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CONTENTS

INTRODUCTION

The purpose of this paper is to demonstrate the usefulness of applying a user-producer perspective to innovation. A set of analytical and normative propositions - which are neither trivial nor conventional are developed by focusing upon the relationships and the interaction between users and producers of innovations.[i]

The ideas presented reflect a collective effort. Since 1977, the IKE group, consisting mainly of economists but also attracting other social scientists and engineers, at the Institute of Production, Aalborg University, has been working on problems relating to industrial development, international competitiveness and technical change. The approach has been heretic rather than mainstream, and eclectic rather than dogmatic. It was developed partially by importing and borrowing from some different new schools with quite disparate origins.

One of the main imports came from France, where Perroux and his followers have put great emphasis on the analysis of vertically organized systems of production. Another came for UK, where Christopher Freeman and others at SPRU have focused upon industrial innovations. In Aalborg a new combination has been tried. Innovative activities within vertically organized units, as verticals of production, industrial complexes and national systems of production, have been analyzed.

The empirical work pursued so far, should be regarded as exploratory. The hypotheses tested have been crude, reflecting a certain vagueness in the theoretical framework. This paper represents a modest attempt towards a clarification. Empirical work from the IKE groupwill be referred to occasionally, but no comprehensive presentation will be attempted.

In developing the argument, I have leaned heavily on some central works by Nathan Rosenberg and Kenneth Arrow. Rosenberg's analysis (1972, 1976, 1982) of how users interact with producers in specific parts of the economy and under specific historical circumstances, has helped to clarify many of the problems involved. Arrow's works (1962, 1969, 1973) on uncertainty and organization theory have inspired essential parts of the conceptual framework.

This paper is divided into seven different parts. Part 1 Introduces fundamental concepts and postulates. Part 2 is a discussion of the relation between market and organization. Part 3 presents empirical illustrations of unsatisfactory innovations originating from specific user-producer relationships. Part 4 and 5 apply the user-producer perspective to, respectively, locational problems and the science technology nexus. Part 6 relates a number of propositions to units of analysis at different levels of aggregation. In Part 7 some concluding remarks are presented.

The user-producer perspective has, thus, been applied to a broad and diverse range of phenomena. This is reflected in the presentation which also has brought me into sub-disciplines of economics, where my expertise is minuscule. There is ample room for users to take part in the debugging of this semi-finished product.

1. THE FRAMEWORK

In this chapter we shall present the central concepts used and the related propositions. Limitations regarding the validity and scope of the analysis will also be pointed out.

1.1. Innovation and Innovative Activity

It is common to regard an innovation as a distinct event, which can be dated in time. Empirical work trying to explain innovation has often taken its departure in a list of such dated events.

In this paper we shall focus upon the ongoing process of innovative activities , as well as on singular events. The outcome of this process is both gradual technical change and discrete leaps in technical opportunities. But, the process is cumulative and even the most conspicuous single innovation has its roots in accumulated knowledge and experience.

1.2. Technical opportunity and User Needs

We shall regard innovations as the result of collisions between technical opportunity and user needs. We acknowledge that single innovations might result from pure accidents, but we do not see this as a normal pattern.

This implies that the innovating unit needs access not only to information about technical opportunities, but also to information about user needs. We shall assume that information about user needs is differing in complexity and appropriability in the economy; but that some costs and efforts always are involved in obtaining the information. The assumption that information about user needs is not a public good is of central importance for the results presented. In the first part of the next chapter we shall specify the need for information gathering on the part of innovating units.

1.3. The Separation of the User from the Innovating Unit

Our analysis relates to the interaction between units innovating and other units, which are potential users of the innovations. This perspective is only relevant if the innovating and the using unit have been separated from each other. In the extreme case, when for example, a scientist as an integrated part of a research project, develops new methods and scientific instruments in order to solve a problem, no informational problems will be involved.

If we disregard such extreme cases, there will always be a separation between the innovating unit and the user. This will also be the case within organizations where different individuals or departments will have to interact and exchange information. It will obviously be the case, when there is a vertical division of labor between different organizations. In Chapter 2 we shall treat the special case where users and producers are separated by a market.

1.4. Innovation and Production

Relating technical opportunities to user needs involves a logical problem. There is an immense amount of user needs in the economy and all users might in principle be regarded as potential users of an innovation. Is it possible to define a set of users, ex ante, that is before the new product has been developed and procured by the users?

To overcome this difficulty, we shall assume that innovational activities take place in units engaged in production. We shall also assume, that this production addresses a definite set of users and that innovations are oriented towards the needs of a subset within this set. The product might be tangible - a machine tool - or non-tangible - a software package.
Production is a routine process resulting in a regular flow of products from producers to users. Innovation is a search process characterized by less regularity in its outcome. Production and innovation are interdependent. Informations obtained in relation to production and in relation to the regular flow of products, feed the innovational process. Innovations reshape production and the regular flows.

This distinction between innovation and production might be difficult to apply to units designed specifically to promote innovation - R&D departments and research institutes - but, even in such cases we believe that certain routine activities addressed towards a specific set of users can be identified.

The fact that innovational activities are addressed towards a specific set of users does not exclude the possibility that the result of those activities - a product innovation - might be diffused to new categories of users whose needs were not taken into account when the innovation was developed. Innovations might result in an extension of the set of users related to the innovating unit.

1.5. Consumers and Professional Users

The concept of needs is in itself a fuzzy one. Should it represent actual behavior in terms effective demand and revealed preferences , or should it relate to the wants of the potential user? Actual behavior can only give limited relevant information to the innovative process. A product innovation will typically address needs, which cannot be fulfilled by existing products. But, it also seems to be an impossible task for the producer to lay bare the indifference curves and to translate them into user needs, which can be addressed by new products.

This problem will, however, take different forms depending upon the character of the user. A distinction between professional users and consumers proves to be useful. The goal function of the consumer is broad and can only be defined in very general terms - utility maximization, satisfaction, happiness, etc, The professional user - that is a user acting within the formal part of the economy - has a more restricted goal for his activities. In the former category, it is dubious to ascribe needs to the user and to separate needs from wants . This is less so, when the user is a professional one. If the goal function is properly defined, bottle necks can be pointed out and new and better ways to produce goods and services might be identified or developed. An external observer might be able to discover needs which the user has not yet been able to put on to his agenda as wants .

This difference between consumer and professional user is also reflected in their respective behavior in relation to innovations. The professional user is expected to be active in his search for new ways to solve his problems. He will also be expected to adapt his behavior and qualifications when new technical opportunities come forward. This might include formal training as well as learning-by-doing. The consumer, on the other hand, is expected to be more passive. He will not engage in systematic search for new products and he will not be prone to adopt products, which involve extensive training and changes in behavior.

This difference in (expected) behavior is reinforced by the producer addressing the respective category of users. The producers of consumer goods will use market research to uncover the needs of the consumers, and they will use advertising both to make new products known to consumers and to influence the needs involved. They will also be conservative in their product innovations, in order to minimize the change in user behavior imposed by the new product. Product innovations in this area might be radical in terms of the technology built into the product. In terms of the interface between user and product , however, they will tend to be conservative.

In this paper we shall mainly be concerned with user-producer relationships were the user is a professional one. This limitation makes it possible to operate with a concept of needs which is reasonably clear. Still, we can include a part of innovative activities, which has had a great impact upon the over-all process of technical change. Some revolutionary innovations - the automobile, television, etc. - have, however developed at the interface between producers and consumers and those fall outside our framework of analysis.

The distinction made reflects institutional arrangements which are characteristic for modern industrial societies. This is to not to say that those arrangements are in any sense ‘optimal’. New institutions involving consumers directly or indirectly in innovative activities, might liberate new social forces stimulating the process of technical change. This is, however, a subject which will not be addressed in this paper.

In certain areas the distinction between consumer and professional user is less clear-cut. Consumers acting as amateurs involved in hobbies might display a behavior which is close to the one displayed by professional users. The user-clubs related to specific brands of home-computers is just one example demonstrating that the amateurs might be as advanced as professionals in terms of both use and innovativeness.

1.6. Behavioral Assumptions

Our analysis will not be based upon very specific behavioral assumptions. It can be applied to units optimizing under conditions of limited rationality and uncertainty as well as to satisficing units. We disregard the possibility of full information and unlimited rationality, however, and we also discard the possibility of totally erratic behavior.

The units studied here are assumed to have certain (possibly vague) goals; and, we assume that they will make some efforts to reach those goals in a reasonably economic way. This implies, for example, that they will be influenced by changes in relative prices and by cost-reducing innovations. The influence might take a long time to show up in actual behavior, and might be weak compared to other forces at work.

We believe that those rather loose assumptions are sufficient for our purpose. A more precise analysis of the impact of user-producer relationships, however, might demand much more strict assumptions.

1.7. Information

We shall make frequent use of some concepts developed within information theory. We shall assume that information is flowing between units, passing through information channels and transformed into specific codes. We shall also assume, that each unit has a memory consisting of accumulated information, as well as, an agenda consisting of items which are scrutinized by the unit.

In a dynamic perspective, the establishment of information channels and codes can be regarded as investments. It is time-consuming, as well as costly, to develop new channels of information and new codes. The memory is growing in volume as new information enters it - either as the result of internal experience, for example - as results of learning-by-doing or learning-by-using, and, as the result of information brought into the organization from external units. As new information is obtained, new items might enter the agenda of the organization and old ones might be excluded.

In Chapter 4, we shall add to this framework distance - a concept relating to differences in location and cultural background of the parties involved in the exchange of information. We shall also discuss, the impact of instability and complexity in messages communicated between the parties.

1.8. Linkages and Channels of Information

The linkages between a user and a producer describe the regular flows of tangible or non-tangible products from the producer to the user. Such linkages can be described by an extended input/output table where capital goods are treated not as final demand, but as intermediate goods.

The channels of information between user and producer describe a flow of signals which are not embodied in the regular flow of products. We shall assume that the network of linkages and the network of information channels will be overlapping to a substantial degree. The linkages relate to production while the information channels relate to innovation. An important aspect of the innovative process is the exchange of disembodied information between the producer and the user via information channels. This is another way to state the close relation between innovation and production.

The relationship between user and producer involves both linkages and channels of information. They also involve the content of the products and the information exchanged - here defined in relation to the technology involved - as well as the characteristics of the user and the producer.

The interaction between user and producer takes three different forms: Exchange of products, exchange of information and cooperation.

We shall regard situations where the user and the producer engage in a common project, as a situation where cooperation takes place. Cooperation can take place between different organizations as well as between separate units within an organization.

1.9. The Stability of Relationships

There are several factors reinforcing relationships once they have been established. The channels of information and the code used within a given channel are costly to establish. As the channel and the code is used, learning takes place and the effectiveness of the exchange of information grows. Alternative channels and codes become relatively leas attractive. Only when alternatives offer substantial returns will it be rational to change channels and codes. Even in such situations inertia might prevail when the old channels can be operated under satisfactory conditions.

This general observation deriving from information theory is reinforced by the characteristics of technology and innovations. When the information relates to technology, the code will be complex and specific making the change of channels and codes extra expensive.

One of the most general propositions, emanating from our analysis, is that the stability of user-producer relationships reinforces the innovative process in certain directions; but hampers it in other directions. The interaction between innovation and user-producer relationships is far from harmonious and states of disequilibrium - reflected in unsatisfactory innovations - prevail. This subject will be illustrated in Chapter 3 by empirical examples. Before that a classical issue in economic theory - the relation between market and organization-shall be addressed in Chapter 2.

2. PRODUCT INNOVATION AND THE ORGANIZED MARKET

In this chapter we shall relate the interaction between user and producer to the market. We shall try to demonstrate that both the pure market and the pure hierarchy have narrow limits to their ability to promote product innovations. In this chapter, we define product innovations as innovations addressed towards the needs of users separated from the innovating unit by a market. Process innovations are, thus, innovations addressing the internal needs of the innovating unit. On this background we shall propose that the actual rate of product innovations can be explained only by the fact that most markets are organized - involving elements of hierarchy as well as elements of cooperation and mutual trust.

2.1. Producer Dependence - Information about User Needs as an Input to the Innovative Process

The product innovating producer has strong incentives to monitor what is going on within user units. As we shall see, it is not primarily a question of getting an isolated signal about a new need among the users. It is a continuous process of information gathering which might involve considerable costs and resources. Firstly, the producer will monitor process innovations within the user units. If the process innovations are successful, the producer might appropriate them and present them to other users as a product innovation.

Product innovations within user units will often imply changes in the process technology. The producer will therefore monitor the product innovations within user units. If a certain product innovation becomes successful, it might open up a new rapidly widening market for new process equipment.

Technological bottlenecks and technological interdependencies observed in user units offer potential markets for the innovating producer. Such problems might be complex, and in some cases the producer must have direct access to specific information about the production process of the user in order to contribute to a solution.

Users of complex and changing technologies will be involved in a process of learning-by-doing. Access to experience and know-how accumulated in this process will be crucial for the producer. When developing a specific innovation, the producer must consider the competence and learning capacity of the users. Very advanced solutions which demand too much of the users will not be diffused.
Finally, when a production innovation has been developed and adopted by some users a more specific monitoring process takes place. In order to debug the innovation, the producer must monitor its use, the learning-by-using taking place and new bottlenecks, etc.

2.2. User Dependence - Information Necessary to Adopt and Adapt Product Innovations

The user will also be engaged in a (more or less intensive) search for information about new technical opportunities which can result in a better performance. He will have incentives to monitor innovative activities among producers and also to monitor the competence of different producers. (The use of a male nomenclature should be read as ‘he/she/it’ depending upon the specific context.)

To be aware of a specific product innovation is only a first step. The user has to gather information making it possible to assess the potential impact upon his own performance, and the compatibility with the competence and learning capacity within the user unit. Especially, if the product innovation is at an early stage of diffusion, such information will be extremely difficult to obtain and a considerable amount of uncertainty will be involved.

The user will experience specific bottlenecks in the regular production process. When developing new products, he will discover that the process technology used must be changed. To solve those problems he might involve an independent producer in the analysis and solution. In order to do that, he must know which user to approach. This gives him an incentive to monitor the competence of producers,

2.3. Incentives to Exchange Information

In order to get an effective solution to his problems, the user must give the producer a certain minimum amount of information about his needs. The more free access the producer gets to such information, the greater the chance for a successful solution. If the user is competing with other users, it might be problematic to give a producer free access to his technology and to his needs. There will be a risk that the producer might appropriate information and distribute it to other users. This places the user in a dilemma to which we shall return in the following sections.

The producer is interested in diffusing information to users about his competence and about his product innovations. If he is involved in competition, however, he will also be in a kind of dilemma. On the one hand, he needs to convince users about the superiority of his competence, reliability, and product innovations. This might demand an extensive disclosure of the product innovations involved. On the other hand, he does not want his competitors to get access to his technology.

2.4. The Need for Cooperation between User and Producer

Certain new products can be ordered by catalogue or bought off-the-shelf by the user. This will be the case for low-priced standard components. Other types of products - typically specialized and expensive capital goods - can only be adopted in a process of cooperation between the user and the producer.

The cooperation might take place in different steps. The user might present the producer with specific needs which the new product should fulfil. When the product innovation has been developed, the producer might install it and start it up in cooperation with the user. In this phase, the producer might offer training in the use of the new product. After the product has been adopted, the user might have a responsibility for updating the product as well as for repair and service.

The extent of the cooperation necessary might vary with the type of product innovation. But we shall assume that most important product innovations involve at least some elements of cooperation. This increases the uncertainty on behalf of the user. The user does not only procure a product with uncertain properties - he also becomes dependent upon the future behavior of the producer. This reinforces the user in his efforts to monitor competence and reliability. The choice of a specific producer might be as decisive as the choice of a specific product innovation.

We, thus, find that the users and producers of product innovations are mutually interdependent in a complex way. We shall now discuss how such an interdependence will be influenced by different institutional frameworks connecting users to producers. To which degree can the market mechanism intermediate this interdependence?

2.5. Perfect Competition and Product Innovations

If a great number of producers are competing, and if the users are anonymous and numerous, all information to producers will be prices signals. It is less clear how the users will get acquainted with new products in such a market. Let us assume than they can observe new products at the market-place by inspection.

It should be obvious that perfect competition does not induce product innovations. The producer does not get any information about user needs which are not already served by the market (the fact that we operate with professional users exclude the possibility of intro-spection and own-use, as a substitute for such information). The user can only observe superficial characteristics of new products. The uncertainty in assessing the impact upon performance will be enormous if the product is complex.

Perfect competition, thus, will imply a weak innovative capability on the part of producers and a weak incentive to develop product innovations with complex properties. Such new products will typically diffuse very slowly or not diffuse at all.

Perfect competition does not, however, affect process innovations to the same negative degree. Here the information about user needs are available within the producing unit and the user can get full and immediate access to information about the properties of the new process. The most important limitation to process innovations will be the small scale of the operation involved. There will be no external market for the new process, and the appropriation of benefits will be related exclusively to cost reductions within the producer unit. This will put strict and narrow limits upon the amount of resources allocated towards innovative activities. Process innovations will mainly result from learning-by-doing and learning-by-using - that is, from activities which do not impose any extra costs upon the producer.

It might be interesting to relate this result to the fact that product innovations are neglected within neoclassical theory. It seems as this is quite logical as far as the basic models operate on the basis of an assumption about perfect competition.

Arrow (1962) has demonstrated that the externalities involved in relation to R&D-activities will tend to result in a sub optimal allocation of investment funds to such activities. The result obtained above points to another mechanism which works in the same direction. It also points to the fact that a market form, assumed to be the only one guaranteeing optimal allocation of resources in a static framework, might be the one least suited to promote technical change. Only, if we assume that producers have immediate access to information not only about ‘revealed preferences’, but also about needs and wants in relation to products which do not exist, can this problem be overcome. As far as I can see, will such a form of omniscience on behalf of the producer be in conflict with an assumption about anonymity in the relationship between user and producer.

In markets which come close to the ideal of perfect competition, we should expect that product innovations are developed by accident rather than as a result of purposeful innovative activities. Trivial changes in product design might be more easy to introduce than complex product innovations. Process innovations - mainly based upon learning - might take place simultaneously within all producer units, but the rate of innovation will be limited by the scale of operation involved.

Do markets characterized by perfect competition exist in the real world? Do they influence technical change in the way predicted? In markets where professional users operate, it is not so easy to find examples. Markets for vegetables and fruit where numerous restaurant owners come and inspect the products of numerous producers, might be one example. Product innovations are not frequent in this area, and process innovations are mainly reflecting learning.

This fact reflects, however, also a combination of conservative users and natural limits to product innovation. We shall argue that the potential for product innovations - in terms of the rate of change in user needs and new technical opportunities - influences the form of the market. Perfect competition can only survive where this potential is small. In the case mentioned above, a future application of biotechnology to product development might undermine the anonymous relationships between user and producer. To which extent this will become the case, will depend upon the willingness to adopt new products in restaurants.[1]

Let us see why a growing potential for product development undermines perfect competition. If this potential reflects new technical opportunities, the producer can benefit from vertical integration with one or more user units. He will get access to information about the needs of the users and he will be able to monitor the application of the new technical opportunities to those needs. On this basis, he can develop products which are superior to those of his competing producers and he can extend his share of the market.

If the new potential reflects new user needs, a user can gain from vertical integration. By integrating a producer the user will get immediate access to the technical competence within the producer unit and he can gear it towards the new needs he experiences. If the user is involved in competition with other users, he will be able to reduce his costs and obtain a growing share of the market.

Vertical integration undermines perfect competition in three different ways. Directly, it diminishes the flow of goods transmitted by an anonymous market. Indirectly, it gives rise to concentration both on the producer and the user side of the market. If we assume that learning by producing and learning by using are important in relation to the new products involved, the process of concentration will be reinforced,

In the treatment of vertical integration, by Oliver Williamson (1975), the main explanation for this phenomenon is said to be the transaction coats when ‘small numbers’ are involved. We shall suggest that vertical integration motivated by information problems, will take place also when ‘large numbers’ are present. Furthermore, Williamson argues that technological factors do not play any decisive role in determining vertical integration. We shall suggest that new technical opportunities will induce vertical integration when large numbers are involved.

[1] The basic idea in this section, that pure markets are dynamically inefficient, has been developed further in a broader discussion of the limits of the pure market economy (see Johnson and Lundvall, 1989).

Our conclusion is thus, that perfect competition forms an environment hostile to product innovations and that a growing potential for product innovations will undermine perfect competition.

2.6. Small Numbers and Product Innovations

Within the category of non-perfect competition several different constellations might occur:

a. One producer might relate to one user, a few users, or to numerous users.
b. A few producers might relate to one user, a few or numerous users.
c. Finally, many producers might relate to one or a few users.

Thus, we have at least eight different constellations involving ‘small numbers’ either on the producer or on the user side of the market. It will, of course, not be possible to go into details regarding all those constellations. Here we shall only present some general implications of small numbers in relation to product innovations. In doing so, we shall refer to the ideas developed by Williamson and we shall use his conceptual framework as far as it applies to the problems treated. Thus, we shall accept that the actors involved are characterized by bounded rationality and that the environment is characterized by uncertainty and complexity.

Regarding product innovations within such a framework gives interesting results. In sections 1.1. and 1.2. we specified the information needs of the producer and the user in relation to product innovations. If we take a closer look at the distribution of information in relation to those needs, we find that ‘information impactedness’ prevails - the producer has access to information about technical opportunities - which the user does not have, and the user has access to information about user needs which the producer does not have.

We also find that ‘uncertainty and complexity’ is involved not only in the environment but also in the product itself. The user will - especially in the early stage of diffusion - have very limited possibilities to assess how the new product will affect his performance. He will also have difficulties in assessing the future services which shall be delivered by the producer. If the producer is opportunistic, there will be ample room for ‘cheating’ the user. The producer might exaggerate his own competence and the capacity of the new product in order to attract users. He may promise to solve problems which he cannot solve, and he may promise to deliver a package of services, which he knows he cannot deliver.

The room for cheating is more limited on behalf of the user. He cannot misinform the producer without risking that it effects the effectiveness of the solution. He can, of course, misinform the producer in relation to factors not directly related to his technical needs. He can overstate his own capability to develop a substitute for the product for example. Finally, the producer as well as the user might ‘spill information’ to competitors of the respective counterpart. Or they might use information obtained to invade the market of the other party. It should be observed, that those specific problems, having their origin in the fact that a product innovation is involved, should be added to the general problems concerning an uncertain and complex environment.

Can a contract be written which eliminates the possibility of cheating in such a situation? I think that it is obvious that opportunistic behavior on behalf of both parties would normally result in haggling and in tremendous transactional costs when complex product innovations are involved. This has two important implications. If opportunistic behavior prevails, small-number markets might be as inefficient as perfect competition in promoting product innovation. We should expect that all, or almost all, complex innovations were process innovations - i.e. developed within presumptive user units. Secondly, this kind of market failure should result in a movement towards vertical integration where users and producers become joined within the same organization. We should expect that most important innovations were located within vertically organized firms. Also, we should expect a correlation in the opposite direction. The greater the potential for product innovations in a user-producer relationship the more this relationship should be mediated by a hierarchy rather than by a market.

At this point, we do not have any systematic evidence relating to all those implications. We do know, however, that empirical studies of great numbers of important innovations indicate that the majority of those innovations are product innovations (Pavitt, 1984) – that is innovations developed for external users separated from the innovating unit by a market - rather than process innovations. This is not easily reconciled with the implications of an organizational failure framework. Later on, we shall question some fundamental concepts within this framework, but first, we shall take into account some factors counteracting vertical integration.

2.7. The Limits of Vertical Integration

The informational problems related to product innovations can explain why vertical integration might be ineffective under certain circumstances when small numbers are involved.

If there is only one user involved and several producers, the user will be able to control the producers by playing one out against another. The room for cheating is diminished and the incentives towards vertical integration are weak.

If there is only one producer addressing several users, an integration of one of those users will equate an invasion of the market of the users. This will increase the producer's incentives to cheat and the risks for getting cheated will grow among the rest of the users. The rest of the users might, therefore, be expected to react - either by developing their own capability in the field controlled by the producer-or by stimulating the entrance of new producers. Only, if the invasion of the market of the users can be expected to result in a very radical expansion of the market share of the user unit integrated; and, only, if the rest of the users have a very limited ability to develop alternative sources for their process technology, will such a strategy be attractive for the producer. This might be the case where a radical product innovation gives a very dramatic increase in the effectiveness in user units and also involves steeply increasing returns to scale.

If there are several producers and several users, the vertical integration might be either up-streams or down-streams. If a user integrates a producer, he will get access to the technical competence of the producer and uncertainty can be reduced. At the same time it is to be expected that the other users will restrict their procurements from and interaction with the integrated producer. They will be less prone to give him access to information about their own process technology. Also, they will fear that he delivers less efficient technology than he delivers to his own user, as well as that he will be transferring critical information to his own user. The producer will get his information input regarding user needs restricted to that which can be attained within the new organization and this might gradually erode his technological competence. This means that the user—by integrating one producer - in the long run might get stuck with more limited technical opportunities than other users.

If a producer takes over a user unit, the same type of problems will occur. His access to the rest of the users will become limited because he has become a competitor.

If there in only one user and only one producer involved, vertical integration might be effective in overcoming contractual and informational problems. Here, other limits - relating to big size - might be operating.

Our conclusion in, that markets characterized by small numbers, and by frequent and complex product innovations, will not easily be transformed into hierarchies. Vertical integration might have detrimental effects upon users as well as producers by reducing market shares and flows of information to the producer level. Only in the limiting case where there is one user and one producer operating on the market, no such negative effects can be expected.

This is another way of stating that product innovations will be ‘superior’ to process innovations as long as the user is not a monopoly. Product innovations can use a broader set of user experiences as input into the innovative process than can process innovations which only can use the experiences and needs of one single user. Here we reach a conclusion opposite the one presented in the last section: Innovations will be stimulated by a vertical division of labor between producers and user belonging to different organizations. How to solve this paradox apparent contradiction? We believe that the answer lies in the existence of organized markets. This concept will be treated in the next section.

2.8. The Organized Market and Product Innovations

In the organization failure framework, a clear-cut distinction is made between the market and the organization. Also, the coordination mechanism supposed to play the most important role within the organization is hierarchy. All parties are presumed to act opportunistically - presenting false information and cheating. We shall question all those assumptions and distinctions.

If a producer is going to supply a specific set of users on a regular basis, it would be unwise to become known as an opportunistic cheater. Especially if we allow for information exchange among the users, it seems as if opportunistic behavior will be less rewarding from the point of view of the producer. Such an information exchange will take place between professional users. Professional users often have their own organizations, which have as one important purpose, to supply its members with such information (when the users are consumers, the room for cheating is bigger, but in this case the room for vertical integration is also more limited - the COOP is an exception).

Especially, when complex product innovations are exchanged the trustworthiness of the producer becomes a decisive competitive factor. The costs inflicted upon the user by a cheating producer will be considerable, and the user will often have to accept the word of the producer as the only guarantee for that the innovation will perform according to specifications. Producers regarded as trustworthy will attract users, while producers regarded as unreliable can present advanced technical solutions without attracting users. This will counteract any tendency toward cheating. An important aspect of a producer strategy will be to build a relationship characterized by mutual trust with users.

This will be reinforced by the fact that producers depend upon information about user needs as an input to their innovative activities. A producer who acts opportunistically risks to be excluded from access to such information. That would put him into a serious disadvantage in relation to markets where there is a big potential for product innovations.

In such areas, we believe that 'codes of conduct' are imposed upon users as well as producers. Such codes might be tacit and vague, but still they will make distinctions between what is acceptable and what is not. They will impose responsibility and restraint upon the producers, defining limits for what is serious misinformation. They will also define limits for spilling information to the competitors of the other party. We also believe, that relatively stable user-producer relationships will develop. Every single user will establish special and durable relations with a subset of all producers and vice versa. This makes it easier to establish mutual trust and effective exchange of information. This vertical semi-integration differs from full integration, in that, it is a more easily reversed relationship that will not have as strong a negative impact upon the flow of information as full integration.

Such subsets of user-producer relationships might involve elements of hierarchy. The user might dominate the innovative activities within producer units which are formally independent and vice versa. We do not, however, believe that all user-producer relationships can be described exclusively in terms of hierarchy. If mutual trust and responsibility are totally absent, such hierarchies will be difficult to operate for the dominant part.

We shall propose that the predominance of product innovations only can be explained by the fact that markets become organized. The clear-cut distinction between market and organization might be a useful analytical tool, but it does not reflect reality. We shall also propose, that the element of organization entering the market cannot be reduced to a dimension of hierarchy. Hierarchical relationships are combined with elements of cooperation and mutual trust. In markets where complex product innovations are addressed to professional users, opportunistic behavior will be counterproductive for producers as well as users.

More generally, one might ask why opportunism should be the most dominating characteristic of human behavior. Substantial resources are invested in bringing up children to be honest, responsible, and caring for others. Why the result should be professional liars, is not obvious. The predominance of competition and economic incentives may foster opportunistic behavior within private firma; but even in this sphere, countervailing forces are at work. At least, this will be the case when complex product innovations are involved.

2.9. Williamson on Innovations and Technical Change

In Williamson (1975), there is a chapter on market structure in relation to technical and organizational innovation. It is, however characteristic that the part of it relating to technical innovation almost exclusively refers to how big firms perform compared to small firms. The exchange of information between user and producer relating to innovative activities is not taken into account. This might explain why Williamson concludes that his analysis:
"Makes it evident that it is transactions rather than technology that underlie the interesting issues of microeconomic organizations".[2]

[2] The criticism of the transaction theory approach and its neglect of innovation and learning has been developed further in Lundvall (1993).

A user-producer perspective brings forward radically different conclusions. The interaction between users and producers exchanging product innovations and information, is a process which has a strong impact upon microeconomic organization. In this chapter we have focused upon situations where the users and the producers are separated by a market. An extension of the analysis to the internal structure of organizations might also produce interesting results. Later, we shall mention some instances where differences in the internal user-producer relationships seem to influence the rate and direction of technical change.

3. UNSATISFACTORY INNOVATIONS

The economist has been characterized, as one who-by training, thinks of himself "as the guardian of rationality, the ascriber of rationality to others, and the prescriber of rationality to the social world" (Arrow, 1974). One of the main preoccupations of economists has been to assess how different institutional frameworks influence the performance compared to what is 'optimal'. Mostly, however, this has been done in static framework. Welfare economics has been more geared to problems of how to allocate a given bundle of resources than to problems relating to innovations.

Microeconomics and industrial economics have focused upon how different market forms influence prices and quantities produced. Antitrust policies reducing the gap between actual and optimal behavior, have been recommended. Is it possible to extend such a perspective to the dynamic efficiency-properties of constellations of users and producers? Can we explain deviations from the, optimal rate, and direction of innovation by specific properties of user-producer relationships? Can we develop a set of policy recommendations based upon such an analysis?

The first problem involved is related to defining what is optimal? Innovations might be regarded as 'invasions of unknown territories'. How should we possibly be able, ex ante, to deem if extensions in one direction is better than extensions in another? The optimal pattern of innovation is not a useful concept. But, this does not mean that any assessment of innovative performance is without meaning. It might be possible to locate situations where the actual rate and direction of innovations does deviate from the potential in a conspicuous way. A systematic analysis of technical opportunities and user needs can demonstrate that actual innovations do not exploit fully the opportunities present, or do not reflect user needs.

One explanation of such deviations between a satisfactory development and the actual development, might be rooted in the specific user-producer relationships prevailing. There are several factors which promote stability and even inertia in those relationships. The costs involved in establishing new channels and codes of information work in this direction. So does the organized markets, where patterns of domination and mutual trust will reinforce stable relationships and make changes difficult to achieve.

A specific constellation of user-producer relationships might foster specific trajectories of innovations. Such trajectories might prove quite insensitive to new technical opportunities and new user needs. A kind of dynamic inertia might become built into the user-producer relationships.

In this chapter, we shall present some results from a project on microelectronics and its impact upon the Danish economy (the MIKE-project). We shall illustrate the concept of 'unsatisfactory innovations' by referring some results from four case studies - each of them analyzing innovative activities within a vertical of production. In the first three cases presented, we gathered information by expert interviews, and technical literature, etc. In the third case, this type of material was combined with a questionnaire addressed to the whole population of users.

The purpose of the presentation, is to illustrate rather than to verify specific hypotheses. This permits us to present the material in a brief and anecdotic form. Each case involves a more complicated picture than the one given here. We have tried to present the skeleton rather than the full body of each case.[3]

3.1. Dairy Processing - A Case of Hyper-Automation

We found that dairy processing plants designed by the producers of equipment and systems were more capital intensive, more inflexible, and more highly automated, than what corresponded to cost-effective solutions and to the needs of the users. Only recently, had the biggest of the users involved developed a capacity of its own to design and produce its own plants. The first new plant designed in-house, diverged radically from earlier generations of plants and it is supposed to diminish costs substantially.

We ascribed this example of unsatisfactory innovations to some characteristics of the user-producer relationships. Two big producers dominated the supply of design and construction of plants. The number of users was high - several hundreds of plants operate in Denmark. The users were organized into cooperative companies, the biggest one controlling more than half of the processing capacity. Those companies have, however, until recently been mainly oriented towards controlling the market for dairy products rather than towards coordinating the procurement of plants and equipment.

The competence of users and producers was only partially overlapping and in certain key areas it was very unequally distributed. The producers had specialized R&D departments developing electronic-based regulation systems, while the users had very limited competence in this area. The technology itself is systemic in character. The control and regulation systems built into the plant is determining how the production process becomes organized. The room for later user adjustments is relatively small.

In this relationship, a hierarchy had developed where the producers were able to impose their standards rather than adjusting to the needs of the users. But, why did producers develop technology which was not cost-effective at the user level? Economic motives can be pointed out. The producers were producing not only the design of the plant, but also essential elements of the hardware. The solutions developed were more intensive in terms of this hardware than what would have been satisfactory from the point of view of the users. The design of plants influenced the demand for hardware. It is difficult to substantiate, but we got the impression that non-economic factors were even more important. It seemed as the producers were following a technological trajectory in the direction of higher and higher levels of automation. It was (implicitly) assumed that a growing level of automation would imply an increasing degree of effectiveness. Apparently, for a long period of time, such a perspective was implicitly accepted also by the users. This trajectory was developed during a phase when it was rational to substitute capital for labor. It was, however, followed long after that changes in the factor proportions and in the relative prices should have induced a new direction of innovations.

We believe that the unsatisfactory direction of innovations would have been changed earlier:

- If the users had coordinated their procurement of equipment,

[3] The concept of unsatisfactory innovations was developed further and presented at the OECD conference on the productivity slow-down in Paris 1990 (Lundvall, 1991).

- If the users had had a stronger competence in relation to electronics based regulation systems, and
- If the technology had been less systemic and complex.

3.2. Clothing Industry - A Case of Unexploited Technical Opportunities

Our study of the clothing industry as user of new technology was lees complete, because we did not have direct access to the main producers of sewing machinery. A recent study of users and producers of textile machinery at the international level by Kurt Hoffman, completes the picture in this respect.

The clothing industry resembles dairy processing in several ways. The chore of the technology is produced by a small number of firms and the users are numerous. The R&D-activity and technical competence of most users is limited. On this background, one should expect that unsatisfactory innovations might occur. Studying the user industry and interviewing independent experts in Denmark, we found no obvious examples indicating that the technology did not respond to user needs. We ascribe this to the character of the technology involved.

The production process in the clothing factory is not systemic. The user remains in control of how to combine the different pieces of equipment procured from the user. A low formal competence in process regulation is compensated by 'learning-by-combining' within the user units.

The Hoffman study indicates, however, unsatisfactory innovations in another dimension. The application of radical innovations in electronics, laser technology and chemistry to the main processes within clothing production, is developing in a slow tempo. The main producers of sewing technology are reluctant to introduce radical innovations. They point to low user competence and conservatism among users as a reason for this strategy. Hoffman points out that their economic interest in securing a market for their traditional products might influence the strategy.

Again, one might regard this deviation from what is satisfactory in terms of how a specific user-producer relationship fosters a trajectory which is only slowly changing in response to new needs and opportunities. The user-producer relationship in this vertical of production both reflects and reinforces a process of gradual product improvement. The producers have no traditional ties, channels of information, or linkages to the science-based industries where the new technical opportunities develop. The users are competing on the basis of production-based know-how rather than science-based know-how. The great number of relatively small user units makes it difficult for users to by-pass the producers and develop radical process innovations on their own.

This is not rule out that clothing technology may change radically in the future. As the gap between actual and satisfactory technology grows, either the old producers or new producers will try to close this gap (the case of quartz-watches demonstrates how some new science-based producers can invade a traditional market in a dramatic way). But, we shall propose that it might be a question of decades rather than months and years before such gaps are closed.

In this connection, it might be interesting to observe that MITI in Japan has developed a comprehensive research and development program oriented towards the modernization of clothing and textile technology. The main thrust in this program - as in programs in the information technology area - is to bring together users of the technology, producers of the core technology and science-based producers in electronics. Such an effort might be regarded as an attempt to compensate for the weak channels of information between producers and science-based industries, and to break the inertia built into the traditional user-producer relationship. I shall suggest that an important explanation of the success of Japanese technology policy is that the importance of user-producer interaction has been realized both in the private and in the public sector.

A recent OECD-study on the competitiveness of the Japanese machine-tools industry also points in this direction. Japanese producers of machine tools had a closer relationship both to their domestic users and to domestic producers of advanced control technology than their counterparts in US and Europe. Even when US-producers where integrated into multidivisional corporations together with users and together with producers of control technology, they were operating at arm's length—each unit oriented towards its own partial financial goals rather than towards strengthening the innovative capability of the whole corporation.

3.3. Waste Water Treatment – Lack of Interdisciplinary Innovations

In order to extend our perspective from mature to new industries we also studied users and producers of wastewater treatment technology. The users studied were 300 local authorities. Today, one domestic producer is dominating the Danish market. The product is systemic. Control and regulation technology plays an important role and the distribution of competence between users and procurer is unequal. This pattern of user-producer relationships is not very different from the one we found in the case of dairy processing. We should expect a hierarchical interaction where the producer dominates the process of technical change and solutions not reflecting the needs of the users might occur. However, we could not substantiate any clear tendency in this direction.

We found that the expertise in the field was embodied in a small number of persons. Some of those were employed by the producer. Others were employed, in an independent technological institute financed partially by the government, at the technical universities, and in the Ministry of Environment. It was characteristic that most of the experts were 'job circulating' between those institutions and that they all knew each other personally. The experts within the ministry of environment assist the users in formulating standards to the systems procured from the producer. The fact that we could not observe any discrepancy between technical solutions and user needs might reflect this pattern of close-built expertise.

On the one hand, it may be argued that the close interaction between the experts was effective in communicating user needs to the producers. On the other hand, one might argue that it was difficult to find truly independent experts able to evaluate the actual trajectory pursued. We believe that both mechanisms may have been at work, but we cannot say which has been the dominating one.

Another factor counteracting unsatisfactory innovations might be that the design of the plant and the production of the hardware has not been so intimately related as in the dairy case. It has been the norm that an independent engineering consultancy firm should design and coordinate the construction of the plant while the hardware should be delivered by other producers. The extreme degree of concentration on the producer side is also quite a new phenomena - ten years ago there were almost ten firms operating as producers.

We found, however, a third type of unsatisfactory innovations in this area. The decisive technological bottlenecks for using new control technology were found at the interface between the mechanical, biological and chemical conditions prevailing in the wastewater and the data-processing equipment used. The lack of sensors effectively transmitting information about the changes in the wastewater and the recipient was a bottleneck seriously reducing the usefulness of advanced control technology.

In spite of this fact, we found that most R&D and innovative activities were taking place either in electronic-based firms with no expert knowledge in biology, biochemistry or chemistry, or in biochemical oriented firms with little know-how relating to control technology. There are economic mechanisms at work - the immediate market might be to small to allow a specialized interdisciplinary producer to be established - the innovative activities mentioned were typically taking place in big firms where the activity related to waste water treatment was marginal.

But, again, we shall argue that the lack of linkages and information channels plays an important role. In this case, the absence of horizontal linkages between science-based firms results in unsatisfactory innovations. Such linkages might be both easier and more difficult to establish than vertical ones. On the one hand, both parties are used to communicating by scientific codes, and on the other hand, those codes are extremely complex and diverging in content - reflecting the specialization within the scientific community.

We shall suggest that there are promising arenas for potential innovations located at the interfaces between science-based industries which are not exploited today, More specifically, one can point to combinations of biotechnology and microelectronics as one such area. In our study of the Danish economy, we suggested that such new combinations might have a radical impact upon traditional industries. But, such interindustrial and interdisciplinary innovative efforts are hampered by the lack of linkages, information channels, and common codes.

3.4 Software Products - A Case of ‘Hyper-Centralization’

The fourth case studied, was data processing and office technology in 300 kommuner - the local administrative units in Denmark. The dominating producer was one company, Kommunedata, owned by the nation-wide Association of local governments (Kommunernes Landsforening). The products studied were software systems related to data processing and office automation. Kommunedata has at its disposal, a very big central data processing capacity and develops programs which are designed to give the local units access to this central capacity. The local units pay for each specific program and for their use of the central processing capacity. The relationship is thus a peculiar combination of market and administrative relations.

This user-producer constellation has been extremely effective in diffusing the data-processing technology to the local administrations. Today EDP is used in every single local unit - also in relatively small ones. We found, however, that the relationship had fostered unsatisfactory innovations as well. The systems and programs were more centralized in their design than both technical opportunities and user needs should infer. A number of local units had developed their own data processing capacity and some had even broken all connections with Kommunedata. Independent expertise argued that the concept behind Kommunedata'e program development does not reflect new needs for as well as technical opportunities for decentralization.

The most striking characteristic of the relationship between user and producer is an extreme inequality in the distribution of competence. Kommunedata has more than 1000 professionals with a formal education in relation to EDP. Only the biggest of the local unite had more than one expert and the vast majority had none. The technology is systemic - the programs cannot easily be changed in order to reflect local needs.

Those characteristics were reflected in the way the users adopted the systems. We found that 80 percent of the users were passive. They had no strategy of their own in relation either to data processing or to office automation. They procured programs from Kommunedata but made no efforts to adapt the programs to their local needs. They were often frustrated in their use because of breakdowns in the central computer and because of limitations built into the programs.

In this case, we ascribed the tendency towards ‘overcentralisation’ mainly to two factors: Kommunedata has its roots back in the fifties and the most rapid expansion took place in the sixties and seventies. Its main activities were developed during a period when big mainframes offered the most economical solution to data-processing problems. The first programs widely distributed to local units were related to taxes and population statistics. In both cases, the immense flow of data involved as well as the need for central registration of the data reinforced centralized solutions. In the latest years, new programs introducing elements of office automation have been developed, for example, office automation programs which link together different branches of the respective local administration. But, still a majority of the professionals at Kommunedata are engaged full time in developing and maintaining the traditional programs and those are still the ‘cash-cow’ of the organization. The new programs seem to be influenced by the general centralized approach. The fact that the price policy has linked the income of the organization to its sale of processing capacity, reinforces a trajectory of centralization which has historical roots.

The other factor at work, is the lack of competence in the user units. We found that a main reason for not developing an independent local processing capacity was lack of qualified personnel. In a period with shortage in EDP-expertise, it is almost impossible for the local units to attract qualified personnel. Their wage policy does not allow them to offer extreme benefits and the environment they can offer is not necessarily the most attractive to specialists in this field.

This, we believe, reflects a more general problem. We shall argue that new basic innovations might stimulate a tendency towards an uneven distribution of competence between the producers of the new technology and its users. At the early stages of development, the producers can offer a more stimulating and more rewarding working conditions for experts in the field. Users will be reluctant to offer the economic incentives necessary to compensate for a less attractive environment.

3.5. Concluding Remarks

In all the four cases, there was a tendency towards producer domination. In at least two of the cases the lack of competence on the user side was reinforcing the unsatisfactory trajectory of innovations. This pattern might inspire a technology policy which is more oriented towards strengthening the competence of users than to the technology policy predominating today.

An extension of such a new orientation that encompass the ‘final users’, workers and consumers, might have radical implications.

In two of the cases, a lack of established linkages and channels of information reinforced unsatisfactory innovations. In one case, the linkage was between a traditional industry and a science-based industry. In the other, it was between two different science-based Industries. This pattern might inspire a technology policy which brings together users and producers into new constellations. Such a concept seems to inspire the Japanese technology policy.
The fact that all four cases only illustrated producer-dominated relationships does not imply that this corresponds to a general pattern in the economy. Automobile and aerospace industries will be dominating users in relation to many smaller units producing, components and process equipment. In such areas, other types of unsatisfactory Innovations might develop reflecting that a few big users are able to direct the innovative process towards their own specific needs. The innovations brought forward might be less adequate for a big population of smaller users. The development of the machine-tool technology might reflect such a pattern.

In our analysis, we focused upon three sets of variables - numbers of users and producers, the distribution of competence and the character of the technology (systemic or non-systemic). This list is to be regarded as preliminary and further empirical work might bring forward other characteristics which are more important.

4. USER-PRODUCER PERSPECTIVE ON LOCATION OF PRODUCTION

The unequal distribution of production in geographical space has been explained by agglomeration effects. In this section we shall discuss one important dimension of this concept - user-producer interaction in relation to innovative activities. We shall argue that long-distance interaction will be prohibitively costly in some phases of the technology life-cycle because of the information problems involved. This contributes to an explanation of the actual division of labor between nations and regions.[4]

We shall also, argue that learning-by-interacting reinforces historically developed user-producer linkages. This contributes to an explanation of the relative stability of the division of labor between regions and nations.

4.1. Distance and Costs of Transportation and Communication

The costs of transportation and communication are growing with the distance. This is the case for goods and persons, as well as, for telecommunicated messages. In modern times, the innovations reducing such costs have been of a dramatic kind. Drastic reductions in the costs have been achieved and today such costs are prohibitive only for few types of products - cheap, bulky and perishable goods - and for long distances. The impact of distance upon the location of production and consumption seems to vanish. At the same time, geographical concentration of production and innovative activities seems to be growing in certain areas - Silicon Valley-tendencies can be observed also in Japan and Western Europe.

How can we explain this apparent paradox? We shall argue that while the development of telecommunication and other related technologies have reduced drastically of simple signals the same has not become true for the transfer of complex and ever-changing messages. When user needs and technical opportunities are complex and going through a process of discontinuous change, geographical distance and cultural distance will make the user-producer interaction less effective.[5]

4.2. The Cultural Distance

If the cultural environment of a user is very different from that of the producer, it will be costly to establish a channel of information and to develop a common code. Not only will different national languages impair the communication, differences in culture will be reflected in different interpretations of identical signals. This will be even more so when market relations are juxtaposed with organizational relations. Codes of conduct, mutual trust and responsibility will typically be easier to establish between parties with a common cultural background.

[4] The role of innovation and user-producer interaction in determining location has been further developed in Lundvall (1999) an in Lundvall and Maskell (2000). The specific problems involved in establishing international user-producer interaction where discussed in Lundvall (1993).

[5] The role (and limitations) of information technologies in facilitating long distance communication has been developed further in Lundvall (1997).

Within the OECD-area, the post-war period has witnessed a decrease in cultural distance different nations. The diffusion of social innovations from US - relating to the work process, the capital market, and not least, the pattern of final consumption - has diminished the heterogeneity within this area. The export of management models has decreased the distance between different national corporate cultures. Still differences persist and still they favor national rather than international user-producer interaction. Thin will especially be the case, when user needs and technical opportunities are complex and discontinuously changing.

4.3. Paradigms and Basic Innovations

Within science there is a continuous work going on aiming at the establishment of a common set of concepts. A common code is necessary in order to transmit scientific results within the scientific community. The standards of performance of a scientific unit are related to its ability to gain worldwide acknowledgement. This can only be attained if the results can be put into a code intelligible worldwide.

But, new paradigms develop and old paradigms become obsolete. When this happens, the old code becomes a restraint for further progress, and new codes begin to develop. This will typically take place in an erratic way - a kind of crisis develops within the scientific community. Several different codes might coexist and compete during such circumstances - some of them mixtures of the old and a new code. The producers of the new paradigm will have difficulties in communicating their results and the users will have difficulties in decoding what is going on. During such a period, long-distance communication becomes extremely difficult. Local scientific communities facilitating face-to-face contact become more well suited to overcome such difficulties than the global scientific community. Not only might the immaturity of the code make 'hands-on experimenting' necessary, the traditional criteria of scientific success might also become inadequate. Mutual trust between scientists and personal friendships might be essential in order to stimulate further progress when rational yardsticks do not work.

As a new paradigm becomes more widely accepted a new process towards a common code develops. Long-distance communication and interaction becomes more effective as more and more users learn the new code. Scientific training has as one important function to disseminate a common code to potential users. It follows that a general diffusion of a new code normally will be time-consuming - perhaps a couple of decades - corresponding to the time it takes for universities to adopt it and communicate it to new generations of students.

The introduction of science-based innovations will have effects similar to the development of new paradigms within science. The codes once learned by engineers and technicians, will not work any more. It becomes difficult for distant users to assess specific product innovations in relation their own needs. Conversely, distant producers addressing users engaged in the new areas will have difficulties in decoding information about user needs. Geographical and cultural proximity becomes a critical variable.

As the technology stabilizes and becomes mature, the technical code becomes simplified.
In technology, as in science, there are permanent forces working towards standardization and towards a common code. In the former case, the incentives are the potential extension of the market to a broader set of users. The importance of cultural and geographical distance declines as the technology becomes mature.[6]

[6] The interplay between innovation and standardisation has been further developed in Lundvall (1995).

The product life-cycle explanation of the dynamics of international specialization can be reinterpreted in the light of a user-producer perspective. According to this explanation, the optimal factor proportions change during the life cycle. The early phase is R&D intensive, the second management-intensive, while the mature phase is intensive in terms of capital and unskilled labor. This explains why industries become relocated from more developed to less developed countries.

A reinterpretation would suggest that the standardization and simplication of the technology makes users of technology less dependent upon cultural and geographical distance to the producers of technology. The fact that textile production technology has been easier to transfer than other manufacturing technologies can be ascribed to its relative stability as much as to its labor intensity. This reinterpretation does not necessarily contradict the predictions of the product-life cycle explanation. But, it highlights some of the mechanisms behind this phenomenon.

4.4. Proximity and Innovativeness

Empirical work in Aalborg - using the OECD data bank on foreign trade - has demonstrated that a substantial part of the specialization in specialized engineering products can be explained by the degree of international specialization of domestic users of the equipment involved. If we regard the index of specialization for a product as an indicator of innovativeness and technical competence (this might be reasonable when the countries compared have similar factor proportions and when access to natural resources is not the decisive factor), we can relate this result to the interaction between users and producers.

One interpretation of the result is that, the producers of capital goods will be better off if they have domestic innovative and competent users to interact with. The geographical and cultural proximity makes the establishment of channels and codes of information less costly and the exchange of information more effective.

An alternative interpretation is that the presence of domestic innovative and competent producers of equipment gives the users an advantage in relation to foreign competitors. Again, geographical and cultural proximity might give the users more direct and easy access to information from domestic producers. We shall propose that both those mechanisms are at work. Both users and producers are learning-by-interacting. A virtuous circle with cumulative consequences is at work.

Such mechanisms will result in a rather stable pattern of international specialization reflecting historical background rather than proportions of general factors or production. Learning-by-interacting creates poles of competitiveness which reflect specific know-how divided between domestic users and producers. The existence of such poles of international competitiveness might prove to be rather insensitive to new technical opportunities and to changing user needs. The existing national network of user-producer interaction will only slowly adjust to external shocks. The ‘virtuous circles’ might become factors delaying a necessary adjustment of the national economy to new external conditions.

5. THE SCIENCE-TECHNOLOGY NEXUS

The interaction between producers and users of scientific results has its own properties. In this chapter, we shall discuss some of the specifics of this interaction. Some of the ideas presented have been inspired by the notes of Paul David on “The Perilous Economics of Modern Science”, while others are closely related to articles by Nathan Rosenberg in “Inside the Black Box: Technology and Economics”.

In the first section of this chapter, we shall discuss how a user-producer approach relates to respectively technology-push and demand-pull hypotheses. In the second section, we shall outline “a system of innovation”. In the third and fourth sections, we try to apply the user-producer perspective to science-based industries and to university-industry interaction.

5.1. Technology-push or Demand-pull?

Innovational activities are often treated as a linear process starting within basic research and ending in economic growth. The results from basic research are regarded as inputs to applied research. Inventions taking place within science are supposed to give rise to innovations. As innovations become diffused they affect productivity and growth in the sphere of production. This unidirectional flow of information might be hampered by lacking competence on behalf of potential users and considerable time lags might be involved - but it is still regarded as unidirectional. Such a perspective will correspond to a technology policy supporting science and R&D-activities.

Another approach has emphasized the importance of demand as a factor stimulating and directing innovations. When demand grows, it will pull R&D inventions and innovations forward, and result in productivity growth. Such a perspective might give rise to policy recommendations of a laissez-faire character. Innovative activities are assumed to adjust automatically to the market forces.

A user-producer perspective raises critical objections to both of those two schools. The supply school under-estimates the active role of users in the innovation process. The demand school does not distinguish demand, as a quantitative category, from user needs as a qualitative category. Increasing investment in R&D might give small marginal returns if the relationships to the potential users are weak and if information about user needs is costly to obtain for the producers. Increasing demand does not necessarily imply that the quality of user-producer interaction increases.

Both approaches can be accused of regarding the system of production as a black box. The supply school concentrates upon the bottom of the black box where R&D is introduced and expects beneficial effects to come out at the top of the box. The demand school assumes that changes at the top of the box - changes in demand - will have beneficial effects at the bottom. A user-producer approach might be regarded as one revealing the content of the black box. The network of user-producer relationships transmits signals from the top to the bottom and vice versa. We shall propose that such an approach will demonstrate that neither the demand nor the supply hypotheses have general, but possibly selective, validity in the economy.

5.2. A System of Innovation[7]

In the economy, some key institutions are involved in different types of innovative activities. The vertical division of labor between institutions is far from clear-cut, but certain types of activities are predominating in each type of institution. The universities are centers for basic research and scientific training. At the same time, they constitute the decisive part of an academic community characterized by its own social norms, criteria of success, and incentives.

Not all science is produced within the universities. Private firms as well as public agencies have their own dependent research units. Such units will typically be engaged in applied research, i.e., research aiming at the solution of problems relevant to the mother organization. In such research units the criteria of success and the incentives will be reflecting the goal of the mother organization rather than those of the academic community.

In between those two levels, there are a multitude of specialized research organizations which are neither integrated in the universities, nor directly subordinated to any mother organization. Some of those are exclusively engaged in either basic or applied research, others combine the two types of activities. Such organizations might work more or less in accordance with the rules predominating within the academic community. A crucial factor determining their behavior will be the funding mechanisms involved.

There are also units still closer to the process of production. Dependent development units operate within firms and public organizations while technological institutes operate as independent units. Their main function is to convert scientific results into practical technical solutions rather than to extend the stock of scientific knowledge. In such units the norms of the academic community will play a secondary role.

Finally, we shall consider all other professional units as engaged in production of tangible goods. Also, in many units, activities related to innovation take place. Learning-by-doing and learning-by-using, produces information which might be crucial to units engaged in applied research and development. The recognition of bottlenecks and other specific problems in production, directs the activity of dependent and semi-dependent R&D units. Phenomena which cannot be accounted for by science will occur in material production and stimulate to new efforts in applied as well as basic research. The agenda of the units of research and development will he influenced by what is going no in the production sphere.

We shall suggest, that innovativeness and competence in the production sphere are factors which have a positive influence upon the units engaged in development and research units.

We shall also suggest, that the strength and form of the relationships between producing units and R&D-units influence the over-all innovative performance. The pattern of historically established information channels and codes will determine how easily the agenda responds to signals from the production sphere.

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[7] This may be the first use of the concept 'innovation system' in a publication (with ISBN No). The concept as rooted in specific patterns of user producer relationships has been developed in a number of later publications and it is now a widely used concept (among the first were Freeman 1987, Freeman and Lundvall, eds. 1988, Lundvall 1988, Lundvall, ed. 1992). Today asearch on the term 'innovation system' on the internet using 'googles' as search machine gives more than 1 million references. The Chinese president has recently referred to the need to strengthen the Chinese innovation system and in the US the concept has become widely used in connection with industrial policy and science policy.

In order to illustrate those two propositions, we shall discuss two different sets of problems. One relates to the concept of the science-based industry and the second, to the cooperation between university and industry.

5.3. Science-based Industries

It is obvious that some industries are using results produced by science more frequently than other parts. Electronics industry and chemical industry are R&D-intensive and interact intensively with institutions pursuing research, including the universities. Other industries, as textiles and machinery, are less R&D-intensive and they have a much more distant relationship to research institutions and universities.

This fact is normally interpreted in terns of the linear unidirectional model of innovations. Scientific break-throughs in chemistry and physics are assumed to have created the basis for basic industrial innovations. The user-producer approach might give a more balanced interpretation of the historical process which has made some but not other industries science-based.

Textiles, as well as machinery industries, were established on the basis of practical experience rather than on the basis of systematic knowledge, during a period when scientific activities were weak and only weakly related to technological problems. The fact that they still operate at arm's length from science is not necessarily reflecting that the problems they try to solve are unsuitable to scientific treatment. It might also express a historical pattern of user-producer relationships which once established has been reinforced.

On the one hand, the practical orientation of their innovation process might have been contagious in relation to the scientific disciplines closest to their field of operation. The lack of ability to express problems in the scientific code may have failed to stimulate the related scientific institutions. The very practical character of work within such institutions may have repelled the most ambitious and competent scientists from those fields of research. The predominance of small-scale production - making it more difficult to exploit increasing returns to R&D - may have reinforced such a tendency.

Looking at the so-called science-based industry, a reverse process might have been at work. Those industries were developed during a later historical period when the scientific institutions were more developed and more geared towards industrial problems. They were able to recruit engineers with a formal education and were from the beginning able to communicate in a scientific code. The strong innovative activity within those firms and their ability to present their problems in a form suitable to a scientific treatment stimulated the scientific institutions and disciplines most closely related to their activity. Strong and effective relationships between users and producers of science were established.

If this is true, one should expect that a new symbiosis between traditional industries and science should offer dramatic returns. Investing in making the related research activities more scientific, stimulating the ability of the industry to communicate in scientific terms, and strengthening the interaction between industry and scientific institutions, should be very rewarding. At the same time, one should realize, however, that the investments necessary might be considerable and the lead-time before the new channels of information will work effectively might be very long.

The interaction between the science-based industries and the scientific institutions is already working smoothly and will, therefore, promise higher returns in the short run, both for the parties involved, and for society as a whole. The hypothesis that the distinction between science-based and traditional industries is the result of historical accident rather than inherent in the technology used, might therefore never be tested in practice.

5.4. The Interaction Between University and Industry

One of the few instances where the importance of user-producer interaction has been explicitly recognized in policy terms relates to the interaction between university and industry. OECD has published several reports on the subject and a new Ad hoc-group studying regional development and technical change seems to put the linkage between university and industry at the center of its analysis (OECD, 1994). The growing interest for this linkage reflects that science-based industries have become more important for international competitiveness. It also reflects that a tendency towards a new type of agglomerations, so-called ‘Centers of excellence’ or ‘Technopolises’ where industrial development seems to be closely linked to ‘excellent’ universities, has been registered. The fact hat most universities have rather weak relationships to industry and the fact that most attempts to strengthen the interaction have failed, has put this item on the agenda of national governments, and international organizations.

The analysis will often end up with a call for more cooperation. The lack of cooperation is often ascribed to a lack of good will and especially to a certain snobbish attitudes within the academic community. Far from denying that such mechanisms are at work, I believe, however, hat they only reflect more fundamental ones having their origin in the character of the user-producer relationships. Without recognition of the more fundamental mechanisms attempts to link universities and industries together, based upon good will might result mainly in disappointment and frustration.

The cultural distance between the industrial community and the academic community is reflecting differences in social norms, criteria of success and incentives. While global communication of research results making the products of academic science a public good, secrecy is an important element in industrial R&D. While material incentives play a subordinate role within the academic community, the contrary is the case within industry.

This cultural distance can be diminished either by changing the academic culture or changing the industrial culture. Introducing secrecy and material incentives into the academic community will in the long run impair its standard and its contribution to economic welfare – not to mention its basic critical function. Introducing the norms of the academic community upon industry would imply radical change in the institutions of the market economy. A certain cultural distance seems to be inevitable and this will make it more costly to establish channels of information and an intelligible code.

Secondly, the scientific code, which is predominating within the academic community, is different from the code predominating within industry. The scientific code is developed to serve as a medium for communication between specialized scientist, while the code of industry is problem-oriented. The organization of academic science into very specialized disciplines, each with its own code, is a factor making communication with industry more difficult.

In this area a reorganization of the universities – or rather of some parts of them – into interdisciplinary units might facilitate communication. Such a reorganization might also have a stimulating effect upon research itself – putting new items on the agenda and giving rise to new disciplines and to new paradigms within the old disciplines. A total disruption of the discipline-orientation of academic research would, of course, be unacceptable, but a mixture of research units oriented towards the traditional disciplines and problem-oriented units might be beneficial both to the academic community itself and to its ability to communicate with external users.

Taking into account all difficulties in communication involved, the fact that centers of excellence where university and industry cooperate, do develop, might seem difficult to understand. Is it not true that Stanford University has played an important role in promoting the growth of Hi Tech-industry in the Silicon Valley? In order to solve the apparent contradiction we have to take into regard the role of the users in the interaction.

Firstly, we shall argue that the users involved in the Silicon Valley - primarily the electronics industry - have certain specific characteristics which have facilitated the interaction. The culture of this industry has been less distant from that of the academic community. The problems to be solved have been easier to pose in terms of specific scientific disciplines. As a consequence, the costs of establishing channels of information and common codes have been relatively less.

Secondly, we shall question the idea that the excellency of the university has been the motive force behind the Silicon Valley-phenomenon. The innovativeness of the electronics industry and its ability to communicate with the university has brought new items on the agenda of academic research. The fact that the industry has been at the forefront of science, often having a lead in relation to world-wide academic research, has meant that the items brought on the agenda have been real challenges to academic science. The ability to communicate those problems in a scientific code has made it easier to attack them from a scientific point of view. This has made Stanford University an environment more attractive to ambitious and competent academic scientists. Everything equal, it is easier to produce Noble Prices in such an environment than at universities having less advanced users. The excellency of the university reflects the excellency of its users.

This is not to deny that an impact working in the opposite direction has been important. The interaction has been to the mutual benefit of user and producer - again, a virtuous circle with cumulative effects has been at work. Our argument is rather one directed against simplistic ideas which exaggerate the role of the university in relation to industrial development. Not all kinds of university-industry interaction will result in mutual benefits. If the industry involved is traditional rather than innovative, distant from the culture of the academic community, and not able to communicate in scientific code, an interaction will be difficult to establish. Such an interaction might even have serious detrimental effects upon the universities. The new questions entered on their agendas might be trivial and posed in terms not well suited for scientific treatment. The industry might get responses difficult to decode and adopt to their problems, etc.

A policy recommending a closer cooperation between university and industry must take those complications into account. One implication might be, that the first step must be the strengthening of the competence of the users. Making recruitment of labor with academic training more attractive to traditional industries might be a necessary step in this direction.

This would diminish the cultural distance and increase the capability to communicate with the academic community. If this analysis in correct, the establishment of an effective interaction between universities and traditional industries will take some time to establish. In the meantime, we might witness how well intended efforts to cooperate create frustration both in the academic and in the industrial community.

We have argued elsewhere that one of the secrets behind the successful Japanese industrial policy is, a more fundamental understanding of the user-producer relationships. It is, therefore, interesting to note that Japan, according to a recent OECD-document, in planning to establish a new type of geographical agglomerations - so-called technopolises. This concept does not put the main emphasis upon the role of universities, but seems to give at least equal weight to the user-side of the relationships.[8]

[8] The interaction between universities and industry is covered much more in depth in Lundvall (2002).

6. UNITS OF ANALYSIS AND PROPOSITIONS

The traditional units of analysis in economics are horizontal rather then vertical. The economy is regarded as composed of sectors as agriculture, manufacturing and services and each sector will be decomposed into industries and subsectors. A user-producer perspective brings into focus vertically organized units of analysis which typically will cross the traditional limits between main sectors and sub-sectors.[9]

In this chapter, we shall relate to each other such vertically organized units and related propositions. This brief recapitulation might also be regarded as a series of research proposals brought forward by a user-producer perspective.

The world economic system might be regarded as a complex network of user-producer relationships connecting units dispersed in economic and geographical space. This network is a product of historical development and it will only slowly adapt to exogenous and discontinuous change. When change of this kind occurs, we should expect a growing gap between actual performance and satisfactory performance. The oil prices shock and the dramatic development in new all pervasive technologies as microelectronics have undermined the effectiveness of the existing global network. This has diminished the positive impact of the basic innovations. A policy which stimulates the reshaping of user-producer linkages will diminish the performance gap and stimulate innovative activities and economic growth. ‘Long waves’ in economic development might reflect the inertia of user-producer relationships (Perez, 1983).

International specialization might be regarded as reflecting competition between verticals or production rather than competition between national industries. The relative or absolute advantages of a specific national industry reflect not only its own efforts but also the innovativeness and competence of domestic producers-delivering process equipment, and domestic users, delivering information inputs about user needs to the industry. A policy which aims at strengthening a specific industry should be based upon an analysis of all stages within the vertical of production. In the long run, the competence of users might be as important as the competence of producers.

National systems of production will be more or less competitive and differ in their innovative capacity. The existing network of user-producer linkages - including linkages between applied science and basic science as well as linkages between the scientific and the technological sphere - will have an impact upon innovative capacity and international competitiveness. In a specific historical period, certain user-producer linkages might become of strategic importance. A policy aiming at strengthening the international competitiveness should address such strategically linkages. What is and what is not strategic linkages will depend upon the existing network of user-producer relationships as well as upon new needs and opportunities.

Industrial complexes related to a broad set of needs (the military-industrial-complex) or to a specific primary sector (the agro-industrial complex) are semi-autonomous network, of user-

[9] Using the user-producer perspective to link input-output analysis to innovation may be seen as one way to operationalise the ideas in this chapter (Lundvall 1996).

producer relationships. They are closely knitted together internally and their linkages to the rest of the economy are relatively weak. Such complexes might have great innovative capabilities because of the historically stable and close relationships between clusters of users and producers. They might also represent, however, a strong resistance to radical change in the network, the code, and the channels of information used, etc. This will be reinforced when they become a basis for social and political alliances encompassing broad segments of the population.

In a period when needs and technical opportunities change radically, the existence of such industrial complexes might become powerful conservative elements delaying the restructuring of the economy. A policy which aims at securing dynamic efficiency should be addressed to the creation, reshaping and demolition of industrial complexes.

The inter-industrial user-producer relationship involves two different steps in a vertical of production. It corresponds to what is at the center of microeconomic theory - the market where firms confront with consumers. We shall suggest that this is an area where a user-producer perspective brings forward several interesting results:

- Perfect Competition - anonymity in the relation between user and producer - is an environment hostile to product innovations. Uncertainty and lack of channels of information transmitting qualitative information has a negative influence on the process of innovation as well as on the diffusion of innovations.

- When small numbers are involved market failure will result when product innovations occur. Uncertainty and limited rationality will prevail in such situations.

- The logical outcome is an economy where no product innovations take place. All innovations should be in-house process innovations. This does not correspond to historical evidence. Product innovations are introduced on the market place.

- This paradox can only be resolved if we accept that the distinction between market and hierarchy becomes blurred in the real world. In markets where product innovations are frequent and important anonymity is eliminated, pure markets become infiltrated with organizational linkages.

- Organizational relationships might in some instances be described in terms of a hierarchy where the producer dominates the user or vice versa. Certain constellations of user-producer relationships cannot, however, be explained in such terms. Elements of cooperation and mutual trust must be introduced in order to explain why product innovation takes place when the user and the producer are of equal strength.

- The interaction between an innovating producer and a user might be captured better by a model of a cooperative positive-sum game than by models emphasizing conflicts of interests.

Microeconomic theory assumes that the single firm is adjusting its behavior to signals in the form of prices and quantities. A user-producer perspective introduces the need for qualitative information about new use-values used as inputs and about the needs of users. More realistic models describing firm behavior introduces the environment of the firm as a factor influencing its conduct and performance. We shall suggest that a breakdown of this environment into user-producer relationships can clarify the analysis of firm behavior.

An important aspect of firm strategies is related to user-producer relationships. The existing forward and backward linkages will act as strong restraints upon what the firm can do - the opening up of new channels of information and the development of new codes will involve investment costs and the outcome is uncertain. The acquisition of formerly independent units operating in a different network of user-producer relationships is not necessarily motivated primarily by the production capacity inquired. It might be motivated by the access it gives to new channels of information and to new codes.

Internal user-producer relationships might differ between different firms. The ability of the internal organization to transform internal and external user needs into innovations, might reflect different organizational arrangements, different incentive systems and different cultural characteristics. Is the competitiveness of Japanese firms an expression for their ability to establish proximity between users and producers within the multi-divisional firms? Is the US-model characterized by arm's length relations between profit-centers detrimental to innovation?

How do the ‘final users’ - workers and consumers - influence innovational activities? A strengthening of their competence and influence might have dramatic effects upon the innovative capability of the economy. Which types of reforms are necessary in order to realize such effects?[10]

[10] The policy implications of a user-producer perspective has been further developed in Lundvall (2001) and Lundvall (2002).

7. A FINAL REMARK

What has been introduced here is neither a general nor a pure theory. One of the more general results obtained in our empirical work, has been that user-producer interaction works in different ways in different parts of the economy. The fact that we focus upon use-value rather then exchange-value introduces a strong historical element in the analysis.
In this paper we have studied user-producer relationships where the user is professional and the innovations involve a certain degree of complexity. The results obtained, therefore, have specific rather than general validity.

We do not, however, regard this only as a weakness of the user-producer perspective (Kornai, 1971, pp. 28-29). Especially, in innovation theory, it has proved difficult to produce hypotheses of general validity. Attempts to reduce innovative activities to be either supply-or demand-induced have failed. Attempts to devote to respectively small and big firms special innovative abilities have not been successful, etc.

Regarding innovative activities from a user-producer perspective might be a way to open op the black box and disclose the mechanisms which are at work. In doing so, it might become possible to developed hypotheses which have at least a specific and specified validity.

Important work in this direction has been pursued at SPRU, UK, where Keith Pavitt (1984) has used an extensive database on UK-innovations to develop a taxonomy of innovation. The user-producer relationships reflected in his taxonomy is related primarily to interbranch rather than to the interorganizational interaction treated here (Pavitt, 1984). We believe that a combination of the two approaches will prove useful.[11]

[11] The assumption that the Pavitt taxonomy would be helpful to work out patterns of interaction has been confirmed – see for instance the Ph.D.-theses by respectively Ina Drejer, Frank Skov Kristensen and Anker Lund Vinding (Drejer 1999, Kristensen 2001, Vinding 2002).

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[i] A wider diffusion of the core of the argument took place through the