and problem-oriented, and the aim is to create a picture that I hope others will question and add to. I will not use references in the text but I will provide some key references at the end. In an ongoing research project the purpose is to come to more conclusive findings. The discussion will be done in the following three steps:

- Changes in performed activities: What has changed in research, technological and business activi-ties? What role does specialization play and how have the interdependencies between the activities developed?
- Changes in activated resources: How has the use of scientific, technological and business resources changed? How are they combined and has the complexity of this combining changed?
- Changes in actors: How have single research or business actors changed internally and in relation to how they relate to others?

In each of the three sections I will start with the scientific aspects, then the business and end with the technological ones.

Activities

A specific feature of scientific research activities is that they are dominated by the activities of human beings-the researchers are very much the activity. It is the collective of researchers who perform all the thinking, conceptualizing and theorizing, and who thereby characterize the research. In this respect there has been no change.

However, the way this human work is done has changed. The first major change is that the research, and thereby the researcher, has become directed towards more specific items; the limitation of each research problem has become narrower and more specific. Parallel to this there has been a clear inter-nationalization; scientific results are systematically spread all over the world. One consequence is that the division of work has become more differentiated as it is derived from a work division based on an international scale. The scientific world has always been highly international but the effects of the division of work and the intensity of communication has increased over the years. This is one explanation as to why each researcher has had to become more limited and specialized in his/her activity. The results of the increased specialization can be seen in publications; there are now thousands of scientific journals focused on different and very specific problem areas. It can also be seen in job descriptions (specifications of occupational roles) such as professor chairs. An effect of the increased specialization is an increased ne-ed for coordination, especially when broader "empirical" problems are approached. Coordination activities are partly carried out within the research community through reviews of research proposals or publica-tions and international conferences, and partly from the outside through some externally initiated audits. Despite what was stated above about the research activity as human based, in certain areas the acti-vities are very much dependent on highly specialized equipment. To do research in the area of advanced physics or computer science is largely a question of equipment. In order for a researcher, for example, to become a Nobel Prize winner in physics, he/she should certainly choose to work in an institute with highly specialized equipment (CERN!).

IResearch activities can also be characterized by their connections to education. A change during recent years is that universities on average have become more conscious about teaching. One of the reasons behind this change is that, to an increasing degree, universities have become interested in attracting qualified international students. One marketing argument is that qualified researchers take part in the teaching. This reduces the amount of research conducted, but it also affects the distribution of research knowledge.

In summary, the research activities are characterized by being performed by humans even if advan-ced equipment is a necessity in certain fields, by becoming increasingly specialized and differentiated and by having an international spread. The higher degree of specialization has also increased the need for coordination activities.

Analyzing activities from the business perspective reveals some important changes. There are signifi-cant signs that technology has become more important in many companies' business relationships with both suppliers and customers. In this way technology has become a more focused factor in the dealings between companies. An interesting and logical consequence of this is that there seems to have been a switch from a focus on the general level of technology/knowledge to more specific issues. Counter-parts must be able to handle the basic technology-that is an absolute and self evident demand — but above that they are evaluated in terms of what they can do more from a technological point of view. This is especially the case in more high tech areas. For companies working in such areas, a key factor is to have counterparts (suppliers and customers as well as research units) that can contribute with different specific technological attributes.

Another important trend is the general increased outsourcing from most business units, which means an increased use of external specialists (suppliers). The change can be interpreted in two complementary ways. First, the demand for knowledge in production has increased in such a way that it is only possible for a single company to cover a small area. Thus there has been a general trend toward specialization, which more or less automatically creates an increased use of suppliers. Second, production knowledge has become easier to access, making it more difficult for the single company to gain advantages from production and has forced many companies to move toward developing the design of the product/service. The difficulties with gaining production advantages can at least be partly explained by the fact that production knowledge can now be more or less acquired from external sources in terms of specialized equipment from suppliers. Earlier the equipment and machinery were designed and developed more by the producers themselves. We can conclude that whatever the reasons, the main change in business activi-ties is that technical aspects have become more accentuated in the exchange between the business units.

Finally, the activities can also be analyzed from a technological point of view. Any technology bro-ught to use is "substantiated" in certain products and thereby in certain production and using processes. Activities can thus be identified as those involved or affected by how a certain technological problem is solved. Most activities looked upon in this way have become more multi-technological. In order to solve technical problems different technologies have been bound together in more and more complex way-selectronics with mechanics, different metals with each other and with other materials such as plastics. One consequence is that more technical links are developed between different activities; even between activities that earlier were regarded as being far from each other. In this way different technologies have become linked to each other. A consequence is that the total activity pattern has become more integrated and activities within and between single technologies have become increasingly dependent on each other.

In summary, there seems to be two different and partly contradictory trends. The first one is that the activities, as analyzed from the three reference points of view, have become more differentiated and thus more difficult to integrate. Second, and contradictory, activities have become more interdepen-dent and thus there is an increased need for integration. Those two trends can, to a certain extent, explain some of the frustration among researchers and managers with the development and thereby with the contemporary situation

Resources

There are two kinds of resources needed for performing research activities. The most vital is, in accor-dance with the earlier discussion of activities, the human resource. One important feature of this resource is that it takes a long time to develop. First, it takes from four to eight years to get a PhD. Then it takes another five to ten years before the researcher reaches the "full" research competence level. Consequ-ently, it takes a long time to increase the volume or to change the characteristics of research resources. Furthermore, during this long development time these resources become highly specialized. They can-not easily be switched over to new fields. Finally, the resource will, as if it is a human being itself, have a specific orientation; the resource in terms of the experienced researcher will not easily accept direc-tions from others. If we look at the total human resources devoted to research, today they are larger than at any time before and they are quickly growing. Clearly, this is one reason for the increased differentiation already identified in the activity section.

The second type of resource important for research, also indicated in the discussion of activities, is the use of advanced equipment. Advanced lab equipment, powerful computers and other machinery, and technicians are important ingredients within a number of research fields. This refers to a number of areas within the pure sciences as well as medicine and computer sciences. When these fixed resources reach a certain total volume they have to be shared. Several research units or even countries have to join together to afford the huge investments such as in the case of CERN.

In summary, the research resources are characterized by being larger than any time before, more differentiated, but still difficult if not impossible to control or direct.

In business, resources have always been important as control of them has been used to create attrac-tiveness. However, over time the types of resources controlled in order to be attractive to others have changed. Once upon a time it was mainly natural resources (minerals, energy, forests and farming). Control of the primary resources was often combined with ambitions to also control knowledge of them. Today, the critical resource is often claimed to be the knowledge itself. But knowledge is a resource with some special features. One is that it is easy to copy. Someone else can easily copy the knowledge that has been embedded into a product or a production process. Successively increased interest in and investments in knowledge have made it less and less possible to be the only one possessing any basic knowled-ge. Consequently, it has more or less destroyed the earlier possibilities to prosper by "monopolizing" a certain technology base. IBM was maybe the last example of this. Still, basic knowledge is important as it is a request for being accepted as a relevant counterpart for others.

However, another type of knowledge-extensive and detailed knowledge of specific technical at-tributes-has become more important in order to increase attractiveness especially in the short run. Through such knowledge a company can gain an edge for its solutions in relation to some specific others. One important way to acquire this special attribute is to work with someone with complementary know-ledge or technology. The advantage with this way of creating specific attributes is that very specific and adapted solutions for the customers can be created.

In relation to the substantive technological world there are several important changes taking place. One regards the utilization of basic resources. In some cases we have come close to the theoretical boun-dary of how a certain resource can be used in relation to a certain dimension. The closer we come to the boundary, the larger the investments needed to further increase utilization. However, at the same time, successively more and more dimensions of each resource have been found. Further, these dimensions are combined in increasingly intricate ways. This change is easy to see if we look at the production resources used today. There, technical dimensions of different materials and components are combined in a very advanced way. For example, advanced material treatment is controlled by electronic equipment that, in turn, is integrated into advanced computer controlled systems. Another interesting fact is that total investments in production resources are larger than ever before. There are two important consequences. First, a radical change of this structure will spoil a lot of existing investments. The resistance to radical changes has thus probably successively increased. Second, as there are many "dimensions" integrated into the structure, simultaneously there are many aspects that can be changed/developed. Such incremental changes often result from how several technologies are combined and used to solve special problems. They deal with advanced applications where knowledge from several areas is combined.

Without any doubt there are more productive resources today than ever before. The size of the total production resources makes it hard to claim that a lack of resources is the main economic problem. Instead the economic problem seems to be how the resources are utilized, how they are combined and directed to solve the huge problems we are facing.

In summary, the total resources have successively increased in all three aspects of interest here. There are more research resources and more productive resources, and companies consist of or control more resources than ever before. The resources have become more differentiated as they are combined with each other in a very multifarious way. A natural consequence is that they have also become more tied together. The combination of resources controlled by different actors seems to be a major way of developing both the knowledge and the productivity of them. The complexity of the interrelated reso-urces has made it more difficult to "manage" them in any simple way for all the different types of actors.

Actors

Within the world of science single researchers have always been perceived to be important actors, and this is still the case. They have been seen as the "institutions". However, there is a clear shift in how research institutions have begun to be perceived and behave as collective actors. Universities and research units are trying to become much more profiled; identified as actors themselves. This is, at least partly, the result of an increased interest from some important counterparts to involve "larger" research actors. Research foundations and governmental bodies have urged research units to specialize through building up research competence in specific fields in order to become leaders in some areas. To accomplish this, the research units must relate to others-to become seen as one of the main actors at least nationally and preferably internationally. One prerequisite has been to specialize, to identify a "new" specific know-ledge/research area. Here we can see a clear parallel to what has happened on the individual level. With many research units specializing in different ways, the total structure has become increasingly differentiated. We don't have just chemistry and physics but physical chemistry and chemical physics -and these are still seen as rather broadly specified. Another important effect has been that the research units have become aware of the importance of having qualified counterparts among the "users" as well as among "cooperating research units". They need such qualified counterparts for several reasons. First, they have complementary resources. The "users" don't just have problems, they also have facilities where solutions can be tried out. Other research institutes may have complementary skills and experiences as well as other users. Second, when there are some research foundations financing the research, both users and research partners can be used as important arguments-they can be used as indicators of the usefulness and the degree of advancement of the suggested research. Third, and maybe most importantly, they can be of help identifying and formulating crucial research problems.

Complementary to the development of very specialized research units, there are also attempts to create cross-sectional research groups around a certain theme or problem (there are different types of centers of excellence). Centers have been a key word and for a while it was perceived as a general solution but it is questionable whether the results corresponded to the expectations. It seems to be quite difficult to bring together specialized researchers from different fields in more long-term projects. It is not enough to name them as a "school" and to give them joint resources to create some kind of highly mobilized unity from a research point of view.

Another change is the increased interest from politicians in research to create economic development, which has taken the form of more resources-larger investments in knowledge production-and has also been accompanied by an increased interest in controlling and assessing the research. Research goals and utilization of research have become critical societal issues. Researchers have adapted to this and have, for example, become very skilled in showing the importance of their research or that it has important connections to issues such as "energy" or "environment". The effect is perhaps largest on the "research application level", but it has affected which research areas get the largest increases in research budgets. It can be important to notice the contradiction in trying to control research. If research is about exploring the unknown then it must, by definition, be impossible to forecast what kind of returns some new know-ledge might create. At the same time there is certainly a need to evaluate and prioritize between different proposals. The classical way to solve this dilemma is to evaluate the project leader instead of the project. Some researchers seem to make something interesting of almost everything.

In business there have also been some clear changes taking place over time. One very dominant change is the increased international orientation of the companies. Today business units often carry out production and/or sales in several (often many) countries. The same is true for R&D, even if it is to a lesser extent. Clearly this has increased the business units' abilities to take advantage of knowledge development in countries other than their origin.

Another change that has influenced the research conducted by companies is related to the total incre-ase in knowledge. Expansion has been so great that today it is impossible for a company to take part in all developments relevant for its activities. Instead the companies have had to increase the use of external specialists. They have had to rely on relationships to others to an increasingly greater extent. But there have been other changes of importance. One is about production. I concluded earlier that the companies have had to successively specialize in production and, as a consequence, many business units have been outsourcing large shares of what they earlier produced themselves. But a danger in increased outsourcing is that the production, and thereby the products, can become more and more similar. If the outsourcing producers use the same specialized suppliers there is a risk for homogenization. To keep up some diffe-rentiation it has become important to obtain some special product attributes from the suppliers. These attributes can be of a design nature, but it would better be if they were of a functional character. Here R&D has become of critical importance.

Another consequence of increased specialization, in terms of limitation to a certain area, is that it has made it riskier with "broader" development projects. Such projects have become so expensive that they request a long-term repayment period. The strategy chosen by many companies is to take smaller steps and to increase cooperation with others. In general business units cooperate with existing suppliers and customers. It is expensive to establish development relationships; they take time and substantial resources as they demand personal contacts, a deep understanding of each other's capabilities, trust, etc. Thus, there are obvious advantages with relationships where the economy already comes from day-to-day commercial activities. In exchange partners where such day-to-day activities are lacking, for example in relation to research units, the development of relationships becomes riskier and less economical.

Three different business strategies seem to have developed in relation to the knowledge factor:

1. Some companies have specialized in exploiting knowledge change. They try to have close contacts with science producers and to take advantage of all knowledge opportunities. These companies are highly active in the knowledge development area and they try to develop close relationships with one or several "leading" centers. These companies try to exploit knowledge development in all possible ways.
2. A second group tries to take part within certain specific knowledge areas but is much more likely to combine the knowledge factor with other key resources. It can, for example, be a certain raw material such as forests, iron ore, etc. or a certain technology. In these cases knowledge interest is more focu-sed on knowledge that is related to these other resources.

The third group of business units has a very passive approach toward explicit knowledge development but will still be highly interested in indirect effects such as in facilities or products with new features based on the new knowledge.

If we look at the actors from a technological point of view, there are always a certain number of diffe-rent actors related to each technology. We can identify actors such as producers and users. Some produce technology in terms of knowledge and as equipment or systems. Others are users taking advantage of the new technology either in their production processes or building it into their own products. The most distinct change among these actors is the increase of units that only partially use a certain tech-nology, i.e. combine it with other technologies. The increase in specialization among both business and science units has often been based on combining basic knowledge areas or technologies with each other. One result is that there is an increase in the number of actors related to each main technology; in this way each basic technology affects more and more actors with their way of functioning. Technologies beco-me mixed and innovations are often the fruit of a combination. One effect is that there are more actors interested in the development of each technology and who have invested in it. They might be influenced in both a positive and a negative way by new knowledge or new products, and consequently will react both for and against new possibilities.

Another change is that technologies have become highly internationalized. We have an international way of comparing production technologies-an international best practice. At the same time — or as a counteraction to the internationalization-there are examples where local factors and resources have become more vital. Examples are some high tech areas such as Silicon Valley but also some regions, such as Third Italy, have become well-known.

Summarizing the discussion of the actors, the number of relevant business actors in relation to basic technologies seems to have increased. Furthermore, they have become more differentiated and more related to each other. Business relationships have generally become more important, especially from a technological perspective. This is due to an increased specialization and some of the actors are extremely specialized from a knowledge point of view.

Two basic ways to relate science, technology and business

The development described above has created a need for a reorganization of the old structure from all the three reference points of view. The science structure is changed through an increase in numbers — a large number of small units have been created-but also with an increase in specialization. Furthermo-re, the collective actors have become much more active and try to control and to mobilize the research in specific ways. The technological structure is changed as more units-both business and science units-be-come more multi-technological and thus more differentiated. Finally, the business structure has changed in a similar way, both increasing the differentiation and specialization and developing closer relationships between each other. These changes have certainly affected the interplay among science, technology and business. Here we'll first look at how the interplay among science, technology and business is supposed to function; I will characterize this as market coordination. In a second step I will try to formulate how the new conditions can be met by an interplay that will be characterized as interactive coordination.

Market coordination

The classic way to handle the relationship among science, technology and business or between knowledge production and knowledge use, is based on what can be depicted by a general market view. From the users' side, involved actors' needs will, according to the model, be aggregated to a general know-ledge demand. The knowledge producers will work in accordance with this demand and try to produce useful knowledge. The distribution of the produced knowledge, i.e. the exchange between the producers and users, will then appear more or less automatic. One example is through written documents: books, articles, research reports and so on. The users will read and absorb the "knowledge" and apply it in their work. A necessary condition is that the different actors understand each other. Shortcomings can be so-lved with more communication or better adapted information However, due to the problem with transla-tion of the information, an important complementary indirect channel also exists-the education system. By combining research and education, the latter is supposed to be influenced and updated by the research. Educated people will then apply the absorbed knowledge in their future work The knowledge producers' need for information about the needs were expected to be solved through the use of advanced users taking part in different research boards (steering or assessment groups).

To increase or make the knowledge transfer more efficient different "middlemen" have come into existence. One popular form, at least in many European countries, has been collective industry research organizations.

The above way of organizing the exchange between producers and users of knowledge is probably quite efficient given two important conditions. First, that the knowledge is of a general type and second that time is not critical. The above described process is general and time consuming.

The described interplay can be characterized as an exchange between actors who are (and have to be) active themselves but who are inactive in relation to specific others. They more or less accept and adapt to what the others are doing.

The pattern is similar to how the relationships between buyers and sellers in industrial markets have been seen regarding technical development. The buyers have been seen as active in the choice between different suppliers but inactive in influencing the suppliers on what they should develop. The idea has been that the buyers should wait for the products to be developed but then actively evaluate them, i.e. to follow and to adapt to the best products offered. Buying companies today realize that this is not enough; the same seems to be happening in the field of knowledge development.

Interactive coordination

In the discussion of the activities, resources and actors from the three different reference points, I have made a number of observations of which quite a few indicate that the basic conditions have been altered. Consequently, there is a need for an alternative coordination method. This alternative is depicted here as interactive coordination. It means that coordination is taken care of in an active interaction between involved units. The interplay is characterized by the users requesting much more specific solutions and by producers designing their activities in a specific way in relation to the counterparts. For an actor to stay as a competent player in this interaction it must have several different counterparts. These should preferably have complementary requests or resources and in this way guarantee that the actor is put under pressure from different angles, which is necessary for a viable development.

A key mechanism in this coordination is developed relationships. It must be advanced relationships that are built on mutual trust, but where both sides put high demands on each other. The increased differentiation will be seen in an increased variation in the content of these relationships. The changes are somewhat similar to the general development of many industrial markets. Important customers do not have the same problems so they demand adapted solutions. Advanced suppliers do not have the same facilities and/or competencies, including counterparts, so they have to be used in different ways (adapted) by the buyers. Furthermore, suitable counterparts do not always exist in the neighborhood so the com-pany has to have close relationships with counterparts sometimes situated far away. As the counterparts are so specialized it is not enough to have contacts with just one but to have a whole set of close rela-tionships.

Furthermore, the relationships have to be rather intensive, which often makes the boundary between the actors fuzzy. The linking of activities in the tying of the resources makes it difficult to identify the exact boundary. Still the separate identities of the actors remain-they do not become one actor.

Middlemen have problems in this interplay. They have to choose between being a competent produ-cer in relation to a set of users or a competent user in relation to the knowledge producers. The situation can be compared with the development of general industrial distributors. Even for them it has become increasingly difficult to stay as a general distributor. Instead, every involved unit must become much more specialized in order to be useful for the others.

The change can be described in terms of what characterizes the exchange between the units. The in-terplay has moved from spontaneous exchange based on market coordination to a much more systematic exchange based on an interacted coordination.

Conclusion

If we now take a very general view of all companies, all technologies and all science there is clearly a large part of this where the classical market coordination is enough. However, a conclusion of this paper is that at least some of the problems bothering managers and scientists today are a consequence of the need to increase the active interacted coordination.

The main consequences for all units involved are:

- Knowledge producers need advanced users and knowledge users need advanced producers — there is a general need for development of advanced knowledge relationships.
- Increased specialization forces the units to work with a number of counterparts who are combined in a specific way-there is a need to develop a network of knowledge relationships.
- Increased internationalization forces the actors to have counterparts from different places in the world-there is a need to develop an international network of knowledge relationships.

Finally, for the future we can expect that all three of these trends will successively become more and more important.

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