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Networks and innovation in the machinery and electronics industry and enterprises (Estonian case studies)

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THESIS ON MECHANICAL AND INSTRUMENTAL ENGINEERING

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Declaration:
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree.

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Võrgustikud ja innovatsioon masina- ja elektroonikatööstuse arendamisel (Eesti juhtumite analüüs)

RÜNNO LUMISTE

CONTENTS

INTRODUCTION

This PhD thesis analyses innovation processes in Estonian machinery and electronics industry (MEI) and prospects of Estonian manufacturing companies of fostering their innovativeness and competitiveness through networks. Networks as an organisational form attract our interest because more and more enterprises are adopting the network approach to develop their business. Neither hierarchy nor pure market based transactions are dominant forms of enterprises' behaviour any more. Innovation presents for us interest because the other forms of economic development (Porter 1985) like natural resource based growth and investment driven growth had come to maturity. The author believes and wants to prove that innovation provides a way to continue economic growth for Estonian manufacturing sector.

The machinery and electronics industry is a part of the manufacturing sector. Manufacturing as an economic activity has declined in importance and its share in GDP has diminished in OECD countries over the last three decades. However, importance of manufacturing will not disappear. Manufacturing will shift to more complicated and higher quality production. In Estonia manufacturing companies accounted for 17% of GDP and employed 130 thousand people, i.e. 22% of the workforce at the end of 2005 (Statistics of Estonia). Challenges arise from the current status, as in income terms Estonia is not yet really part of the developed world. Several indicators showing the social and cultural level are quite similar to the highly developed neighbours in Northern Europe, but economic indicators are lagging substantially. It is a challenge to catch up with the industrialised neighbours.

Development of social and cultural life is impossible without economic growth. According to Pavitt (1984), capital goods producing industries enable to create innovations in the other industries and to make the natural resources and service sectors more efficient. Electronics products and machines help also to reduce labour demand by substituting labour intensive processes with machine controlled processes.

Economic shifts and changes have shaped drastically the Estonian economy. The first phase of transition was quite often characterised by active competition for resources and hostility between entrepreneurs. From the market point of view, this period can be described as positioning itself on the market and establishing the first links with customers and suppliers. Very often resources needed by enterprises (labour, machinery and equipment) were not constraints to development. The situation with foreign resources (market contact, market know-how) was the opposite. The situation has changed quite a lot over the last years. Now enterprises seem to have a shortage of local resources like labour and a certain excess, or at least no deficit, of financial resources. Resource constraints are accompanied by a poor business infrastructure. Businesses in Estonia that use labour-intensive processes will find pressures they cannot resist from low wage countries. A well functioning training system can provide a good labour force and trust between employers can help overcome financial difficulties (paying in advance by customers and getting raw materials on credit).

Estonia has achieved some macroeconomic stability. Macroeconomic stability is a good platform to improving productivity and development of MEI. To improve productivity in terms of sales and value added Estonian firms must increase the value of goods produced per employee and improve the position of firms in the market. Productivity and profitability depend on using innovation, capital investments and well-organised networks, position in the value chain and transactions.

Purpose, research tasks and data sources of the thesis

The main objective of the thesis is to investigate networks, innovation mechanisms and tools and their interrelations in Estonian MEI and to find tools and methods to enhance competitiveness of enterprises. The thesis seeks to evaluate the development of networks and the position of Estonian enterprises in the nearby and regional markets and to find possibilities of improving the performance in the long-term period. The study will improve the understanding of how the Estonian MEI make changes and how they are organised in cooperation networks. The research tasks and propositions are:

- To analyse firm theories (network theory and innovation theory) that are related to our tasks and to find means to use these theories in the following analysis of firms' opportunities and to give recommendations for using these opportunities;
- To synthesize and systematize a classification of networks and use classification for the following analysis;
- To create tools for analysis of business networks and the outsourcing process of Estonian MEI firms prospects in value chains;
- To analyse the performance of Estonian MEI in the global and regional economic environment and to find new development opportunities;
- To investigate relations in networking types and innovation process in Estonia and to give proposals for the development of networks;
- To investigate the use of new technologies and new practices by Estonian MEI firms and find reasons for failures and missing of opportunities;
- To create methods for analysing the innovation capability of Estonian MEI firms and opportunities to move up in the value chain to knowledge intensive high-skilled manufacturing sectors and better positions there.

The main research questions addressed in the thesis are:

(1) How is Estonian MEI organized and what is the organizational configuration of this industry? Most important is to investigate the links in relation to main business processes and to determine also the forces shaping industrial organization in the future.

(2) What is the nature of the innovation process inside the Estonian industry?

The main hypothesis of the thesis is: Innovation and networks of Estonian MEI are depend on each other and the resources and network type and quality determine the innovative performance and potential. Certain types of networks allow the creation of innovations of certain type and level.

Owner-managers were interviewed and case studies of firms were composed with the aim to find internal factors of innovativeness and networks' creation and to investigate the background of managers and its influence on the firms' development. Each main research question includes several smaller research questions that are designed to complete the "big" picture and support the main research question. The network research is aimed at finding out and describing the structure of existing industrial networks from the technological and international trade points of view.

The empirical part of the work is based on three databases. One is a general database of the Statistical Office of Estonia and the statistical reviews "A Industry", "A Science, Technology and Innovation". The author selected, grouped and analysed the data for the needs of the current doctoral thesis in the period 2000-2007. The second group involves the European Community Innovation Surveys databases (CIS-3 and CIS-4). The author of this doctoral thesis has specified and filtrated data on innovation. The third part of empirical sources includes data from personal face-to-face interviews about innovation and networks. For in-depth analysis we also present six typical case studies of industrial firms. We use case study analysis to complement quantitative analyses with a qualitative one. Case study research was selected because great changes have occurred in firms' structures, new organizational forms have replaced traditional structures and relationships and firms are heterogeneous. Different research methods were used. Primary research was used in case study research, which involves interviews. In the theoretical part synthesis of existing works about networks and innovation was used. The other methods were statistical analysis and observations.

Structure of the thesis

Estonia's machinery and electronics industry can be viewed as a holistic system only conditionally. Internal links between Estonian MEI firms and with the firms in other sectors are missing or the intensity of those links is relatively low. Rapid changes and reorientation of markets have caused the need to investigate the relations that are based on neither market nor hierarchies. Participation in cooperation networks helps to leverage firm resources and determines the development of Estonian machinery and electronics industry in long term. Due to the limited size, the author has investigated the most important aspects of cooperation. The structure of the thesis and the relationships of different parts are depicted in Figure 1.

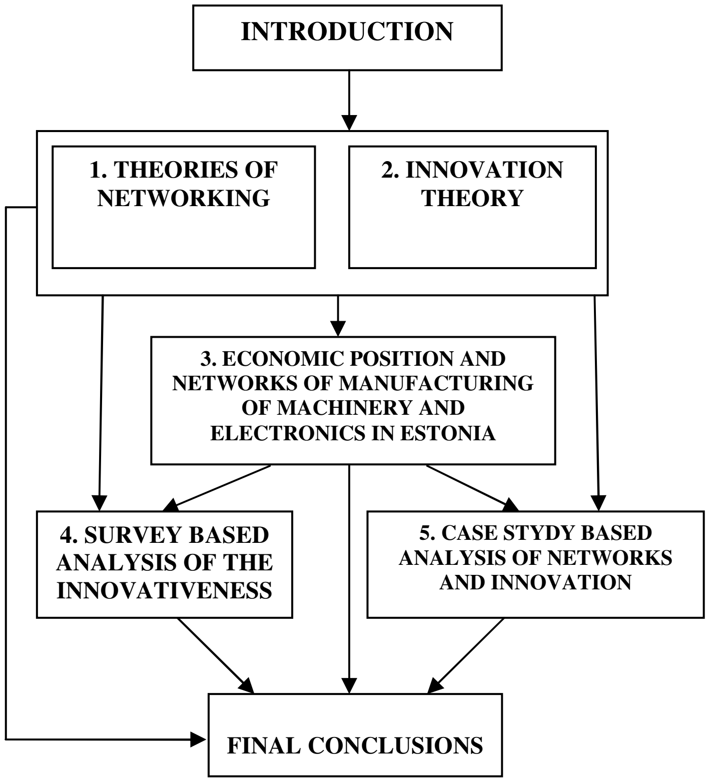

Figure 1 Structure of the thesis and connections between the parts

The thesis contains five chapters. The first and second chapter of the thesis will introduce the main theoretical schools (conceptions), explaining the interaction between enterprises. The Network Theory and Innovation Theory were chosen as primary theories because they describe more adequately development processes of industry. The third, fourth and fifth chapters have empirical character. In the third chapter, the author analyses the major indicators of Estonian machinery and electronics industry. The fourth chapter describes and analyses innovation methods in machinery and electronics industry. In the fifth chapter after quantitative analysis of machinery and electronics industry in previous chapter a deeper qualitative analysis of networks and innovation is made by using case study research method.

In the final conclusion we give the information what hypothesis and propositions found evidence and what didn't found. In conclusions we also stress to the most important parts of theory that found evidence in Estonian machinery and electronics industries. The thesis ends with conclusions and recommendations and with the potential further work and suggestions for future studies.

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1. NETWORKING – ADAPTION OF GLOBAL MARKET FORCES AND LOCAL RESOURCE FORCES

1.1 Network terminology, historical development and network classification

The network approach to the industrial organisation has attracted several researchers' attention. Some researchers have committed to social network research and some to business strategy but none of the approaches is about a sole dominant position. The reason for absence of a dominant theory could be that in the real life exist a large number of very different and also effective network organisations (Sydow and Windeler 1998) and gathering of all those theories under one roof is a complicated task. Various approaches of network research have also different development paths.

The basic unit of analysis in network theory is *relationship*. Unlike other theories that mainly examine internal characteristics of the object, social network analysis investigates ties and relations between units. Relationships are interactions between two or more units. Objects of observations are actors (Lechner 2001). Network could be measured on the individual firm level, on dyadic level or group/network level.

The terms "*network" and "networking*" is often used in a broad context and in different ways by different authors. Very often networks have also local characteristics and local context, which we will describe later. Ebers and Jarillo (Ebers and Jarillo 1998) have mentioned differences in the networking behaviour and features between industries. For example, networks in ceramic-tile industry differ from the networks in automobile components industry. Whether these differences are due to industry-related factors or other circumstances like particular constellation of interests among network members it is not yet clear. Carlos Jarillo and Mark Ebers (Ebers and Jarillo 1998) denote as an industry network a set of organisations (e.g., firms, unions, state agencies, associations) that have developed recurring ties (e.g., buyer-supplier relationships, joint activities, informal ties) when serving a particular market.

Carlos Jarillo and Joan Ricart (Jarillo and Ricart 1987) define *strategic network* as a form of organisation that is web of "long- term, purposeful arrangements among distinct but related for profit organisations that allow those firms in them to gain or sustain competitive advantage vis-à-vis their competitors outside the network". Robert K. Mueller (Mueller 1988) defined networks as links between independent enterprises, which have joined on the basis of common values. Robert Mueller also makes distinctions between *enterprise networks* (Ger. *unternehmenswerke*) and *production networks* (Ger. *produktionswerke*). Johanson and Mattson (Johanson and Mattson 1988) describe network as a mode of organisation that is not based solely on the price mechanism, nor on a hierarchical relationship, but coordination through adaptation.

Lechner (Lechner 2001) determines network as the sum of inter-firm relations and firms that deliver a competitive final product as a coordinated system. Different research objectives have helped to create different network terminology. A common share of all those terms is that inside the networks exist *separate units* whose interactions are based neither solely on the market nor on the hierarchy. The second very important characteristic is the existence of *complementary resources* that present the interest to the actors in the network. Resources are used within a confined supply chain. In our context is important that network *is a group of firms and ties between them that deliver particular products and related services*.

Network organisations could be seen in many industries. Most widely used examples of industry networks are tile, apparel, and machine tool industries in Northern Italy (Porter 1990, 1985, Brusco 1982), software industry in Silicon Valley (Saxenian 1994) and machine tools, IT and automotive industries of southern Germany (Herrigel 1995; Lane and Bachmann 1996; Lechner 2001). Network types of organisations seem to be more represented in the diffused industrial sectors. Quite often such industries use skilled or semi-skilled labour force.

Network analysis has borrowed ideas from several economic schools. Strategic alliances, organisational social research, transaction cost theory, business strategy, relationship marketing, entrepreneurship and industrial district research are a few of them. Loosely organised industrial structures have existed always, but network approach for the explanation of industrial organisation evolved during the last two decades. It became increasingly important in the wave of globalisation and spread of information technologies in the 1990s.

Among the network research we can distinguish North-American approach that tracks its roots to the consumer market research, Italian approach that derives from industrial district research and Northern European based Industrial Marketing and Purchasing research (IMP) (Tikkanen 1998, Lechner 2001). We should also mention that there are strong links between North-American approach and business strategy research.

There have also been arguments that *industry networks* are a current variation of the 1970's idea of *industrial districts* (Grabher 1993; Harrison 1992 cited by Ebers and Jarillo 1998). This could be disputed, but in the opinion of most of the authors the term “industrial district” was initially associated with close geographical and functional proximity. In most of the cases, industrial districts and firms in the districts have extended their activities outside the initial area and in several cases multinational firms have established subsidiaries in the districts.

One form of network in the literature is strategic alliances. Strategic alliances are an example of voluntary cooperation in which organisations combine resources to cope with the uncertainty created by environmental forces beyond their direct control. These alliances are organised through a variety of contractual arrangements, ranging from equity joint ventures to arm's length contracts (Gulati and Gargiulo 1999).

Empirical evidence suggests that the number of inter-organisational alliances prior to 1980 was very small, but there has been virtual explosion since that time (e.g., Herbert and Morris cited by Gulati and Gargiulo 1999).

In our work we use the following network definition: *Network is the sum of inter-firm relations and firms, which deliver a competitive final product as a coordinated system and operate on the logic of exchange that is different both from the logic of market and hierarchy*.

Networks can be seen as technical, organisational or social phenomena and respectively classified. They can be also characterised by legal terms like: strategic alliances, joint ventures, long–term supply partnerships (Ebers and Jarillo 1998), as hybrid forms of organisation (Williamson 1991), intermediate-form organisations (Powell 1990, 1996; Sydow 1992). Network researchers distinguish between confederate, conjugate, agglomerative, organic (Oliver 1990 cited by Ebers and Jarillo 1998), competitive, symbiotic, dyadic/triadic, multi-organisational/sector-wide (Alter and Hage 1993 cited by Ebers and Jarillo 1998) networks.

We can divide the process of describing the networks into 3 categories: describing the *separate firms* and their characteristics in the network (Figure 1.1); describing the *relationships* between two or more units; and wider *economic environment* where firms operate. The two latter ones have received most attention of the empirical and theoretical researchers, but often the distinction between the groups is non-distinguishable (Lechner 2001).

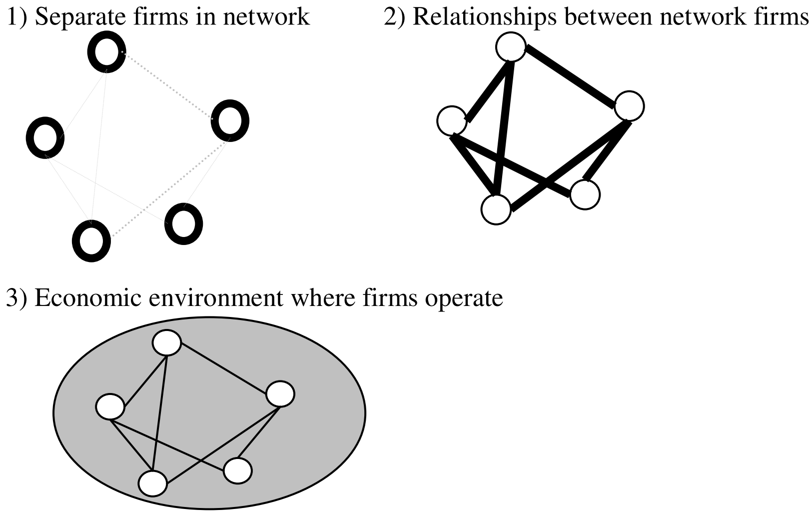


Figure 1.1 Three levels of network analysis

Networks could be classified on the basis of different characteristics. The classification presented by us is depicted on Figure 1.2. The study of different parameters of networks helps to understand the functioning of networks and relations within networks. Networks may have a more *formal* or *informal* structure. Legal antitrust practices, tax laws and local ways of conduct can influence formal operations in the networks. Especially we should mention here Mediterranean countries with strong ethnical, community and family ties and "bottom-up" networking (Seremetis 1994, Coro and Grandinetti 2001).

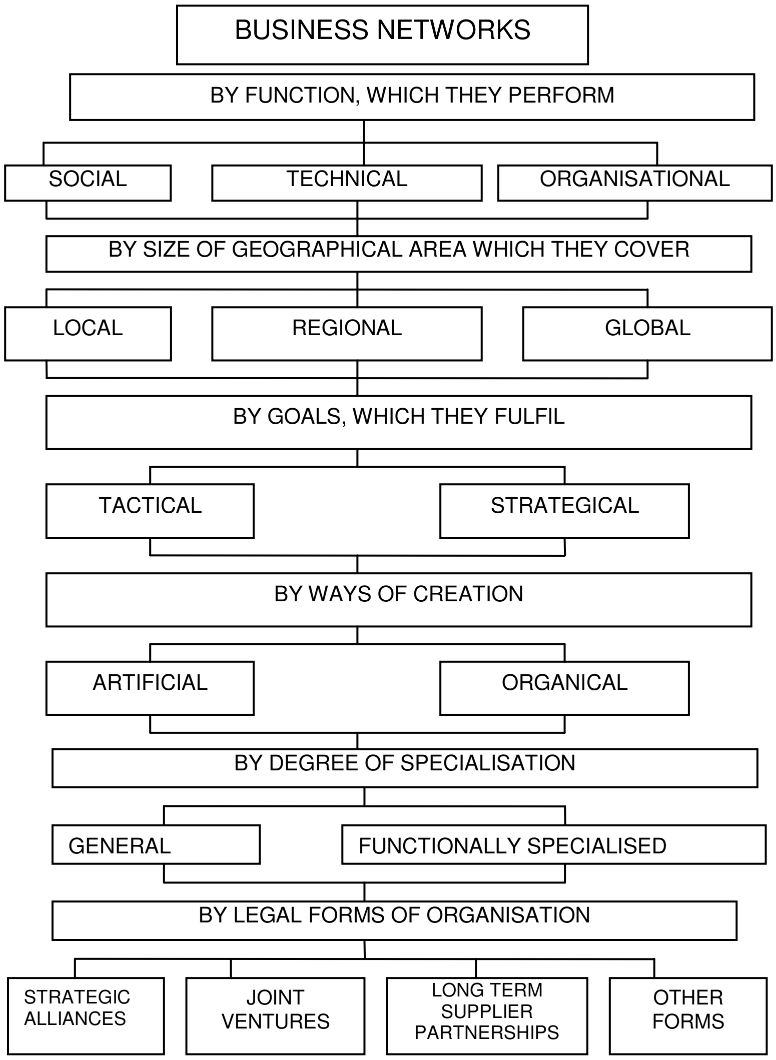


Figure 1.2 Classification of business networks

The different types of networks are appropriate for different goals. Some types of networks are most useful of early stages of entrepreneurial activity, other on later stages (Casson and Della Giusta 2007). Careful definition and classification of networks are necessary in order to analyse of networks in generating interpersonal and interorganizational trust and increasing the stock of social and other types of capital. One and the same network could be classified by different characteristics.

The impact of social networks can be investigated at the local, regional and global level. Where the utilization of specific resource endowments is concerned, the regional level is appropriate; it is this level that the impact of networking on industry and firms can be most discerned. In the social network the elements are generally people, in a physical or technical network the elements are generally natural features, buildings or equipment linked by channels along which some kind of traffic flows (Haggett and Chorley 1969). Global network is the network that links every person, every resource and every location, directly or indirectly, to each other, through different types of physical and social connections. Every other network is subset of this encompassing network (Casson and Della Giusta 2007). Development of global economy and networks influences the development of economy and networks on the all levels.

1.2 Network functioning

The presence of technological infrastructure is often the factor that designs networks and vice versa. By technological infrastructure we mean institutions for acquire production factors. Those factors are most commonly scale intensive and therefore it is more efficient to acquire them together with other network participants (SMEs) than to create own resources. The factors may be both immaterial (information) and material.

For example, in Nordic countries there is a highly developed technological infrastructure for the creation and utilisation of technological information (Seremetis 1994, Blomström and Kokko 2002). This infrastructure includes technical universities, research institutes, laboratories and vocational schools, which are also extensively used (Seremetis 1994, OECD Eurostat 1996).

Technological infrastructure creates the medium for interaction in the Nordic region. Use of wider sources of information enables for firms and especially for SME-s to get outdated and sophisticated information. The Eurostat Community Innovation Study (CIS-2) showed in 2000 that in the period of 1996-1998, 4% of European (European Economic Area) enterprises in the manufacturing sector regarded universities as important sources of information. 3% of enterprises considered government and private non-profit research institutes as important sources of information. In Denmark, Finland and Sweden, the use of universities as an important source of information was 1-3% percentage points higher. The respective number in Denmark was 6%, in Finland 7% and in Sweden 5%. The share of research institutes, as an important source of information was also 1-2% points higher than on average in Europe (Eurostat 2001). Development of technological infrastructure helps to gain a better position in the network.

Common infrastructural facilities could be (Seremetis 1994, OECD 1996):

- testing laboratories for the support of quality control and certification institutions. Laboratory equipment is costly and complete utilisation of resources within one enterprise is very often not the case;
- common use of high-cost catalogues, common marketing and market studies;
- training and education facilities
- research laboratories and facilities
- pool of specialists
- transport and communication infrastructure.

Technological services offered by key actors in the network depend on the needs of actors. The key role in the process of common creation of technology is played by demand for technological know-how. In the case of marketing needs common marketing institutions are the key actors.

Power distribution between network members

Different actors occupy different positions/roles in the network. Having been called by Gulati and Gargiulo (Gulati and Gargiulo 1999) *positional embededness,* power can influence organisations' ability to access fine-grained information about potential partners as well as its visibility and attractiveness for other organisations throughout the network. Social studies (Gulati and Gargiulo 1999, Krackhardt 1990) suggest that central actors have a larger "intelligence web" through which they can learn about collaborative opportunities, hence lowering their level of uncertainty about partnership. As discovered by Gulati and Gargiulo (Gulati and Gargiulo 1999) "central organisations in network" tend also to cooperate with "central partners". For example biggest shipyard likes to buy from biggest steel dealer. For better control of supply chain central actors can lead the hierarchy creation among suppliers (Uusitalo and Malinen 1999, Håkansson and Lundgren 1995).

The term "*power*" is often connected to the concept of dependence (Håkansson et al. 2002). In the past purchasing strategies were oriented to an avoidance of dependence of suppliers. In the nowadays situation where several firms have mutual dependence on customers and suppliers, purchasing efforts have been shifted from avoiding dependence of suppliers to finding mechanisms to handle dependence (Håkansson et al. 2002).

Overcoming of power and power relations are other important factors that influence the structure of industry. Sydow, Windeler and van Well found in Germany (Sydow et al. 1998) that even if smaller insurers overcome their entrepreneurial independence ideal, which keeps them from forging horizontal alliances, the insurance brokers would have great difficulties establishing a viable cooperation network. Insurance brokers are not powerful enough vis-à-vis to insurers.

Stronger position in the network doesn't necessarily mean that there is one-side "power play". Central position in the network gives the hub firm better opportunities to assess the network and to benchmark own network's efficiency towards the competitive networks. This information can raise the concerns about the effectiveness of all network firms and lead to the concessions since the hub firm's destiny depends upon the survival of entire network. That was the case at the beginning of 1990s in Japanese car manufacturing firms (Sydow et al. 1998).

Position in network is not permanent stage. Ambitious and capable manager, designer or enterprise could raise its potential. In longer term it comes evident that different capabilities lead also to the change of network position and different power relations. As a notable example we can bring here South-Korean enterprises who started as suppliers and subcontractors of Japanese car manufacturers in 1960-s. With growing knowledge and experience they realized in 1980-s that they are capable to manufacture full car and started manufacturing of them under their own brandnames.

Power relations become visible during the process of termination of relations. The extent that one party has to the relationship more alternatives than the other is asymmetry of relationship (Turnbull et al. 1996). However, "too" tough handling of suppliers could harm the reputation and stimulate the concentration of suppliers or building of additional safeguards.

Local context in networks and industrial environment

Local spirit and strong sense of community are often characteristic of the networks. Pride over the region and regional production is widely expressed by local entrepreneurs. Feeling of local community plays an important role in the creation of regional networks.

Trust creates the environment for transactions. Granovetter (Granovetter 1985) revitalised after 1980-s in classical sociological theory the idea that economic action is embedded in social networks. According to Granovetter (Granovetter 1985), the micro-foundations of embedded economic action rest on "the widespread preference for transacting with individuals of known reputation", for resorting to "trusted informants" who have dealt with potential partner and found this partner trustworthy, or even better, for relying on information from one's own past dealings with that person.

Understanding of a particular industry requires not only personal, like mentioned by Granovetter (Granovetter 1985) but any kind of relations, especially inter-organisational relations. These relations are important for developing a more comprehensive, socially informed, and dynamic understanding of a specific industry (Sydow et al. 1998). Different environments and communities influence local networks in different ways.

Most organisations are embedded in a variety of inter-organisational networks, such as board interlocks, trade associations, and research and development ventures. In case of Estonia or other smaller communities there can be also family links, university-time links etc. The creation and the actual inter-organisational division of work, and in particular, the design of inter-organisational relationships are greatly influenced by the structures of the industry within which the network is organised (Sydow et al. 1998). The same industry can have one form in one country and some other form in other country. Extremely variable forms of integration are in car-parts industry between the car parts producers and assembly firms. However, despite the differences in integration, they produce physically similar parts (Mytelka 2002).

Networks can be created in two ways. The initial starting-point of the first method is market. After the first market based transactions firms start to exchange more information and adjust each other to partners needs. Sydow (Sydow and Windeler 1998) called this method "quasi-internalisation". Another method is based on the outsourcing of a particular function or activity. The method might be called also "quasi-externalisation" (Sydow and Windeler 1998).

To reduce the search costs and to alleviate the risk of opportunism associated with strategic alliances, organisations tend to create stable, preferential relationships characterised by trust and rich exchange of information with specific partners (Dore 1983, Powell 1990 cited by Gulati, Gargiulo 1999). Initially it is easier to create close relationships with firms that are geographically close. After some time such ties and such "embedded" relationships (Granovetter 1985) accumulate into a network, which becomes a growing repository of information on the availability, competencies, and reliability of prospective partners (Gulati and Gargiulo 1999). Communication with the enterprises at the close distance may happen as a response to the adoption of new management systems (JIT-Just in Time). Several enterprises have created supplier villages. Volvo Car Corporation supplier village in Göteborg is one such example (Gadde and Håkansson 2001). Efforts made by electromechanical company Tarkon AS to create a suppliers' network in Tartu might be another.

Enterprise networks can be created by voluntary action of actors, mostly SMEs (bottom-up), or the second way of network creation can be the initiative from national/local government or a large central firm (top-down). The governments nowadays very often see the creation of good business climate and promoting of networks as one of the key tasks in their economic policy. Networks that are created on the basis of local spirit and voluntary action of SMEs are tending to be more informal, based on local ownership and very often also have family links (Seremetis 1994, Kalantaridis 1996). Networks that have received the initial push from public institutions tend to be more formal, more institutional and geographically more disperse (Drakopoulou-Dodd et al. 2002). Despite best wishes, a kind of bureaucratic attitude can be a reason for lesser efficiency and formality.

Besides the geographical proximity and common behaviour, networks include common communication and information institutions. These institutions can be family ties, church, professional federations, learning centres or others. The current network behaviour influences also newcomers. Inter-organisational networks are the evolutionary product of embedded organisational action in which new alliances are increasingly embedded in the very same network that has shaped the organisational decision to form those alliances (Gulati and Gargiulo 1999). According to Doeringer and Terkla (Doeringer and Terkla 1996), clustering of local organisations in industry can be promoted by advantages drawn from the local factor market and those derived from relationships with organisations outside the immediate value chain of an industry, such as trade associations, government agencies, financial institutions, universities and unions.

If the western world importance of social contacts and networks to entrepreneurship and economic development has been widely recognised since the 1980s, then in Estonia due to weakness of social capital are conceived that situation more lately.

The majority of individuals are embedded in social situations and can take advantage of the social relations in which their ties are embedded (Kim and Aldrich 2005). By making connections with others, individuals are able to achieve more than if they acted alone. The network thus becomes a resource underpinned by social capital, which constitutes an intangible asset (Field 2003). Social capital has variously and broadly defined as involving building and maintaining of networks and the norms of behaviour that underpin them (Putnam 2000). Anderson et al. (Anderson 2007) define social capital as an asset. Economists used the "market value" term. This market value is reflected in the expected net present value of the future stream of benefits generated by asset. Social networks channel information to the entrepreneur that he can use to identify profit (Casson and Della Giusta 2007). The innovative entrepreneur develops social capital through building networks, which provide external sources of information, support, finance and expertise allowing mutual learning and boundary crossing (Cope et al. 2007). The focus of this thesis is on "instrumental" benefits of network membership, such as promotion of productivity and trade, rather than "intrinsic" benefits, such as personal recognition and support.

1.3 Motivation factors in networks and structure of industries

Similarly to every economic structure, the purpose of networks and inter-firm cooperation for SMEs is to cope with the competition pressure. Several studies suggest that networking has enhanced the capabilities of SMEs to increase their competitive edge (Seremetis 1994, Jarillo and Ricart 1987).

Rationales of networking can be technology development, increased market power, market development, reduction of uncertainty and cost saving (Ebers and Jarillo 1998). Globalisation effects cause several of the above-mentioned events, concentration of industrial production and rise of scale/scope intensity of production. Most of the authors are of the opinion that development of particular inter-organisational networks is driven by exogenous factors, such as distribution of technological resources or social structure of resource dependence (Burt 1983 cited by Gulati, Gargiulo 1999). Gulati and Gargiulo mention also reduction of environmental uncertainty.

Reasons for co-operation may also be advantages drawn from the local factor markets and those derived from relationships with organisations outside the immediate value chain of an industry, such as trade associations, government agencies, financial institutions, universities and unions (Sydow et al. 1998). When market requires products with certain distinctive output characteristics the firms have to find optimal ways for acquiring inputs.

We should also remember that every industry might have several types of networks. Sydow, van Well and Windeler (Sydow et al. 1998) discovered in the typology of networks in Germany included:

Less complex networks simply aiming at pooling resources;

- Information technology-driven networking;
- Regional networks of brokers, following the model of flexible specialisation;
- Strategic networks led by a hub firm and approximating to some extent franchise systems;
- Well-known global networks of the "mighty players" among the actors.

Four reasons for horizontal networking in the services industry, related to the industry were: combining of capabilities to offer a wider range of services and extend market reach; expertise extension and pooling of expertise; overcoming capacity difficulties by organising themselves into new networks; creation of network type market driven organisations (Sydow, van Well and Windeler 1998).

Networking benefits include:

- mutual learning that leads to faster product development and thus first mover advantage (Oliver cited by Ebers and Jarillo 1998);
- co-specialisation by exploiting profitable product-market niches (Jarillo and Ebers 2001);
- better information flow and improved coordination of resource flows that leads to cost and time savings;

- economics of scale that can be achieved through joint sourcing (Dussauge and Garette cited by Ebers and Jarillo 1998);
- setting up barriers to entry to a market with protection of long-term rentability of network members investment (Porter and Fuller 1986);
- for small entrepreneurial firms, keeping the owner-manager status is a high motivating factor. Harrison (1992) called it concentration without centralisation.

Industry networks or hybrid type organisation forms could have advantage over market procurement and in-house development of innovations in cases when they combine the incentives for efficient and effective performance of markets with the monitoring capabilities and commitment associated with internal organisation. These characteristics are particularly important for large-scale innovation because this task today often exceeds the capabilities and resources of a single firm, while it involves highly specific investments, tacit knowledge, and high degree of uncertainty (Mowery et al. 1996; Teece 1997 cited by Ebers and Jarillo 1998: 13).

It has been argued that risk sharing/or risk transfer is one of the main reasons for creation of networks. For example, large firms can use subcontractors during the peak times and when demand is slack, keep production in-house. This practice is opposite to the trust building between buyers and subcontractors and inevitably subcontractors understand the impacts of such policies quite quickly. Surveys of Japanese subcontractors indicated that buyers – assembly firms covered most of the risks (Kawasaki and McMillan 1986 cited by Jarillo and Ricart 1987: 90).

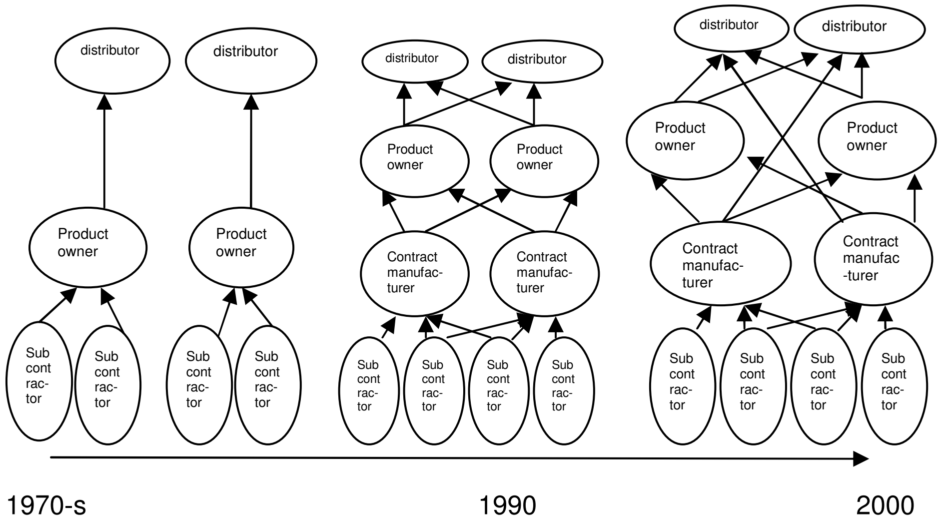
A motivational factor for enterprises in the network is to better utilise their resources and to reduce the transaction costs. The final goal is to create a competitive advantage.

1.4 Development of networks

All major sub-groups of metal industry have different types of networks. Among the major factors affecting the shape of business networks are the complexity, cyclicality of demand and technology development (Autio and Yli-Renko 1998). Development of world economics is accompanied by specialisation and increase of sophistication.

Industrial structure is changing constantly the supply networks. Changes concern the scale-, scope of activities and closeness of relations. Companies specialise and try to position themselves better in respect to partners, either to mass manufacturing or small or medium-series manufacturing. General trend is movement towards the more tight relations between the customers and producers. In high growth branches, the structure is changing faster and in mature industries slower. Simplified industrial structure in fast changing electronics industry can be brought as an example (Figure 1.3).

Several additional activities have been shifted to the partner. Procurement, purchasing, local sales in the Baltic States, some design activities, larger scope of manufacturing activities is some among them. This has led sometimes to the position change in the value chain.



Time period
Figure 1.3 Development of networks in electronic industry
Sources: Ali-Yrkkö (2001) and Ranta (1998)

Every advantage involves risk and every problem is a challenge. In the outsourcing process with good contacts, supplier can spend less on marketing and communication. Free resources can be spent on other activities like production and learning. However, working without marketing can cause substantial risks. For the reduction of risks the company can develop the relations with a number of key-clients. Preferably the partners should be in different industries. It is very good when company can offer different clients solutions based on the same technological platform. The main risks for the supplier are client specific investments (Pajarinen 2001). Ceasing of contracts with the main customer can leave the client specific investments obsolete or lower their value substantially. Another source of risks is the long supply chains (Pajarinen 2001). Delays of payment or other economic difficulties in the beginning of chain can leave more remote parts in the supply chain in a difficult position.

In the Baltic Rim Area, the main contractors or central firms in networks have shifted out the mainly capacity manufacturing. Big growth of outsourcing started in the middle of 1990s. Outsourcing has created new industrial structures with companies whose main products are manufacturing services. Several manufacturing contractors are already so big that without their existence industry cannot function.

We should have in mind that there are two sides of subcontracting and both parties perceive relationship differently. Firms (if there is not same ownership) have different goals and future strategies. For example low cost supplier could have vision to develop itself with new know-how to more sophisticated supplier or product owner in the future (Outsourcing Center 2004, Paija, L. 1998, Jonsson et al. 2004).

Existence of opportunism is discussion object between the economists but we expect that opportunism (own profit maximizing) from the both sides is part of relationship.

There is no clear formula or method for subcontracting. Decision factors of subcontracting could be both subjective and objective. Sometimes individual attractiveness could be deciding factor during the choice of suppliers. Author who assisted the buying company during the company visits 5 year ago (Lumiste 2003) saw that a buyer was positively impressed by personal behaviour of supplier company manager. Supplier company manager met potential client at the reception and made company tour by himself. Handshakes and smiles with floor managers and key machine operators showed good communication and labour relations. In other companies meetings were with salesman in remote offices.

Among the objective (mechanical) factors that affect the success of relationships is partners size, its position in regional networks and global supply chain. Different countries have different ownership, family and social networks and with the change of position in the supply chain the supplier firm could achieve even a better position in local networks and grow to a competitor of the buyer in the supply chain. An influential buyer from his side could oppose change of roles in the supply chain, terminate the partnership and switch to another supplier. When DRAM company Infineon discovered that there is change of perspective and lack of willingness to have solely low cost fabrication with Mosel Vitelic in Taiwan it terminated the strategic partnership and formed a new partnership with other firm (Infineon's … 2003).

1.5 Conclusions

Networks were examined with the aim to investigate their influence on improving the performance of industry and firms. The main conclusions from network research and other theories are the following:

- Based the definitions and classifications of networks it is possible to analyse different networks, their influence on the development of industry and firms and to give recommendations for developing different types of networks;
- Weakness of social networks restrains economic development and local economic environment and culture have a strong influence on the type of

networks. It is necessary to find ways of fostering cooperation of enterprises with different working culture;

- There should be both public and private action to upgrade local business infrastructure that serves as a tool for business competitiveness;
- Technological development, increased market power, market development, reduction of uncertainty, cost saving, and social capital development could be motivation factors in networks. The influence of motivation factors on the development of networks should be analysed to give recommendations for the creation and reconstruction of enterprises' networks;
- All networks are not necessary and some networks can influence negatively the development of firms; means need to be found to eliminate the influence of negative factors on the performance of networks;
- Technological and marketing capabilities are heterogeneously distributed on the market across competing firms and the differences between enterprises could be long lasting; it should be analysed how enterprises have found these capabilities and which capabilities they must develop in the future;
- Public industrial policy should be targeted for the creation of viable networks.

2. INNOVATION IN INDUSTRY

2.1. Concepts of innovation

Word innovation derives from Greek word *innovare*, what means to do something new. Innovation is a sophisticated process and publicly several different terms are used. Most commonly used methodology and terminology are given in OECD Oslo Manual (OECD 1992) and Frascati Manual (OECD 2002).

Innovation as concept of economy and terminology of innovation were given by famous Austrian economist Joseph Schumpeter. Joseph Schumpeter (Schumpeter 1911) defined economic innovation as the: (1) introduction of a new good —that is one with which consumers are not yet familiar—or of a new quality of a good, (2) The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before, (3) The carrying out of the new organization of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position, (4) the introduction of a new method of production, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially, (5) The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created. First three of about mentioned characteristics could be counted as product innovations and the last two as process innovations.

In business and economics, innovation is often divided practically into four types (OECD 1992, 2002):

Product innovation, which involves the introduction of a new good or service that is substantially improved. This might include improvements in functional characteristics, technical abilities, ease of use, or any other dimension.

Process innovation involves the implementation of a new or significantly improved production or delivery method. Process innovations improve main process technologies and supportive technologies.

Marketing innovation is the development of new marketing methods with improvement in product design or packaging, product promotion or pricing.

Organizational innovation involves the creation of new organizations, business practices, or ways of running organizations. Organizational innovations could cover both inside organisations and outside links of the firm. Use of subcontractors and rented labour is sample of organisational innovations.

Oslo Manual (OECD 1992) defines also technological innovation.

Technological innovation – technologically implemented new products, processes or services and significant technological improvements in products, processes or services. It requires an objective improvement in the performance of a product or in the way in which it is produced or delivered.

Innovators (innovative enterprises) – enterprises that have introduced new or improved products or services on the market or new or improved processes. Enterprises can have innovation activity without introducing an innovation on the market (it may either have unsuccessful or not yet completed innovation projects).

Research and experimental development (R&D) – creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications, such as technologically new or improved products and processes. Manufacturing of prototype and design are often the most important phases of R&D. Software development is included as long as it involves a scientific or technological advance. R&D can be carried out within the enterprise or R&D services can be acquired. R&D is the sources of more radical and revolutionary innovations, while more incremental innovations may emerge from practice. Part of R&D in innovation process is discussed in chapter 4.

In our work we use the following innovation definition: *Innovation* meaning changing from new idea to new product, new or improved production, marketing or organisational method. Technological product and process innovations comprise implemented technically new products and processes and significant technological improvements in products and processes (OECD 1992, 2002).

There are close connections between development of technical and technological processes and development of resources, society and policies. These connections we can examine by using a model composed by author (Figure 2.1).

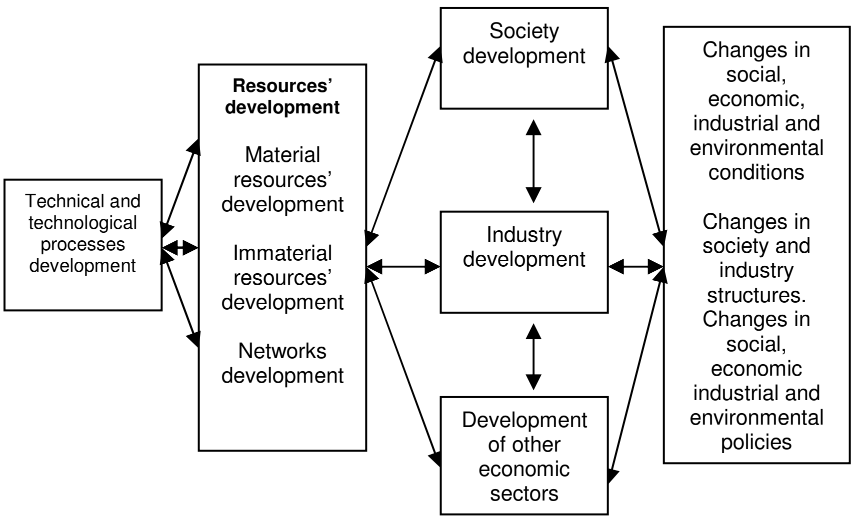


Figure 2.1 Factors influencing the development of technical and technological processes.

On Figure 2.1 left side of the drawing represents mainly opportunities that technology development gives for MEI. Right side of the Figure represents mainly the factors creating the demand for industry. Within certain time period and within certain sub-branch of machinery and electronics industry different factors could influence the changes. For example rising fuel prices encourage put more resources into research targeted to the reduction of fuel consumption.

For scientific research phenomena needs to be measured and accounted. Main methods of the measuring the innovative activities are the measurement of inputs of innovation and the measurement of outputs. Among the inputs are the financial resources spent on innovation and man-hours involved in innovation, number of technology licenses bought and number of linkages with universities. Among the outputs of innovation are number of patents, sales from newly invented products and share of valuable patents, number of scientific papers, market share and other economic characteristics (Terziovski 2001). In chapter 4 are discussed relationships between innovation activities and expenditures, between firm size and outputs, also are measured innovation effects.

In the innovation research we can distinct five generations of research. Innovation theory also has several fathers i.e. influences from other theories. Joseph A. Schumpeter gave first definition of innovation in the field of economy. Basic foundation for innovation theory lies in the Joseph Schumpeter's idea of "creative destruction" (Schumpter 1911). Creative destruction occurs when innovation makes old ideas and technologies obsolete and therefore causes the creation of new economic structure.

Second generation of innovation researchers in 1950s and 1960s introduced the concepts of product innovations, process innovations and business use of inventions. First was used concept of systematic innovations (Davis and North 1971).

Important part of innovation theory is diffusion of innovation i.e. adoption of new ideas and technologies by wider ring of users. Based on empirical evidences researchers described adoption curve of innovations (Tarde 1903, Ryan and Gross 1943). The adoption curve becomes a s-curve when cumulative adoption is used. French sociologist Gabriel Tarde originally claimed that sociology was based on small psychological interactions among individuals, especially imitation and innovation. Diffusion of innovations theory was formalized by Everett Rogers in a 1962 book called "Diffusion of Innovations". Rogers stated that adopters of any new innovation or idea could be categorized as innovators, early adopters, early majority, late majority and laggards, based on a Bell curve. Each adopter's willingness and ability to adopt an innovation would depend on their economic profitability, awareness, interest, evaluation, trial, and adoption. E. Rogers showed these innovations would spread through society in an S curve, as the early adopters select the technology first, followed by the majority, until a technology or innovation is common. Adoption curve has basically two parts: first part p, which is the speed at which adoption takes off, and q, the speed at which later growth occurs. A cheaper technology might have a higher p, for example, taking off more quickly, while a technology that has network effects (like a fax machine, where the value of the item increases as others get it) may have a higher q.

Third generation of innovation research in 1970s and 1980s concentrated on industrial innovations (Freeman et al., 1982). As a new terms and concepts were introduced incremental innovation, radical innovation, change of technology system and change in techno-economic paradigm.

Fourth wave of innovation research in 1990s investigated mainly (national) innovation systems. Main topics were functioning of innovation systems and comparison of national innovation systems (NIS) (Freeman 1987, Nelson 1993, Lundvall 1992, Högselius 2005).

Fifth generation of innovation tackles the problems of knowledge innovation. Main interest areas are science innovation, knowledge innovation: the creation, evolution, exchange and application of new ideas into marketable goods and services for the excellence of an enterprise, the vitality of a nation economy and advancement of society as-a-whole (Amidon 1993, He Chuanqi 1999, 2000).

Innovation theory has strong links with resource based view and business strategy research. Most of the research in the field of innovation is made by US, Japanese and European researchers. However we should also mention here the research made about the "catch-up economies". For natural reasons we could mention research made by Indian, Chinese and Singapore origin scientists (Ghoshal, He Chuanqi).

2.2. Diffusion of innovations

During the last decade most of the patented innovations have been created by the big electronics firms situated in United States, European Union and Japan (Malecki 1997). Electronics industry innovations have reshaped several other manufacturing and service sectors. Dominant share of knowledge creation and legally protected intellectual property creation happens in relatively confined geographical area and relatively small number of firms. Other firms, other nations and larger audience of users could consume and enjoy those creations through process called technology diffusion. The diffusion of innovation process can be tracked on a micro level as is the case of an individual who is a targeted member of an audience, or traced at the macro level when considering economic development or technological advances.

Part of the innovation diffusion research is the transfer of technology from more developed regions and countries to less developed ones. Adoption of different innovations in less developed countries is always accompanied with the transfer of habits, attitudes and knowledge from more developed countries. In his book "Inventive Activity, Diffusion, and Stages of Economic Growth", Stanislav

Gomulko defines different stages of technological growth that any economy can be divided. In the first stage development of the technological sector as well as the level of technology are in their "embryonic-initial" stages. Both the share and rate of growth are low. The society is frequently faced with a great scarcity of primary commodities, living on a low level of subsistence, and with a lack of social policy tools (Gomulko 1971). Technological sector has no influence to the economy and there are two channels for diffusion to a less developed country. The first channel for diffusion is the exchange of knowledge and the second channel for diffusion is innovations from other countries.

Diffusion rate is dependent upon two factors: the degree of openness and receptivity from the country and the rate of growth of exports. The degree of openness and receptivity' of less developed country is influenced by three main conditions: transportation sectors, communication sectors and the general education levels of the population (Gomulko 1971).

In the second stage of economy the rate of growth of the total population gradually begins to accelerate due to increased knowledge and achievement of a certain level of technology. "New expanded supply and demand by society necessitates a larger absorption of foreign-made innovations and augmentation of the technological sector." (Gomulko 1971).

In the third stage is a continuation of the growth rate at the end of the second stage. Growth is brought about by the high rate of growth of the technological sector and/or by massive diffusion. In the fourth stage the rapid rate of the third stage decreases due to an exhaustion of one or more of the growth rate variables.In the fifth stage economy is congruent with the growth of the country when it is already a part of the technologically leading area of the world. The expansion of the economy follows growth of the country's population (Gomulko 1971).

Just as the adoption process relates to market segmentation, Gomulko presents an example of how the diffusion process can be applied to the economy and technological levels of less developed countries. The diffusion of innovation process consists of four elements: the innovation, communication through information channels, over time period, among the members of a social system.

A similarity found amongst the various research studies on the diffusion of innovation process is that the adoption process or the rate of diffusion can be charted on an S-shaped curve. Of vast importance to those in the advertising field is the innovation-decision process. Rogers (1976) defines the innovation-decision process as the process through which an individual passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision.

If economy moves stage by stage up and change more innovative, the parallels occur development of networks: developed economy needs more sophisticated networks

2.3 Sources of innovations

There are several conditions needed to be innovative and creative. Obligatory is the endowment with information for innovation. Proper endowment with information means here that company spends on the acquiring of information optimal resources and that the information gives clear direction for improvements. Different (innovation) information sources could be used by firm for such purpose. Sources of information could be other manufacturers, users, suppliers or other organisations. Choice of the information sources depends on the size of firm, socio-cultural aspects, level of economic development and other factors. Sources of innovation and business information have been the interest of researchers and public institutions.

It has long been assumed that product innovations are typically developed by product-manufacturers. Because this assumption deals with the basic matter of who the innovator *is,* it has inevitably had a major impact on innovation related research, on firms' management of research and development and on government innovation policy. Eric von Hippel (von Hippel 1988) showed that this basic assumption is often wrong.

Research and development are important sources for "breakthrough innovations". The more radical and revolutionary innovations tend to stem from R&D, while more incremental innovations may emerge from practice – but there are many exceptions to each of these trends. Current trend of manufacturing is that products are getting more customized and one designer of product is customer. Investment goods followed this trend already in 1970- and 1980-s. Cars and computers in 1990-s. Within the certain range final buyer of car could choose what kind of engine he/she wants and several other technical parameters. This is big development since Henry Ford time when his son proposed to build next car model not in black but red color and Henry Ford came enormously angry. Producers have several options for getting feedback about the already working investment goods and customer wishes. Maintenance and service business give information about the functioning of machines and the direction of improvements. Good client service about the parameters is needed by customers.

Sources of innovation information depend on company size. The largest technology companies have the largest technology staffs and manage them most effectively. They are able to take the high risk of failure and consequently to have high gross margins of revenues. SME-s often lack of such possibilities. Small size of companies makes also difficult the developing of information infrastructure like technical libraries and other specialized services.

Eric von Hippel (von Hippel 1988) showed that the sources of innovation vary greatly. In some fields, innovation users develop most innovations. In others, suppliers of innovation-related components and materials are the typical sources of innovation. In still other fields, conventional wisdom holds and product manufacturers are indeed the typical innovators. In the newest book “Democratizing Innovation” von Hippel (von Hippel 2005) say that innovation is being democratized, he mean that users of products and services—both firms and individual consumers—are increasingly able to innovate for themselves. User - centred innovation processes offer great advantages over the manufacturer - centric innovation development systems that have been the mainstay of commerce for hundreds of years. Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents. Moreover, individual users do not have to develop everything they need on their own: they can benefit from innovations developed and freely shared by others.

The trend toward democratization of innovation applies to information products such as software and also to physical products (von Hippel 2005). For example, von Hippel (von Hippel 2005) in the fifth chapter uses the history of mountain biking to propound that users can also “be sophisticated developers”.

Closeness to the final customers gives for firms big advantages over the customers. In literature have been discussed mainly the effects of purchasing power of main contractors over the subcontractors (Uusitalo and Malinen 1999, Gadde and Hakansson 2001). Information and opportunity to create core competence based on that information could be even more important. Interesting example of combining both user and developer knowledge is Southern Estonian firm Ritsu AS (www.ritsu.ee). Company is producing both loghouses and equipment for the production of loghouses. Company started as designer of machinery for wood industry and later added loghouse production for testing the own machines. Company has developed simultaneously both sides of production. Analysis of sources of information for innovation is in chapter 4.

2.4 Innovation models and technology trajectories

Innovation trajectory is dependent on innovation type, market structure and competition over time (Abernathy and Utterback 1978). Pavitt (Pavitt 1984) identified four types of technology trajectories. Taxonomy of firms includes: firms in supplier dominated industries, specialized supplier firms, scale intensive producers and science based firms. Some authors distinct also firms in information intensive sectors like software development. Supplier dominated industries are traditional manufacturing sectors like textile production and agricultural processing. Most of the innovations are caused by the using of new technology. Very often that technology is transferred from other more technology intensive sectors.

Specialized supplier industries are machine tools and instrument industries. Such industries are characterized by high customization of products, strong links between users and producers and by relatively low volume. Biggest source of innovation information are feedback from customers and most of the innovations are incremental. Several machine-building firms from “old” EU belong to that group.

Scale intensive sectors are steel production, bulk materials and to certain extent electronics mass manufacturing. Main innovations are process innovations and they are initiated both by in-house activities and in cooperation with suppliers. Science based sectors are research and development intensive areas like electronics components production, pharmaceuticals and biotechnology. Main innovation activities in science intensive sectors are in-house research and development and contracted research. Science based firms try to create competitive advantage through mastering and protecting of proprietary technologies.

Being part of certain industry or being in certain position in the value chain determines to a large extent also the type of innovation. In emerging industries firms tend to perform product innovations.

R. Rothwell explains (Rothwell 1994) the evolution of innovation through five generations of behaviour. The first and second generation of innovation models are simple linear market pull and technology push. Main factors pressing firms to innovate are a market need and new solutions created by scientists. The third generation or coupling innovation model recognizes interaction between different elements and feedback loops between them. The fourth-parallel model of innovation stresses integration within the firm, upstream with key suppliers and downstream with demanding and active customers. This model emphasizes the linkages and alliances. The fifth or system integration model assumes extensive networking, flexible and customized response and continuous innovation.

There is no single model of innovation in any particular industry. We can speakabout the co-influence of different models. Among the metal industry sectors where technology push is the main factor of innovation is manufacturing of new electronic components. Market need is influencing contract manufacturing in the electronics sector (Radosevic 2003).

The coupling model is used by enterprises in specialized small series machinery production. Parallel models of innovation stressing downstream integration are relevant in metal industry sectors getting the most of the revenue from services rather than production. Locomotive building and long life service, escalator production and maintenance are just a few examples of such industries. The fifth system integration innovation model is relevant for specialized software producers where co-creation of products is essential.

Due to the difference in institutional setup, education and resources innovation trajectories could differ substantially from country to country. For firms in developed countries innovation often results as continuation from basic research and later development. Successful cases from China and early Japan in the 1950s however show different paths. Instead of attempting to use “its own” genuine technology successful firms have tried to imitate technologies outside their own firms. For countries who joined world economy later copying and learning are one of the best ways to raise their technological competence and later to start to improve the existing products. This so-called latecomer advantage helps to leverage the knowledge created by other persons and institutions. As an example we could cite here Lars Magnus Ericsson who started as the salesman of Bell telephones more 100 years ago. Technical talent and entrepreneurial skill allowed him to master and improve the existing technology and to found his own telephone firm.

Such innovation pattern is called 3-I, an acronym of imitation, improvement, and innovation (Xu et al. 1998). Imitation and improvement stages are accompanied first with process innovations. This is a second big difference from developed economies where in many cases the first innovations in high-tech industries tend to be product innovations (Utterback 1994; Xu et al. 1998). Despite the different socio-political and cultural environment, the innovation methods in China seem to be more similar to Estonian ones than those referred in mainly US literature. Theories of Gomulko (Gomulko 1971), Rothwell (Rothwell 1994) and Xu, Chen, Guo (Xu et al. 1998) helped us to construct a Figure, that shows the prevailing connections between development stages, models and methods of innovation (Figure 2.2).

Prevailing connections mean that there must be other, different innovation connections between firms. For example, on the lowest stages R&D would be a source of innovation and on the fifth stage firms would use imitation.

Innovation processes in Estonia are quite similar to the innovation processes in other European emerging economies. In the 1990s and the beginning of the 21st century in Estonian machinery and electronics industry could be characterized by market driven innovations. The market for machinery and metal products as the main factor shaped the demand for industrial products, but also certain favourable coincidences played their role.

Dominative method of innovation was transfer of technology through foreign investments. Technology transfer was in most cases accompanied with combining local and imported solutions and adaptations to the local environment.

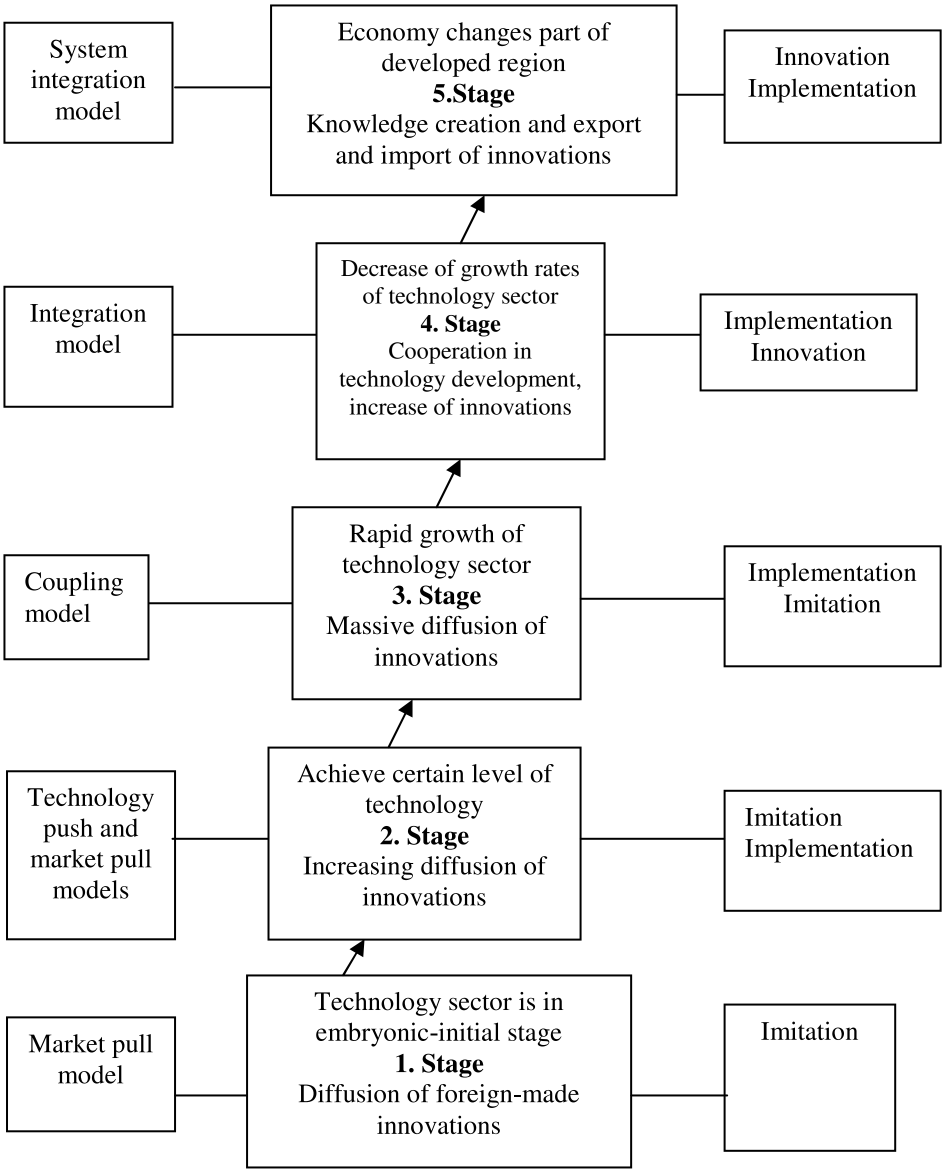


Figure 2.2 Prevailing connections between development stages, models and methods of innovation. Source: Authors Figure based on Gomulko (Gomulko 1971), Rothwell (Rothwell 1994) and Xu, Chen, Guo (Xu et al. 1998) theories.

The main innovations in the Estonian metal industry have been made through green-field investments and strategic investments into existing plants (Kurik et al. 2002). Transfer of financial capital has been accompanied with the transfer of knowledge, methods and contacts. Innovations have reshaped most of the value chain. Production technology itself has remained most stable in traditional branches. Biggest changes occured in service-type activities in manufacturing like sourcing, planning, distribution and financing. Like other manufacturing sectors the metal industry has become more service type, it is using higher customization and client specific applications. Product innovations are less visible because in many cases development work has been outsourced or technological solutions created previously outside the firm have been used (Kurik et al. 2002).

Innovation type and scope are mostly determined by the enterprise's network. Enterprises receive signals both from sourcing and distribution networks and based on those signals change themselves or shift to other networks.

At the beginning of 1990-s the innovation permissive factors included the collapse of former relations and ties. On the basis of destruction, which was not always creative, it was possible to build up new relations. There was minor interference from the side of the government and trade unions. In the conditions of relatively high employment the main wish was to increase the number of jobs in industry (Terk 2000). An opposite picture could be seen in Western Europe with strong existing labour relations and trade unions. Everyone tries to maximize their income but in the case of global market also factor prices tend to equalize.

Globalisation and consolidation of commodities markets have made raw material prices quite similar in Eastern European emerging markets with those in Western Europe. Only labour has been the relatively cheaper resource in Eastern Europe. Changing labour prices push to invest into new technologies that could reduce or keep on the same level the share of labour cost to the total cost (Kilvits et al. 2003).

Every investment gives also a push for additional services and innovations in the service sector. According to Gomulko (Gomulko 1971), the investment process is always accompanied with the need for different services. For example investments into machinery manufacturing could create the need for special services like maintenance and design and for general services like transportation and utility services.

Part of the innovations in emerging economies are caused by changing regulative environment. New global, regional and national regulations create new demand and therefore new market niches. As an example, could be given environmental regulation pushing towards the use of new energy technologies. Production of parts of wind turbine is big part of the portfolio of several Estonian firms.

Another circumstance that gave a push to the innovation was jumping over certain generations of technology. Mostly this trend affected manufacturing related services like wide use of the Internet. Several activities were at the beginning done in the Internet rather than using the existing paper and other data storage based technologies.

2.5. Innovations types and technological cycles

Technological cycles are seen most directly in nonassembled or simple products (skis, tennis racquets). In more complex assembled products (e.g., computers or watches) and systems (e.g. radio or voice mail), technology cycles apply at the subsystem level (Tushman and Smith 2004). Technology cycles are composed of technological discontinuities that trigger *periods of technological and competitive ferment*. During periods of ferment, rival technologies compete with each other.

This turbulent innovation periods close with the *emergence of industrial standard or dominant design* (Anderson and Tushman 1990). The *era of incremental changes* begin selection of dominant design and continues with architectural and market-based innovations: This period is broken by next substitute product. The next technological discontinuity then triggers the next wave of technological variation, selection, and retention or next technological cycle.

Incremental, architectural, and discontinuous or radical innovations are defined by their technological impact on subsystems and/or linking mechanisms, market based innovations are those innovations that are targeted to new markets and customer segments.

Incremental innovations are innovations that push existing technological trajectory for existing subsystems and linking mechanisms. Such innovations are associated with significant improvements in products and enhanced customer satisfaction over time (Myers and Marquis 1969, Hollander 1965). Incremental innovations reinforces the capabilities of established organisations, while radical innovations reinforces them to ask a new set of questions, to draw a new commercial skills, and to employ new problem-solving approaches (Tushman and Anderson 1986).

Architectural innovations are innovations that change the architecture of a product without changing its component. These innovations involve shifts in subsystems and/or linking mechanism and are often initially targeted to new markets (Henderson and Clark 1990). The essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way. The important point is that the core design concept behind each component and the associated scientific and engineering knowledge remain the same (Henderson and Clark 2004, Persson et al. 2006, Ullrich and Eppinger 1995).

Discontinuous or radical innovation involves discontinuous technological change in a core subsystem. Such technological shifts trigger cascading changes in other less-core subsystems and linking mechanisms (Tushman and Smith 2004). For example, in the photography industry, digital imaging was a competence-destroying change in the camera's core subsystems.

The distinctions between discontinuous, architectural and incremental innovations are matters of degree. Discontinuous or radical innovation creates unmistakable challenges for established firms, since it destroys the usefulness of both architectural and component knowledge (Tushman and Smith 2004). Incremental innovation tends to reinforce the competitive positions of established firms, since it builds on their core competencies or is "competence enhancing" (Henderson and Clark 2004). It is important to ignore the potential of sustained incremental change. Continuous improvement of this kind has received considerable attention as part of "total quality management" movement, reflecting the significant gains which Japanese manufacturers have been able to make in improving quality and productivity through sustained incremental change (Robinson 1991).

We can compose innovation classification for describing the innovation by different characteristics (Figure 2.3). The first characteristic shows object of innovations (product, service or process); the second - the degree of novelty or type of innovation (incremental, architectural or radical) and the third shows where change is occurred – location (on the existing or on the new market).

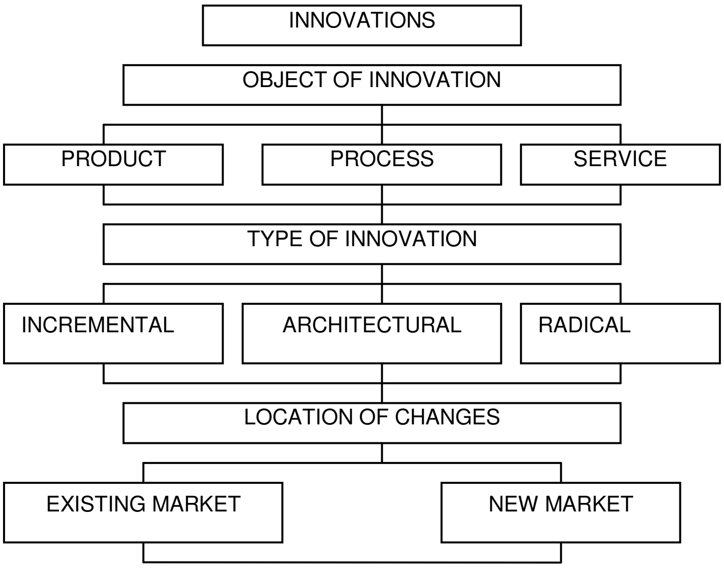


Figure 2.3 Three-dimensional innovation's classification

The innovation figure consist three dimensions. We would have different capacity of characteristics if we use concrete data. Changes of innovation's characteristics take place by influence of different factors. These factors we will treat in our case study analysis in chapter 5.

2.6. Knowledge management and innovations

Innovation management and knowledge management have close ties between them. Innovation based knowledge management applications focus on providing environment in which knowledge workers create new knowledge. We have accepted the definition offered by Albanna (Albanna 2000): “The management of knowledge resources is essential to the ability of business organisations to change, adapt, and seize new opportunities as they compete in this fast changing global environment. It is likewise essential for development processes, which are focused on reducing the social and economic gaps between developed and developing nations.”

The aim of companies will become the knowledge-based companies. This development will not be occasional as Edvinsson and Malone (Edvinsson and Malone 1997) observe, “Companies can plan to increase their “knowledge value”; this increase can be forecast and modelled”. The question is where the company would make its investments. Knowledge management applications described in literature commonly a single view of this multifaced question. Binney (Binney 2001) have systematised knowledge applications described in literature and grouped elements of knowledge management and labelled them:

- transactional;
- analytical;
- asset management;
- processed based;
- developmental; and
- innovation/ creation knowledge management.

Knowledge management spectrum is a framework, which covers all the knowledge management applications reviewed. We would use knowledge management spectrum as a tool to inventory and position current knowledge management related activities in firms and would plan the future knowledge management activities with aim to increase the innovativeness of firms. For our investigation are more important elements of two spectrum’s groups: developmental group and innovation and creation group. Developmental tools touch primarily human resources: skills, competencies, learning, teaching and training. The aim of firms is to develop “learning organisation” and collaborative skills. Collaboration in the creation of new knowledge is more effective through the networks. Choice of the knowledge management tools depends from development stages, used models and methods of innovations (see Figure 2.2).

Hamel and Prahalad (Hamel and Prahalad 1994) observe that just being a learning organisation is not sufficient. They mark that the learning process must be translated into managerial competencies, which permit the firm to more effectively serve customer needs. Different kinds of innovations have different impact on the established capabilities of the firm.

Nonaka (Nonaka and Konno 1999) best summarizes innovation/creation knowledge management, when he says, "Knowledge is manageable only insofar as leaders embrace and foster the dynamism of knowledge creation. The role of top management is as the providers of "base" for knowledge. Their task is to manage knowledge emergence." Creation of friendly environment for innovation is important task for knowledge management. In case study analysis we will evaluate possibilities to use knowledge management spectrum and will treat influence of spectrum's elements to the final results of knowledge management.

2.7. Networks and innovation

Knowledge economy creates new types of co-operation. Nowadays information technology tools enable communication at long distances at almost no costs. Virtual development and peer groups can also help to develop new intellectual products. Often the users of same products create those new products. For example, development partners help to create new CAD (Computer Aided Design) systems. In exchange for participating in development, the developers learn to better understand the product and sometimes at a discount rate.

Networks are inseparable from the process of innovation. In the early days of mass industrialisation, different stages of production and product development were performed separately in a subsequent manner, as a so-called linear model of innovation. Basic research was followed by product development and product development by production and marketing (Johannesson et al.2004). Later methods have benefited a more integrated model of innovation where in different stages of production interacting and multi-functional teams are created. Several authors (Rosenberg 1982, Malecki 1997, Autio and Laamanen 1995) say that the integrated model of innovation requires a wider scope of different contacts and interactions between different functions. Such interactions give feedback, which by it can create new innovations. The market-driven integrated model of innovation is also more flexible and better suited for rapidly changing markets (Frey 1989).

Networks initiate and perform innovations; they distribute the innovation results. Innovation networks of firms always include independent customers, independent suppliers and may also include affiliated firms, joint ventures and public research institutions.

Networks can initiate innovations in different ways. The simplest and most common way is for independent customers to ask for a product improvement. For large firms in Europe the customers are the most common outside source of technical knowledge (Tidd et.al. 1997: 83). Most of the customers of the engineering firms are located in host country and in neighbouring European countries.

A different type of innovation partners are public universities and research institutes. Due to public restrictions, management practices and lower business orientation, large firm partners for universities tend to be national rather than in neighbouring countries (Tidd et. al.1997: 83). Several industries demand constant updating and technical modernisation and therefore a big knowledge pool is required. Such pool of innovation can be created only by setting up a network of knowledge organisations. As an example we can bring the Swedish forest cluster, which is supported by a network of universities, research institutes and enterprise associations (Blomström and Kokko 2002: 36). Another role of universities is to provide firms with graduates. Two-way communication between enterprises and universities helps to train people better suited for industry.

Through the globalisation our world is getting smaller, the scale intensity of mass products is growing, causing further specialisation. For the SMEs with limited resources a question arises – how to benefit from their own innovations. The hardest problem for small firms is distribution of their innovative products and services. This is not possible without existing networks. There are various organisational forms, but using of distribution networks of large firms is a common way to foreign markets. This is the normal case in high tech industries where Nokia has been the distributor of small firms' innovations embodied in the Nokia's own products (Autio and Yli-Renko 1998). Another form of distribution for smaller firms' products is for multinational firms to use trusted suppliers in new products in new locations. For example, Shell used valves produced by Valmet during the building of an oil terminal in China (Metso Shell .. 2003: 58).

2.8. Conclusions

Innovation theory has been developed stage by stage. In the innovation research we can distinguish five generations of research (Gomulko). The development of economy and innovation in transition countries does not copy exactly similar developments in Western countries, hence we must choose from innovation models the ones suitable for the current development stage.

Transition economies have no opportunities for comprehensive radical innovations. These countries could consume and enjoy new technical and technological creations through the process called technology diffusion. New products are getting more customized and the final designer of a product is the customer. The author of the thesis supports the position of von Hippel (von Hippel 2005) that innovation is being democratised, meaning that users of products and services - both firms and individual consumers - are increasingly able to innovate for themselves.

The development of technical and technological processes influences the resources of industry and the development of resources in turn influences the development of industry. The development of industry depends also on changes in society and structures of industry, changes in the environment and changes in policy.

Theories of Gomulko (Gomulko 1971), Rothwell (Rothwell 1994) and Xu, Chen, Guo (Xu et al. 1998) helped the author to construct a complex model of innovation, which shows the prevailing connections between development stages, models and methods of innovation. The author of the thesis supports gradual development of economy where different development stages apply appropriate different innovation models. On the lower stages of economy it is not possible to use complicated models of innovation because of lack of competence. However on the highest stages also simple models of innovation are used. Borders between development stages are not rigid, particularly in transition economies where simultaneously with out-of-date technologies ultramodern technologies are used. Innovation types (radical or discontinuous, architectural and incremental) have a close connection with technological cycles. The classification of innovations is presented in Figure 2.3.

Research conclusions from The Innovation Theory are the following:

- Development in Figure 2.1, development stages model in Figure 2.2 and innovation classification in Figure 2.3 can be used for research of machinery and electronics development;
- There are close connections between firm's resources, networks and innovations;
- Innovativeness level and innovation methods are interrelated; in addition to imitation and implementation MEI needs resources primarily for incremental innovations;
- Knowledge economy creates new types of innovations; it is important to create a knowledge based learning organisation of MEI and make investments into workforce;
- Firms have created their own networks and have joined regional and global networks of innovations;
- Networks help to disseminate innovation results. Innovations import prevails over export, MEI should find means to export its technical and technological solutions.

3. ECONOMIC POSITION AND NETWORKS OF MANUFACTURING OF MACHINERY AND ELECTRONICS

3.1. Economic characteristics of machinery and electronics industry

In 2005, the number of machine building industry enterprises totalled approximately 1,100. Most of the enterprises (approx. 700) were relatively small workshops with less than 9 employees (Figure 3.1). The number of bigger enterprises was small with only 14 enterprises more than 250 employees. The number of large machinery manufacturing firms has during the independence period declined twice – from 30 to 14 (Estonian Encyclopaedia Volume XIV).

Despite the large number of firms, people are employed mainly by medium-sized and large firms (Figure 3.1). A small number of large and medium-sized enterprises employ approximately half of the workforce. The firm size structure has been relatively stable during the last decade. The cup effect[1] is not yet visible in machinery industry. The only exception here is electronic industry that seems to benefit bigger international firms rather than smaller ones.

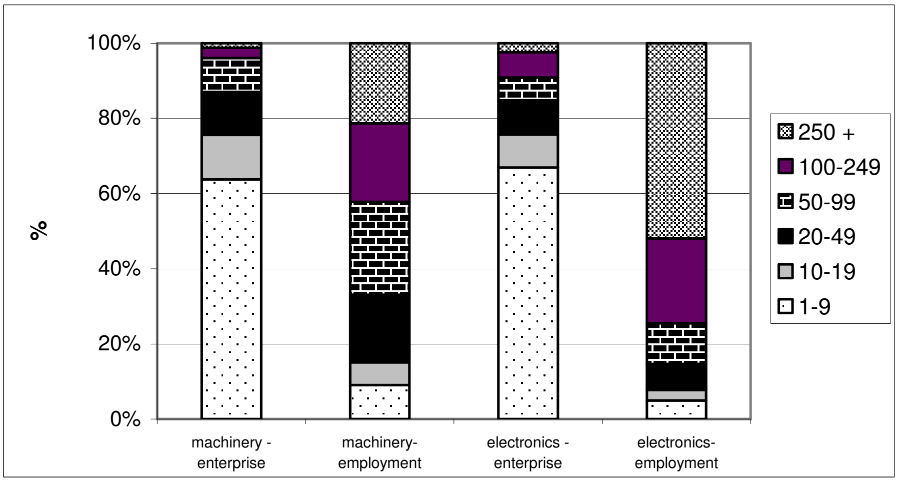


Figure 3.1 Structure of enterprises and employment in machinery and electronics industry by size of enterprises Source: Statistical Office of Estonia

In different sub-sectors of electronics industry, mainly medium-sized and large firms generate most of the income (Figure 3.1*). In telecommunication equipment manufacturing, one large firm generates most of the turnover (Elcoteq). Data are

[1] Firm structure with a small number of very large firms and a big number of small firms. Medium-sized firms are almost missing.

not indicating considerable concentration of electronics industry. However, there are remarkable concentration trends and division of suppliers into semi-hierarchies.

Machinery industry turnover has grown substantially during the independence period (Figure 3.2 and Figure 3.3). Reasons for that are internationalisation of industry, integration into the world economy, wider use of purchased components, growth of local economy and inflation. Particularly is worth mentioning the widening of international metal industry outsourcing networks to Estonia and local demand for capital goods.

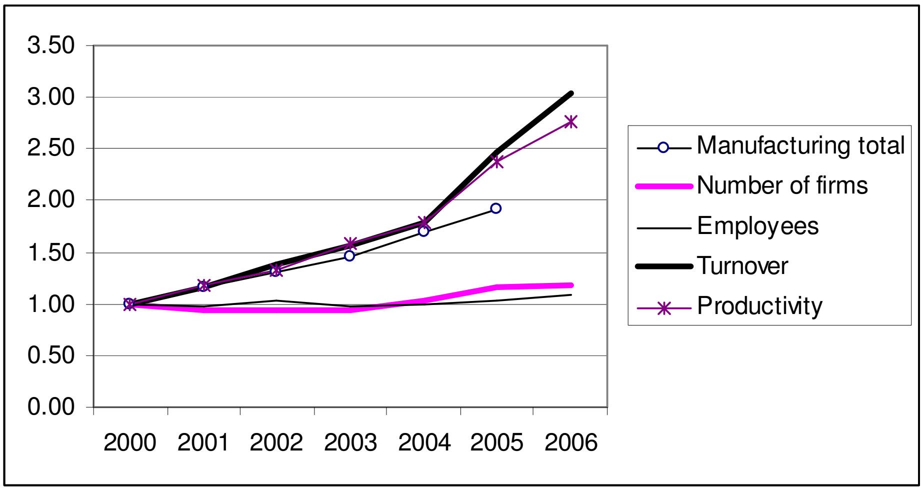


Figure 3.2 Indexes of main characteristics of machinery and equipment industry 2000-2005 Source: Compiled by author by using materials of Statistical Office of Estonia

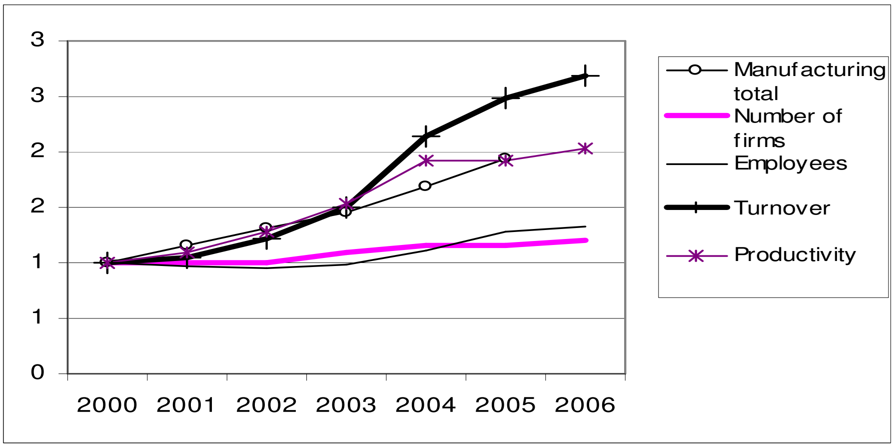


Figure 3.3 Indexes of main characteristics of electronics industry 2000-2005 Source: Compiled by author by using materials of Statistical Office of Estonia

Electronics industry has shown also substantial growth during the independence period of Estonia. The reason for such growth has been primarily relocation of manufacturing activities and full factories from Nordic Countries to Estonia.

All sub-sectors of the machinery and electronics industry have grown faster than total manufacturing during the independence period. Reasons for the growth are some green-field foreign direct investments, development of new branches that did not exist before, such as computer manufacturing and mobile phone equipment manufacturing.

Estonian manufacturing industry is less capital-intensive than machinery and electronics industries of several EU-15 countries (Table 3.1). This is obvious that after the economic difficulties at the beginning of the 1990s, the fastest growth was achieved by less capital-intensive industries. Major investments in the machinery industry started in the mid-1990s and have accelerated since then. However, it should be noted that a big share of industrial material investments went into land and buildings that are indirectly related to production. Less than half of tangible investments were made for acquisition of machinery in the period 1999-2005. The respective proportion in Western Europe is around 80% (Table 3.1). In real terms the Estonian worker has 2-3 times less endowment with machines and tools than their counterpart in Northern Europe. The investment level into development was even lower.

Table 3.1. Investment per worker in the manufacture of machinery and electronics (in thousand euros)

	Manufacture of machinery and equipment n.e.c.						Machinery and equipment share in gross investments 1999-2005
	1995	1997	2000	2003	2004	2005	
EU 27	:	:	:	:	4.1	4.2	
Germany	:	:	4.8	4.1	4.2	4.3	85%
Estonia	:	:	1.9	1.6	1.4	3.3	48%
Latvia	:	:	1.2	:	1.6	2.5	
Finland	6.2	5.4	5	4.3	4.1	4	73%
Sweden	4.7	5.9	5.8	6.1	5.1	5.2	80%
	Manufacture of electrical and optical equipment						
EU 27	:	:	:	:	5.5	5.4	
Germany	:	:	7.6	5.2	5.8	5.9	89%
Estonia	:	:	2.1	2.9	4.3	3.2	68%
Latvia	:	:	1.2	1.9	1.4	4	
Finland	9.1	8.9	10.8	5.1	5.5	7.3	83%
Sweden	6.9	7	10	4.4	4.2	4.1	87%

Data related to 20 and more employees

Source: European Enterprise Survey 2007, Eurostat

By the number of enterprises there is no extensive foreign ownership in Estonian machinery and electronic industry (Figure 3.4). However, enterprises with foreign ownership produce most of the products of machinery and electronics industry. An overwhelming share of telecommunication products, automobile parts and precision instruments are produced by foreign owned firms. Smaller firms in machinery industry are mostly locally owned.

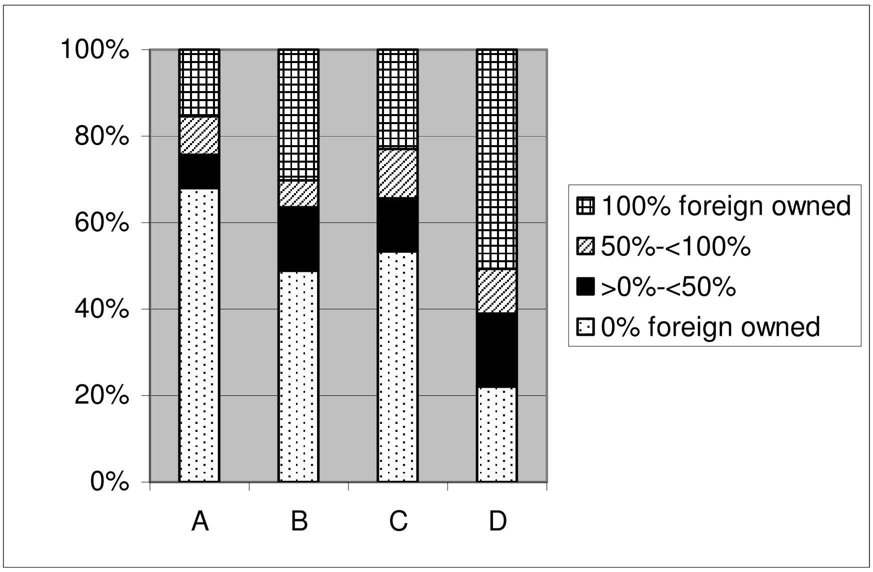


Figure 3.4 Structure of machinery (A) and electronics (B) enterprises and structure of turnover in machinery (C) and electronics enterprises (D) by share of foreign ownership
Source: Compiled by author by using materials of Statistical Office of Estonia

Foreign ownership tends to prevail in the industries were tight integration is needed with customer and manual operations take minor role. Local ownership plays a bigger role in industries where manual assembly operations play a bigger role and products are local customer oriented.

3.2 Human capital of machinery and electronics industry

Estonian machinery and electronics industry offer jobs to approximately 18 thousand people. This is about one-eight of the manufacturing labour force and 6% of private sector workforce. At the time when several industrial sectors are reducing their workforce, metal industry is recruiting new people. There are quite a lot of job advertisements in Estonian newspapers (summer 2007).

Most of the studies (PWP 2001) admit that there is a lack of skilled workers and engineers. Government institutions, employer organisations and trade unions declare in their programme documents that there is a shortage of skilled workers and mismatch between employers' demand and labour market (educational system) supply. European organisations and Estonian counterparts among them have also adopted several policies to tackle labour training issues. At the same time, numerous Estonians work abroad in metal industry and engineering companies.

The lack of resources is almost a permanent situation in most of the economic sectors. Every economic sector and firm competes with other sectors and firms for the (best) labour. Metal industry is competing with service sector and other manufacturing industries for workers and with technical service firms for engineers. And finally, the decision-makers are people themselves who prefer this or that particular activity.

Endowment with good labour requires several activities. First, it should select labour force, train and upgrade it and provide motivation. At the same time, the industry should also have competitive product prices. Development of the pool of labour is a task of all networks and the solutions are both nation-wide and company based.

Engineers

The future of every country, industry and firm depends on the people who are governing the processes. In case of manufacturing such persons are people with special skills like managers, designers and technologists. Quite often the above-mentioned persons have had 3-5 years of special education and additional training in firms. Although formal education is not the only indicator of particular person's qualities on the national level, the number and ratio of graduates show the commitment to the particular field of economic activity. However, we cannot say that during the last decade spending on engineering education has been growing or on the same (relative) level with neighbours.

The Estonian manufacturing industry is with a relatively small “brain”. The ratio of engineers to total labour is smaller than in Finland and Sweden (Statistical Office of Estonia) however ther is more office workers and other mid-rank white collar employees. The structure of Estonian metal industry (including machinery and electronics industries) employees is given in Table 3.2. Breakdown of supply chain into different operations reduced processes requiring bachelor and master level education during the 1990s.

Table 3.2. Structure of Estonian metal industry employees in 2003

Position	Number (1000)	%	Finland (2002) %
Management	3.6	10	26
Specialists	5.5	16	14
Office personnel	1.4	4	
Blue collar	25.4	70	60

Source: Statistical Office of Estonia

At the beginning of 1990, a lot of engineers moved to the sale positions or to the positions of managers of small companies. This made several smaller firms more competitive but at the same time "hollowed" also the big firms' technology content.

In terms of experts, the number of engineering graduates is relatively small (Papstel 2004). Statistics do not confirm that grave picture (Figure 3.5). Several problems will be faced when a large number of engineers go retire to pension in the period from 2005 to 2015.

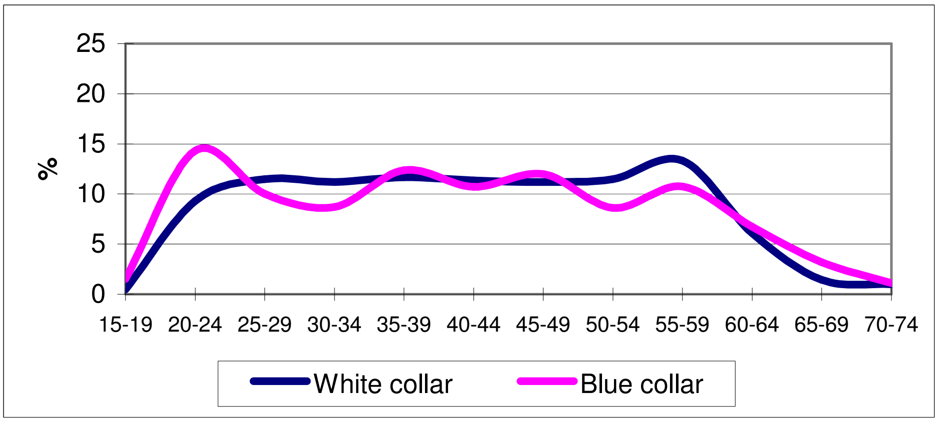


Figure: 3.5. Age structure in metal industry, 2001
Source: Statistical Office of Estonia

The relative age structure of white-collar personnel in metal industry is quite similar to that of Estonian population. However, we must admit that there is no redundancy or extra capacity among engineers. Compared to Scandinavia, where there is quite a big generation of young engineers, there is no similar tendency in Estonia. We can even say that the relative growth of non-technological office personnel has been faster than that of technical personnel.

Changes in the situation cannot happen only with changes in the resource allocation but it needs more changes in attitudes. Local industrial traditions in Estonian metal industry are relatively small – technical education has been provided less than 100 years. Sustaining and permanent crafting skills are also relatively small compared to countries with longer industrial traditions.

The role of engineers in the economy of a small nation is bigger than only participation in the production process. In technologically advanced countries engineers have often a pioneering role. There are not many pioneering engineers-entrepreneurs (innovators) like Laval and Ericsson in Swedish history, Ford or Westinghouse in U.S., or Tupolev and Paton in the former Soviet Union. Among leading businessmen there are several engineering graduates, but their business success is not very clearly based on technical innovations.

EU accession and integration into Europe has brought several advantages. Estonian engineers can integrate their qualifications on the European level (Tallinna Tehnikaülikool 2002: 35). The qualification integration provides opportunities for technology transfer and innovations.

Formal European education schemes like LEONARDO enable to get international experience and access to knowledge developed in the EU. A sign of integration is that for providing engineering education, Tallinn University of Technology has cooperation links with other universities in Nordic countries and other regions.

Workers

Most of the SME managers consider lack of qualified workers as the prime obstacle to their company's development (PWP 2001). Problems of labour are especially acute in countryside firms. For the countryside and worse performing firms it is quite difficult to find and train appropriate people. Urbanisation, demographic problems and cost of the moving do not ease the situation probably in the future either.

Lack of appropriate people is not only Estonia's problem but affects the whole European Union. For example, lack of qualified personnel is in German manufacturing regarded as the main obstacle to innovation (Janz et al. 2002). Labour shortage in the European Union is caused by several factors. The first and most important is the decline of relative wages and benefits compared to the other sectors of economy. A big growth in services and especially in public services created several workplaces that have a much higher job security level even when the salaries are lower than in manufacturing. The second problem is the image problem. The general attitude towards the natural sciences in some parts of Europe and Estonia is relatively low. Industry and even high-tech parts of it are not primary targets for more talented graduates. The European cultural environment has been seized by a kind of disdain of manual workers (Drucker 1999). In the period of industrial revolution, several craftsmen turned into successive entrepreneurs and had a relatively high status in society. The same trends continued also in the developing countries at the beginning of the 20^{th}

century. The second half of the 20th century involved a rise in competition and decreasing returns. It is hard to say what could be the solution to overcome the dead point. Definitely the image of manual workers should rise vis-à-vis to the office people. This rise cannot be evoked only with marketing and publicity. People are materialists and without clear economic benefits the solutions will be short lived.

Business down-cycle in the 1990s caused a major dropout from metal industry. Several people changed their profession. The down-cycle and new opportunities in other economic sectors caused a shift to the other sectors of economy. Several firms retained only people who had attitude and discipline problems. As a heritage of "old times" alcoholism and work discipline are also problems, but the importance of this problem is rapidly declining among existing firms. At the beginning of 1990s, the doors freshly open to Europe started to attract younger workers to leave from Estonia to older European Union countries.

Price rises and the cyclical nature of industry cause tighter wage control schemes and tense relations with trade unions. However, demand for labour gives a strong negotiating position also to the trade unions. Rising labour costs decrease competitiveness of weaker enterprises in such cases.

In an interview, Mr. Soon, chairman of the Metal Industry Trade Union said that there is a tendency toward the declining job security in employment contracts. However, macroeconomic conditions and especially declining supply favour the opposite direction. In the opinion of Trade Unions, lower job security is causing migration to neighbouring countries.

Social benefits and economic competitiveness are very often moving toward one and the same direction. The newly industrialising nations should never forget that the surest way to increase their international competitiveness is to raise the standard of living and educational level of their citizens, and to cultivate a strong and sophisticated domestic market. After all, it is the consumer who is the real parent of technology (Moritami 1982).

The rising labour costs are creating several challenges. On the macro-economic level there are two ways to tackle the challenges. The first way is to dedicate efforts to the restructuring of firms and finding new opportunities for new emerging sectors. The second way is to find opportunities within the framework of existing industries.

The current time period could be characterised by fast development of technologies. Big changes happen in information technology, process technology and customer handling. Final customers get often a wider choice of opportunities and therefore have stronger influence on the processes and products.

New industries and growth sectors are developing between the outside the borders of traditional industries (and service sector). The firms and people who have knowledge in both traditional sectors have the best chances to innovate. Metal industry and especially electronics industry have been rapidly growing industries. Very often metal industry branches have been part of the growth of new industries. The development of telecommunication sector and production of medical apparatus serve as some of many examples. However, the metal industry growth has been cyclical (IMF 2002). Every down-cycle eliminates weaker firms and every up-cycle gives opportunities for both newcomers and existing firms. Qualifications of workers in metal industry are following the same trend. Especially people in mass-market factories are tending to lose their job during the recession periods.

Greenwood and Yorukoglu (Greenwood and Yorukoglu 1996) hypothesise that rapid technological changes favour workers with high skill levels, those who can better adapt to the early stages of innovative cycles. Later on, when technology becomes user-friendlier, the demand for unskilled workers will increase (Greenwood et al. referred by Mokyr 1997).

Some of nowadays worker skills are information technology skills. The use of information technology and computer skills is important for almost every future worker. Computer skills are important both for finding relevant information and for operations on the factory level. Most of the manufacturing industry processes require IT usage. Lack of IT skills has been mentioned as a problem on the European metal industry level (EMF-WEM 1999).

Development of information technology has changed functioning of logistics and other services. Computers are able to perform the communication and initial data processing works. Tool operators or foremen can receive work orders directly from customers by intermediation of only computer or from operator in the customer outlet. There have been discussions how information technology has influenced job productivity (EMF-WEM 1999). According to surveys, information technology doesn't always improve productivity but it is a necessary pre-condition for existence.

Worker training problems in small countries are related to economies of scale and scope. Very clearly, the demographic situation in Estonia does not favour the creation of scale intensive industries in Estonia. On the other hand, with the accession to the European Union the price of labour force is rising and making firms less competitive. The only solution to survival in such case is becoming more skill-intensive. The situation is to some extent eased by other industries that reduce their labour force. In order to move up in the competence level it is necessary to "flatten" the hierarchies and increase the workplace competence.

Skill requirements have changed during the last decade. Of course, professional attitudes towards the job and good understanding of one's field are essential in every profession and in every time period but several new needs have emerged.

The first new quality is communicative skills. Better communication skills are needed nowadays. In previous times, production-floor personnel communicated only with production supervisors and sometimes with production development people. Nowadays it is expected that foremen or group leaders are able to communicate with industrial customers from other firms, suppliers and developers and in contact with them make adjustments.

Employment in metal industry has also a gender effect. Traditionally metal industry had been one of the most important employers of male labour. A general image of metal industry has been a large number of crafts people who were organised into unions. This trend has changed in recent years. Male labour tends to be more expensive than female labour and therefore has a bigger influence on the labour cost rise.

The changing communication has influenced also the internal life of firms. Among important skills in the manufacturing industry are teamwork and collective work attitude. Because several products are the creation of teams rather than individual persons' teamwork skills are required. An interesting personal selection method was brought in by a Swedish entrepreneur who said that he has played in a football-team and likes to hire former football players. They know how to communicate with each other and how to perform in the team.

Problem solving is the third skill. In technically complex systems it is important to take the responsibility and solve the problems autonomously. Estonia and also the neighbouring Nordic countries do not have enormous big scale factories with centralised systems. In contrast to relatively stable centralised systems where predominant solutions are prescribed, life in medium-sized manufacturing firms requires more autonomous solutions.

There are several positive sides in working in metal industries. From the author's point of view, the feeling that machine is working, or feeling pride in a superior product could be a source of pride and high image. Another positive feature is the satisfaction with your work that you are able to do something with your own hands. The biggest problem in finding new employees and young workers is the image problem (EMF-WEM 1999). Potential students of vocational schools consider metal industry as a closed career trap or no career at all. Movements from the status of worker to middle management are quite rare in Estonia. Setting up one's own enterprise by metal industry workers is even more unusual. A solution to the problem could probably be a wider education and project management courses.

The low image of metalworking and metal business is also induced by the considerations that metalwork is dirty and unhealthy. There are oil-spills, welding-gases and dust of processing. By the adoption of EU legislation and quality standards the situation has significantly improved, but the image continues to live on his-own (Conversation with Metal Industry Trade Chairman).

Educational institutions

Educational institutions rarely participate directly in the supply chain, but they are important partners of networks on the macro level. As a first task, they provide industry with relevant people and help with continuous education.

Secondarily, they are creators of technology and act as brokers of technology between enterprises and research institutions. Thirdly, they provide different engineering services to firms.

The neutral (non-profit) role in engineering community gives educational institutions a good position for knowledge distribution. For example, quite often software and equipment firms are offering their products at discount rates with the hope that students become consumers of that software or equipment in the future. Like most of the specialised service providers, educational institutions in Estonia face problems of scale and scope. Machinery and elctronics industries need a large variety of specialists. When companies need to concentrate on certain core competencies they need specialists in certain niches. This makes educating quite difficult because demand for such specialists is relatively small and educating of them economically is not efficient. Instead of educating narrow specialists, Estonian universities are offering broader education.

However, dilemma remains – does broader education in industry offer substantial competitive advantages in the labour market and does it create competitive advantages for firms? In case of mature industries it is clear that broad education does not give big differentiation and therefore competitive advantage. The picture is different in the case of innovative and rapidly changing industries. Rather than narrow high qualification, broader education with entrepreneurial attitude gives more flexibility and better chances in economic competition.

New knowledge and new industries are created with combination of different technologies. Very often rapidly developing industries need multidisciplinary specialists. People with broader education give flexibility to traditional industries.

Continuing education is a natural meeting point between industry and education. In a small economy, engineers can meet and exchange experiences and get information about latest developments (Tallinna Tehnikaülikool 2002). There is no official statistics, but according to expert assessments of the Engineering Federation, until now formal courses at Tallinn University of Technology and at other technical education establishments were not very often attended by working engineers. This can be due to both university marketing and client attracting problems, and enterprise attitude and financial problems. Knowledge updating needs a formal structure for continuing education. Links between the industrial technology level on the one side and the level of engineers and managers on other side are vital. Missing of such link could be one of the reasons why British industry did not hold its leading position 100 years ago.

Human capital identification is important, but what is taught in schools and how efficient it is and how students translate it to better techniques are even more important (Mokyr 1997).

Training of people or accumulating of technical/industrial knowledge is a long-term task on the national level. When companies want to develop certain product lines with certain competencies, it takes at least 8-10 years from admission to university until an experienced engineer is educated.

Productivity

Productivity of every person, unit and country is one of the measures of competitiveness. Productivity measurement is one of the most important parts of economic analysis. It is relatively easy to measure output of manual workers in mass production. The situation is more complicated with the increase of the knowledge component. As P.Drucker (Drucker 1999) said, *"we don't know yet how to measure productivity in some of our newer industries"*.

The productivity increase in recent years (Figure 3.6.) could be associated with the acquisition and adaptation of new technologies, better training of people and outsourcing of less efficient activities. Despite the fast growth productivity (turnover per employee and value-added per employee), productivity is relatively low compared to the competitors (not only Finland and Sweden, but also Latvia and Lithuania (TTU, Engineering Federation 2002)).

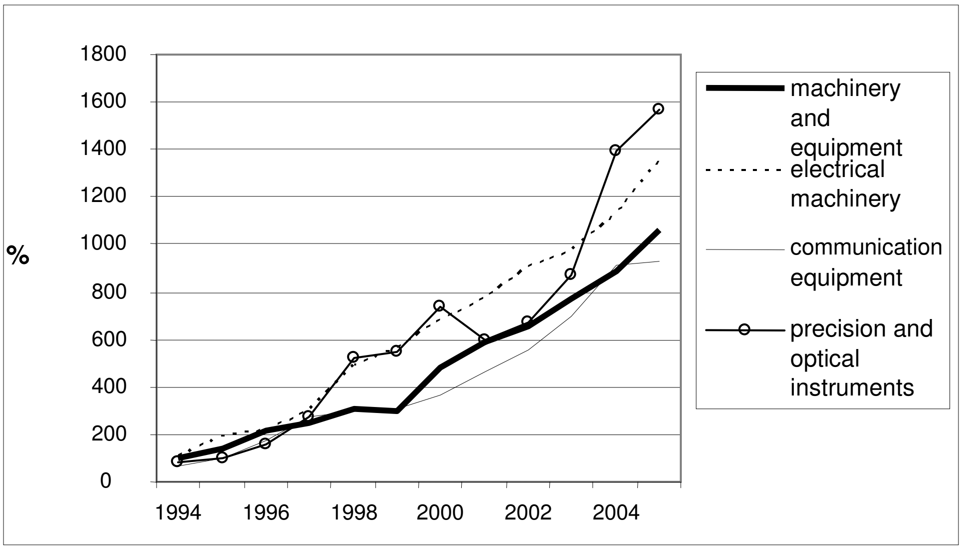


Figure 3.6 Productivity indexes of metal industry branches in current prices, 1994-2005 Statistical Office of Estonia

Lower productivity could be caused by two reasons: the productivity of single worker is lower due to his/her personal qualities and attitudes, or endowment with capital stock. Another reason for low productivity could be high overall costs. This could be due to the relatively large number of personnel not directly related to production: security guards, production supervisors, office personnel.

Bigger number (share) of non-production personnel could be caused by need to translate orders from customers to the production personnel. Translation means here not only translation from one language to another, but explaining of technical drawings, splitting incomplete customer requirements into applicable technological processes, computing for production and even communicating with customers and all other preparation works needed for production. With the training and changing of attitudes this reason for productivity gap may decrease in the future. Both arguments drive to the main conclusion that the qualification and training of direct production personnel is at a relatively low level. As said Mokyr (Mokyr 1997), "*The productivity growth depended, as it always does, on the thousands of small and anonymous improvements introduced by workmen on the shop floor*".

3.3 Conclusions

Estonian machinery and electronics firms have gone through several development stages and reached the present situation characterized by EU integration, extended personal networks with Nordic and other EU countries. The innovation process is oriented towards customer driven solutions. Transition from planned to market economy changed the products of enterprises; the current product portfolio includes a large number of intermediate products and contract-manufacturing products instead of final products (Viia et al. 2007).

A small number of large and medium-sized enterprises employ half of the workforce. In telecommunication equipment manufacturing, one large firm (Elcoteq) generates most of the turnover. Such a situation creates risks to Estonian economy, when Elcoteq migrates its operations from Estonia to other country with the aim to optimise labour and other costs (Kilvits et al. 2003).

Since 2000 machinery's turnover and productivity have grown very rapidly. The fastest growth was achieved by less capital-intensive products. Estonian SMEs are supplied worse with machinery and equipment than Nordic enterprises and produce simple and cheap intermediate products.

There is lack of skilled workers and engineers in the machinery and electronics industry and firms compete with other sectors and firms for the best labour. The future of Estonian machinery and electronics industry depends on manpower with special skills like managers, designers and technologists. At the beginning of 1990 the Estonian manufacturing industry lost a lot of engineers who moved to salespersons' or managers' positions of small companies. Compared with Scandinavian firms a big generation of young engineers is lacking. Several problems will be faced when a large number of engineers retire.

Innovation capability depends on resource allocation into technical and vocational education, increase of relative wages and benefits compared to the other sectors of economy, improving of the image of people working in manufacturing. The labour prices are rising, the only solution for survival is becoming more skill-intensive. Financial indicators (net sales, net profits, total assets) have increased in last years remarkably, which creates good opportunities to invest into human resources in parallel with investing into machinery, equipment and premises. As a negative trend overinvestment into buildings and land should be noted. Growth of real estate prices created lucrative opportunities for businesses to participate in real estate development. However, this took resources away form (perceived) core activities.

4. SURVEY BASED ANALYSIS OF THE INNOVATIVENESS AND NETWORKS IN MACHINERY AND ELECTRONICS INDUSTRY

4.1 Innovation survey and methodology

European Commission (Eurostat) is conducting after every four years European-wide surveys (Community Innovation Survey – CIS) for better understanding of innovation processes. According to the Community Innovation Survey (CIS) methodology, the survey has been held in the European countries four times. The latest (Community Innovation Survey or CIS 4) was held in 2002-2004 The previous survey (CIS 3) was conducted in 2000 and Estonia participated in this survey as the sole post-socialist country. The survey was conducted in Estonia by the Statistical Office of Estonia, which described the innovative activities of enterprises. Data processing and analysis for CIS survey was performed by the Estonian Institute of Future Studies. The author had a privilege to participate in this process together with researchers from the Institute of Future Studies and Statistical Office of Estonia. Using the program FoxPro, the author made calculations and compared the results with other sectors and other countries in Europe. Results of the calculations were discussed with the specialists from the Estonian Institute of Future studies and from the Engineering Federation.

Comparisons with other countries are based mainly on CIS 2 (1994-1996) and CIS 3. The author used European Community Innovation Survey results for UK, Finland, Germany and Denmark. The number of enterprises involved in the survey is given in Table 4.1. More detailed international data about machinery and electronics industry branches were available in terms of the share of innovations in different branches and innovation financing. The response rate to Innovation Survey was 71% in all Estonia and 80% in machine building and electronics industries.

Table 4.1. Enterprises in the survey, 1998-2000 and 2002-2004

	Enterprises in statistical profile	Share of exports, %	Part of enterprise group	With foreign equity
1998-2000				
All enterprises	3490	34	850	983
Manuf. of machinery	78	56	24	30
Manuf. of electronics	92	64	33	39
2002-2004				
All enterprises	3789	30	871	932
Manuf. of machinery	78	33	22	25
Manuf. of electronics	97	62	47	51

Source: Statistical Office of Estonia and author's calculations

Despite the fact that the Community Innovation Survey was centrally methodically co-ordinated all over Europe, it seemed to the author that there were certain differences in committing of survey. These differences could be caused by different response rates (between 79% in Luxembourg and 4% in UK), local business differences and interpretation of information. With the EU Commission's decision, participation in the CIS 4 was mandatory for the firms (previous ones were voluntary). Questionnaires of Third Innovation Survey (CIS-3) and Fourth Survey (CIS-4) had different questions and different answer options.

4.2 Innovators

The share of innovating firms (Figure 4.2) shows overall economic and innovative activity in industry. Innovative firms are those that:

- have new or significantly changed products or services in their portfolio;
- have or had innovation projects;
- formally co-operated in innovation activities with other enterprises or institutions.

Data about CIS-4 were fragmemnted during writing but in CIS-3 were Estonian companies less innovative than traditional European companies (EU-15). Preliminary data about Estonian firms showed that compared EU-27 were more innovative. 33% of the firms in Estonia had innovative activities in the period of 1998-2000 (Figure 4.1) and 49% between years 2002-2004. In EU-15, 44% of the enterprises had some innovative activities in 1998-2000 and 42% in EU-27 (Eurostat 2004). There are also big differences between EU countries starting with Germany and Austria where respectively 65% and 53% of the firms were innovative and ending with Bulgaria and Latvia where respectively 16% and 18% of the firms where innovative. Innovativeness varies also strongly across sectors. Among most innovative sectors are production of electrical machinery & instruments and other capital goods producing sectors and least innovative are sectors of raw material processing. We can definitely say that Estonian firms in machinery and electronics industry are more innovative than manufacturing firms in general.

Estonian machinery and electronics industry firms look slightly less innovative than metal firms in EU-15 (CIS-3). However, the main trade partners, Finland, Sweden and Germany have much more innovative metal sector firms (Statistics Finland, Statistics Sweden). Enterprise's size has a strong influence on the firm's innovativeness. In Europe, large firms are conducting most of the innovative activities. The picture in Estonia is similar (Table 4.2). Estonian large firms are relatively small compared to the large firms in Northern Europe. In European terms they qualify more as medium-sized firms. Another difference is that the relative number of large firms is small compared to our Nordic neighbours.

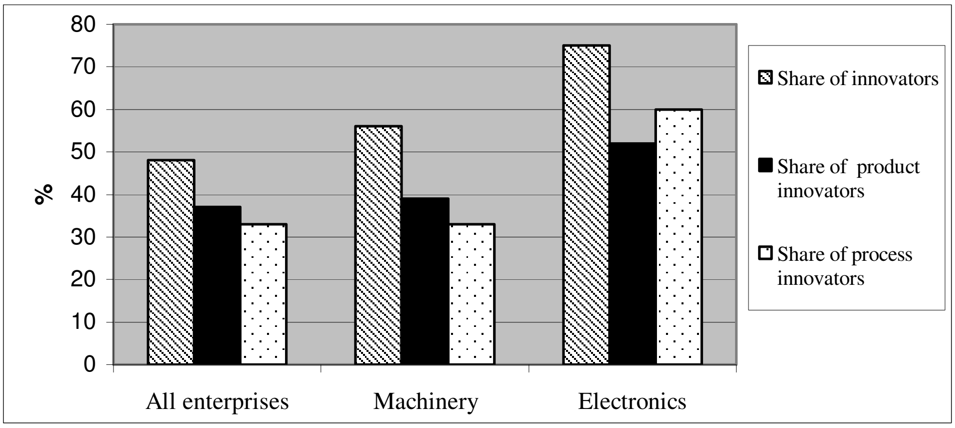


Figure 4.1 Share of innovating firms in Estonia, %, 2002–2004
Source: Statistical Office of Estonia and author's calculations

Table 4.2. Share of innovative firms, %, 1998-2000 and 2002-2004

	1998-2000					
	share of innovators	share of product innovators	share of process innovators	share of innovators in Finland	share of innovators in Latvia	share of innovators in Sweden
Total	33	24	23	44	19	47
Machinery	42	37	25			
Electronics	35	25	33			
	2002-2004					
	share of innovators	share of product innovators	share of process innovators	share of innovators in Finland	share of innovators in Latvia	share of innovators in Sweden
Total	49	37	33	43	18	50
Machinery	52	39	33	65	22	59
Electronics	67	52	60	56		64

Source: Statistical Office of Estonia and author's calculations

The survey conducted by Calvert et al. (1998) in 6 EU countries and our investigation showed that there is a positive relationship between firm size and innovation output (Table 4.3 and Table 4.4). If to compare relationships between size of sales and sales of new products, we see that sales of new products in EU take bigger share than sales of new products in Estonia. These results can also lead to a conclusion that in certain sectors with dominance of large firms, like automobile and telecommunication sector, there is strong concentration of innovative activities and good channels to commercialise innovation. Those sub-sectors are scale-intensive in innovation.

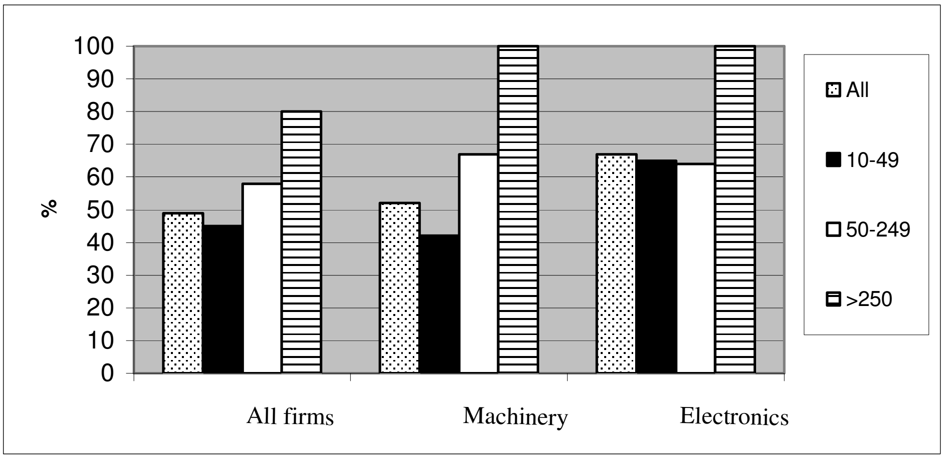


Figure 4.2 Innovative firms in machinery and electronics industry by size
Source: Statistical Office of Estonia and author's calculations

Table 4.3. Share of innovative firms by size, %, 1998-2000 and 2002-2004

1998-2000				
employees	All	10-49	50-249	>250
All enterprises	33	28	45	70
Machinery	42	26	75	75
Electronics	35	38	36	90
2002-2004				
employees	All	10-49	50-249	>250
All enterprises	49	45	58	80
Machinery	52	42	67	100
Electronics	67	65	64	100

Source: Statistical Office of Estonia and author's calculations

There are no big differences between product and process innovations by the breakdown of innovation developers involved: half of the innovative enterprises do it themselves, almost a quarter in cooperation with other parties and the rest equally by concern or by other enterprises and institutions (Figures 4.3 and 4.4).

Most of the new products in Estonian manufacturing are developed by enterprises themselves (Figure 4.3 and Table 4.5). This is a little surprising. The explanation lies in the high share of subcontracting works in manufacturing enterprises as a result of which new products are probably developed by the parent company or in co-operation with clients.

Table 4.4. Relationship between Firm Size and Innovation Output

Relationship between Firm Size and Innovation Output (* = $p < 0.05$)		
Sector	Dependent Variable: Log of sales of new products	
	Log of sales	
Metal industry sub-sectors in EU		
	Coefficient	R^2 (adj)
Machinery	0.995	0.76
Electrical equip	0.962*	0.79
Communication equip	1.059*	0.86
Instruments	0.960	0.73
Estonia (2004)		
Machinery	1.023	0.64
Electronics	1,011	0,51

Source: Statistical Office of Estonia, author's calculations, Calvert et al. 1998

Product development by firms is mainly conducted in the sectors where links between client and final producer are stronger than links between final producer and intermediary goods producer. Examples of such sub-sectors are manufacture of basic metals and manufacture of computers.

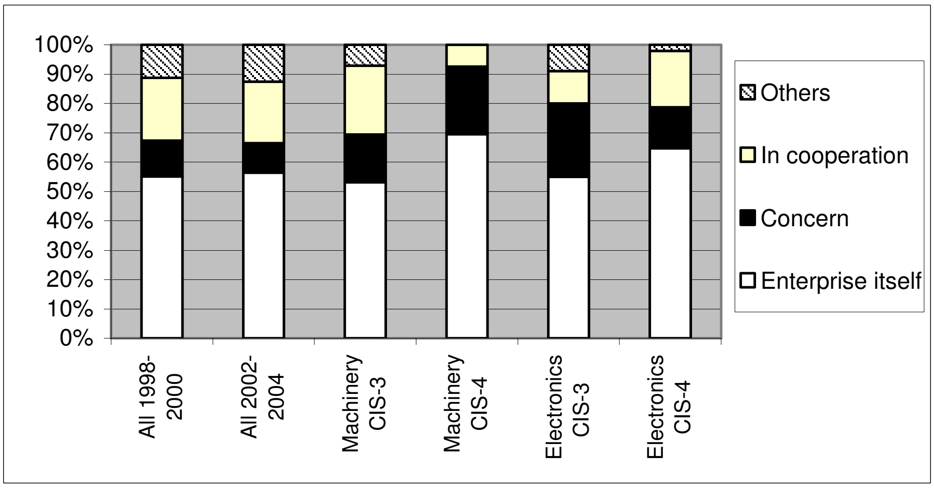


Figure 4.3 Distribution of product developers, 1998–2004
Source: Statistical Office of Estonia and author's calculations

Table 4.5. Distribution of product developers, %, 1998–2004

	Enterprise itself	Concern	In cooperation with partners	Others
1998-2000				
All enterprises	54	12	21	11
Machinery	52	16	23	7
Electronics	55	25	11	9
2002-2004				
All enterprises	56	10	21	13
Machinery	69	23	7	0
Electronics	64	14	19	2

Source: Statistical Office of Estonia and author's calculations

Product innovations are vital for small enterprises producing non-standard goods. Dominantly products innovations are made by enterprises own efforts. Process innovations are developed by enterprises themselves, but in electrical machinery the processes are developed mostly outside the enterprises, by suppliers and other units inside the concern. It is positive sign to technological development that more firms themselves are developing their products.

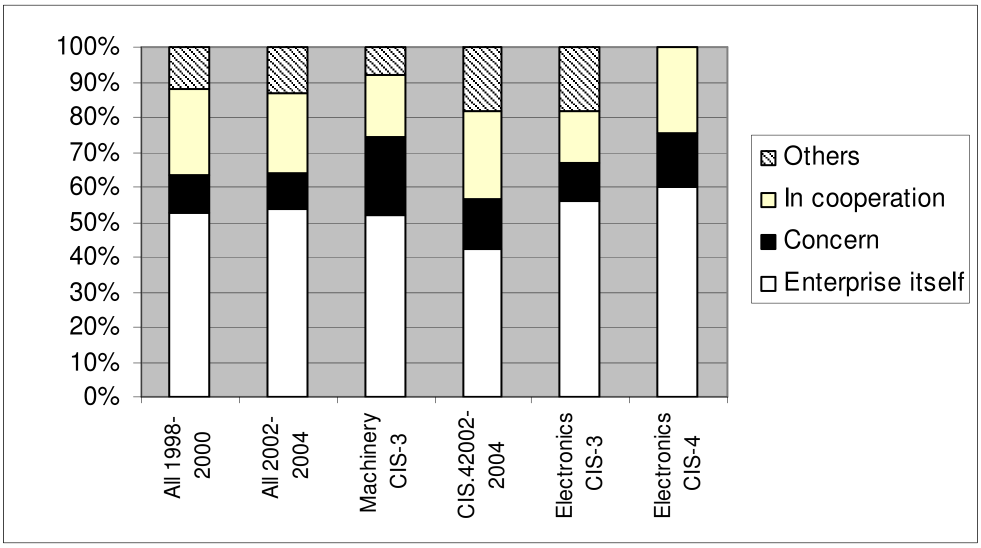


Figure 4.4 Distribution of process developers, 1998–2000
Source: Statistical Office of Estonia and author's calculations

Process development is mainly done inside machinery and electronics industry firms (Figure 4.4 and Table 4.6). The only exception is medical & optical instrument producers, who use outside process development. Trends in machinery and electronics are towards the development of processes in cooperation with partners.

Table 4.6. Distribution of process developers, % of all enterprises

	Enterprise itself	Concern	In cooperation	Others
1998-2000				
All enterprises	52	11	24	12
Machinery	51	22	17	8
Electronics	56	11	15	18
2002-2004				
All enterprises	54	10	23	13
Machinery	43	15	25	18
Electronics	61	16	25	0

Source: Statistical Office of Estonia and author's calculations

4.3 Innovation activities and expenditures

Like the term "innovation" that covers several activities and stages, innovation expenditures cover a large scope of costs. Very broadly, innovation expenditures cover costs of bringing new products to the market and costs of developing new processes. Among these expenditures are resources spent on the development of both tangible and intangible assets. The most important cost articles in new EU member States are resources spent on machinery and equipment for producing novelties, and research expenses.

The level of innovation expenditures or ratio of innovation expenditures to turnover in Estonian manufacturing is relatively modest (2.3%) compared to the EU-15 level (3.7%). The gap is quite big compared to the Nordic countries, but in comparison with the Southern European countries, the situation is not very different (Kurik, Lumiste, Terk, Heinlo 2002: 30). There is a relative gap in the level of innovation expenditures between large enterprises in Estonia and in Western Europe. Large enterprises in Western Europe spend several times more on innovation than large enterprises in Estonia (Kurik, Lumiste, Terk, Heinlo 2002: 31).

Different sub-sectors of metal industry have different innovating capacities and renewing cycles. Some industries get innovations from other firms in the form of new components and new machines. Capital or material assets-intensive sub-branches are basic metals and motor vehicles. Relatively less capital investments are made by companies in electronics and instrument sectors.

Like in most of new EU member states in Eastern Europe the dominantly biggest share of innovation expenditures in Estonia goes to acquisition of new machinery, equipment, software and other types of materialised technology. In the period 2002-2004, 73% of innovation investments were made into machinery and other capital expenses. 20% went to research and development and 7% to other types of innovation expenses. There are big differences in the distribution of innovation expenditures across Europe. Gap is between old EU and new EU and Northen Europe and Southern Europe. This could be due to both different industrial structure and development level. There is a tendency that more advanced (in GDP terms) industrial countries spend dominant resources on research and development and less developed countries on acquisition of machinery and equipment. Compared to Finland where 57% of innovation expenditure were spent on intramural (inside the enterprises) research and development expenses and 11% on contracted research, Estonian manufacturing firms spent 20% and 4%, respectively on intramural and extramural research. At the current stage of development, technology transfer through acquisition of capital goods is the easiest and fastest way for Estonian firms (Table 4.7).

Table 4.7. Distribution of expenditure on innovation, %, 1998-2000 and 2002-2004

	Intramural R&D	Extramural R&D	Machinery and equipment	Knowledge	Training	Marketing of innovative products	Design and bringing to the market	TOTAL
1998-2000								
All enterprises	13	7	60	2	3	5	10	100
Machinery	13	3	70	4	1	2	3	100
Electronics	8	1	24	0	8	1	56	100
2002-2004								
All enterprises	20	4	73	3				100
Machinery	34	8	58	0				100
Electronics	34	3	63	0				100

Source: Statistical Office of Estonia and author's calculations

Estonian metal industry sub-branches have some differences compared to their counterparts in Western Europe (Archibugi et al. 1997). Manufacturers of machinery and equipment spend relatively more on capital investment and less on research and development. In electrical and optical equipment manufacturing in Europe, equal shares are spent on capital investments, research and other innovation activities. In the period 1998-2000, the dominantly biggest cost articles were design and bringing to the market.

The second difference from EU countries is the lack of marketing costs of innovative products in most of the sub-sectors. The exception here is computer producers with 24% of costs spent on marketing of new products. Large enterprises spend relatively more on research and product development and smaller enterprises spend more on training and commercialisation of novelties.
In EEA, 69% of innovators in manufacturing conducted R&D on regular or occasional basis. In Estonia, 40% of innovative enterprises in manufacturing have performed R&D activities in the period 1998–2000 and 43%. The intensity gap between enterprises in different size class was also quite substantial. Among the total population of manufacturing enterprises, 44% of large enterprises conducted R&D activities compared to only 11% of small enterprises. However, research and development plays a minor role in innovative activities of manufacturing firms in Estonia.

Table 4.8. Expenditure on R&D to turnover, %, 1998-2000 and 2002-2004

	Total expenditure to innovation	Intramural R&D	Extramural R&D	Total R&D
1998-2000				
Manufacturing	2.4	0.3	0.1	0.4
Machinery	17	0.2	0.1	0.3
Electronics	6.5	0.6	0.1	0.6
2002-2004				
Manufacturing	3	0,6	0,1	0,7
Machinery	19	0.8	0.2	1,0
Electronics	8	1,4	0.1	1,5

Source: Statistical Office of Estonia and author's calculations

The R&D level in different metal industries is around 1% (Table 4.8). In Western European countries, the lowest ratio of expenses on research and development to turnover was in the transport equipment sector with 1.7% and the highest in radio equipment sector – 6.1% (Archibugi et al. 1997). The process of research and development has been underestimated in the surveys due to the fact that surveys in general show lower than real level of development in SMEs. Some recent trends like more hiring advertisements for engineers indicate the need for growth of development capabilities.

4.4 R&D in innovation process

Research and development are a source for new ideas. Formally we cannot overestimate business R&D figures. There are two reasons why R&D data should be discussed with certain kind of reserve. First, statisticians like to measure research and development in "car factory" model-firms which have routine processes and strict lines between departments (Braadland, Ekeland 2002). The second problem is the so-called supply chain approach where everything starts from basic research and continues with applied research, testing and production. Research activities can be integrated into the life of small firms so that the distinction and measuring of them is impossible. Technological innovation does not presume basic or even applied research; the idea for new products/services or processes might be taken over or obtained from practical experiences – the important thing is that the new product/service or process is new to the market or to the enterprise itself.

As a part of the survey, enterprises were asked about research and development activities in firms. Among industrial firms, 39% are doing occasionally or continuously research (Figure 4.5 and Table 4.9).

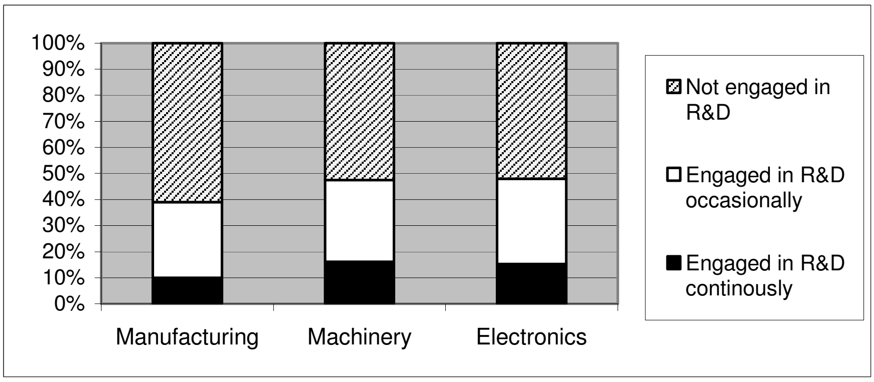


Figure 4.5 Share of enterprises involved in intramural research and development
Source: Statistical Office of Estonia and author's calculations

Table 4.9. Share of enterprises involved in intramural research and development, % of enterprises

	Engaged in R&D continously	Engaged in R&D occasionally	Not engaged in R&D
2000			
Manufacturing	10	29	61
Machinery	16	31	52
Electronics	15	32	51
2004			
Manufacturing	35	10	53
Machinery	34	6	60
Electronics	57	3	40

Source: Statistical Office of Estonia and author's calculations

Table 4.10. Share of enterprises'expenditure involved in intramural research and development, % of enterprises

	No expenditure for R&D	Less than 1%	Over 1% till 3%	Over 3% till 5%	5% and more
2000					
All	83	11	3	1	2
Machinery	78	12	6	3	2
Electronics	62	24	14	2	12
2004					
All	71	20	5	2	2
Machinery	60	20	12	6	2
Electronics	40	31	15	6	8

Source: Statistical Office of Estonia and author's calculations

In EU-15 (1998-2000) (Kurik et al. 2002), 69% of firms were committed to research and development activities. Most of those activities were done occasionally. Research and development costs were higher than 1% of the turnover in 20% of the machinery industry firms and 29% of electronics firms. Compared to the situation with previous survey four years ago research and development expenditures show growing trend.

4.5 Benefits from innovation process

According to Peter Drucker (1999), entrepreneur has two basic functions: innovation and marketing. Innovation process is a firm's renewing process: finding new ideas and methods and implementing of them. In this thesis we discuss technological innovations.

At a certain stage of life, every firm is innovative. Some firms put more efforts and resources to innovation process and some less. Shares of turnover from new products are given in Table 4.11. Innovation intensity depends on the nature of industrial sector, maturity of the sector, competition level and other factors. Intensity of innovating activities differs considerably in different stages of the supply chain. In the case of machinery and electronics industry sectors that have complex products (generators, machinery) innovativeness of different components and assemblies varies substantially.

Table 4.11. Share of turnover from new and significantly improved products, %,

	New for enterprise itself	New for enterprise's market	Unchanged products
1998-2000			
Manufacturing (Estonia)	10	5	85
Machinery (Estonia)	17	5	78
Electronics (Estonia)	51	20	29
Manufacturing (EU-15)	32	7	61
Machinery (EU-15)	37	8	55
Electriconics (EU-15)	52	12	36
2002-2004			
Manufacturing	4	13	76
Machinery	14	16	70
Electronics	24	8	68
Manufacturing (Finland)	19	6	75
Manufacturing (Sweden)	21	8	71

Sources: Eurostat, Statistical Office of Estonia and author's calculations

The most commonly used indicator of innovating activities is the share of new products in company's product portfolio. Product can be innovative for the firm and its direct customers and for the market.

By turnover, innovation is a concentrated activity. An average of 44% of enterprises in Europe in the period 1998-2000 had some innovative activities (Eurostat 2004). At the same time, 55% of the turnover from new or improved products in European manufacturing came from 1% of the largest product innovators (Eurostat 1/2001 CIS: 4). The top 1% of the largest electrical and optical instrument producers created 67% of the turnover from innovative products and top 1% of machinery & equipment producers made 39% of innovations.

Innovation creation in Estonia is less concentrated than in the older members of European Union (EU-15). In EU-15 on average, 1% of product innovators with the highest turnover in new and improved products represent 55% of the total turnover of innovative products in manufacturing (Eurostat 1/2001). The respective number in Estonian manufacturing is 46%. The role of innovative small enterprises is to participate in the creation of innovations and the role of large trans-national firms multiplication and distribution of innovations.

4.6 Protection of innovations

Protection of intellectual property is one of the preconditions to ensure that inventors or innovation creators and investors gets paid and can invest into new creations. Protection of intellectual property can be performed both through legislation and business strategy. Legal ways of protecting intellectual property are registration of patents, trademarks, design solutions and other ways. Business strategy ways of secrets are lead-time advantage, secrecy rules for the firm and clients, and complex design.

Between 1998 and 2000 32% of Estonian firms said that they protected or planned to protect their intellectual creation by different methods (Table 4.12 and 4.13). 15% of enterprises used different legal ways of protecting their innovations in period between 1998 and 2000. In the period 2002- 2004 13% of industrial enterprises used legal methods to protect their intellectual property.

Table 4.12 Methods of protection of innovations, % of all enterprises 1998-2000[2]

	Total	Legal ways of protection	Patent application	Registration of design patterns	Registration of trademarks	Copyright	Secrecy	Complexity of design	Lead-time advantage
Manufacturing	32	15	4	1	14	2	12	10	22
Machinery	39	12	3	1	9	4	6	8	15
Electronics	36	9	3	3	8	1	14	14	18

Source: Statistical Office of Estonia and author's calculations

Table 4.13. Methods of protection of innovations, % of all enterprises 2002-2004

	Legal ways of protection	Patent application	Industrial design registering	Trademark registering	Copyright claim
Manufacturing	13	3	1	12	1
Machinery	14	6	3	13	3
Electronics	18	0	3	12	0
Machinery industry in Finland		26	12	14	1
Electronics industry in Finland		22	14	13	2

Source: Statistical Office of Estonia, Statistics of Finland and author's calculations

The protection level of innovations by patenting is very low in Estonia. Despite the facts that machinery and electronics industry on global level has several high-tech areas like telecommunications, semiconductors, lasers, and computers and is

[2] Questions in 1998-2000 Questinnaire and 2002-2004 Questionnaire are not totally identical and therefore full comparison is not possible.

very actively participating in the patenting process, the Estonian metal industry enterprises make very few patent applications. Particular data about applications by metal industry firms and research institutions are confidential, but the total number of local patent applications in the Patent Office of Estonia in the period 1994-2003 was stable on the level of 12-20 applications. A few of them are made by metal industry every year. For example, the Swedish based global engineering firm, Sandvik, has 3,700 patents (SAS 2001). In Table 4.13 are also data about intellectual property protection in Finnish machinery and electronics industries. Gap is approximately tenfold.

The absence of local patent applications does not mean that patents have no place in local economy. Patenting is in many cases done by bigger concerns. The difference between patenting by firms with local origin and foreign owned firms indicates that foreign owners are more active patent applicants (Table 4.14). Medium-sized and large firms also tend to protect their intellectual property more in legal ways.

Table 4.14. Share of enterprise with patents in Estonia in 2000, by ownership and size, %

	No foreign equity	With foreign equity	Small firms	Medium firms	Large firms
Machinery	6	13	2	15	50
Electronics	10	15	13	7	28

Source: Statistical Office of Estonia and author's calculations

From the business strategy point of view, relatively expensive patenting is the only one way of protecting intellectual property. Raising of the customers' knowledge of the own's quality, signing of non-disclosure agreements with employees and clients are simpler ways to protect intellectual property. The general firm information security methods are also applicable.

4.7 Innovation co-operation and networks

Innovations are rarely conducted by one firm. Today the main innovations are results of cooperation of firms, universities, consultants and other network actors. A bigger web of actors provides access to extra financial resources, information and other resources. In the period 1998-2002, 34% of innovative manufacturing enterprises in Estonia had cooperation arrangements for innovation activities (Table 4.15). 17% of innovative industrial firms had cooperation agreements in EU-15. Large European industrial firms make innovation cooperation in 61% of the cases and small firms in 11% of the cases (Eurostat 2004). It is quite evident that enterprises within a concern, the suppliers and customers occupy the first places in the ranking list of co-operation partners. The opinions about these cooperation partners are preferably high, and in the case of other co-operation partners, medium-good opinions prevail.

Table 4.15. Involvement in co-operation arrangements in innovation activities, %, 1998–2000

	Share of enterprises with cooperation arrangements among innovative firms	Distribution of cooperation partners, %							
		Other enterprises within concern	Suppliers of equipment, materials, components or software	Clients and customers	Competitors	Consultants	Enterprises offering R&D services	Universities and higher schools, their units	Public and private non-profit R&D institutions
Manufacturing	34	24	56	43	32	30	16	15	9
Machinery	33	32	38	48	41	28	30	12	22
Electronics	50	32	65	54	10	31	7	32	18

Source: Statistical Office of Estonia and author's calculations

Table 4.16. Involvement in co-operation in innovation activities, %, 2002-2004

	Co-operation existed	Within enterprise group	With suppliers	Clients	Competitors	Private R&D institutions	Universities	Public R&D institutions
Manufacturing	31	24	21	21	17	11	8	9
Machinery	24	45	53	42	20	23	9	10
Electronics	34	38	31	59	45	35	12	11

Source: Statistical Office of Estonia and author's calculations

34% of the innovative manufacturing firms had cooperation agreements. 44% of these contracts were only with national level partners, 23% with only international partners and 29% with both national and international partners. Most active foreign partners were in Nordic countries and Germany.

Large enterprises tend more to have both foreign and national partners and smaller enterprises national partners for innovation. Enterprises participating in a tight subcontracting process (automobile and telecommunication) tended to have relatively more co-operation contracts than enterprises that serve mostly local clients or produce standard goods (Table 4.17).

Table 4.17. Cooperation partners by location, %, 1998-2000

	Share of enterprises with co-operation arrangements	Estonian partners	EU 15 and EFTA	Eastern Europe	USA	Japan	Other countries
Manufacturing	13	81	64	23	7	3	17
Machinery	33	54	53	35	8	0	23
Electronics	50	84	59	9	33	0	31

Source: Statistical Office of Estonia and author's calculations

Table 4.19. Cooperation partners by location, %, 2002-2004

	Estonia	Europe	USA	Other Countries
Manufacturing	12	11	1	2
Machinery	23	21	9	3
Electronics	83	82	20	9

Source: Statistical Office of Estonia and author's calculations

Rules of industry and cooperation partners are not something that stay passive and stable. Networks and firm's position in them are changing constantly. Factors like change of political environment (new trading blocs), new technologies and others are the main winds of change.

4.8 Sources of information for innovation

Innovation is a complex process where several information sources are used. Firms can get requests, guidance, advice and new ideas from multiple sources. Getting information depends on several factors, such as location (urban area or rural), size, belonging to a bigger enterprise group, belonging to certain network, etc.

Sources of innovation can be both inside the firm and outside. Innovation can be a product of internal research and development, or of market demand.

Sources of information can be (CIS-3 2002):

- internal: from within the enterprise itself or other enterprises within the enterprise group;
- market: from suppliers, customers, clients, consultants, competitors, commercial laboratories or research and development enterprises;
- institutional: from the public sector, such as government research organisations and universities, or private research institutes;

- professional: from conferences, trade associations, technical/trade press or fairs and exhibitions;
- specialised: from technical standards, health, safety and environmental standards and regulations.

There are national and regional differences in using different sources of information. The most important source for innovation information in EU manufacturing has been (CIS-2, CIS-3, CIS-4) internal sources of information. Among a few exceptions here are British and Danish firms which regard clients and customers as a more important source of information (DTI Statistics 1998, Analyseinstitut for Forskning 2003). The use of innovation information also depends on enterprise's size-class. Large enterprises have more resources and use more intensively all kinds of information sources. Certain types of information like information about competitors, university research information and conferences are used almost exclusively by large firms (Eurostat 2004). Suppliers as a source of information and fairs and exhibitions are used equally by large and small enterprises. Product innovators use more market and internal information and process innovators use information from suppliers of equipment.

Estonian enterprises use less most of the outside sources of innovation than EU enterprises (last lines in Table 4.18, Table 4.19). This may be due to the fact that market services and public information sources are not yet on the same level with EU-15 countries. A more important source of information for Estonian firms, compared with EU-15 firms, were suppliers of production equipment and raw materials. Relatively more expenses than in EU-15 are spent on machinery and machinery suppliers also have a bigger role in innovation processes.

Another difference is the use of other enterprises belonging to the same enterprise group (concern). 11% of Estonian enterprises used sources inside the concerns, compared to 7% of enterprises in EU-15 (Eurostat 2004). This could be due to that the share of enterprises belonging to enterprise groups is relatively big among innovative firms. Local firms are less active to innovate than EU-15 firms.

Sources of innovation for firms in the machinery and electronics sector are not very different form other manufacturing firms with a few exceptions. The period 1998-2002 was an active quality certification period in transport industry and therefore consulting services were widely used. The use of public sources like universities seemed to be more extensive than in the economy in general.

Table 4.18. Sources of information considered as very important for innovation in Estonia, %, 1998-2000 (Only enterprises with innovations)

	Within the enterprise	Other enterprises within concern	Suppliers of equipment, materials	Clients or customers	Competitors and other firms from the same industry	Consultants	Universities, their units and institutes	Professional conferences, meetings, journals	Fairs and exhibitions
All enterprises	36	14	25	25	10	4	1	8	14
Machinery	42	8	11	31	8	6	1	1	12
Electronics	36	10	13	34	7	5	4	6	27
Industry in EU (CIS-3)	37	7	19	27	11	2	4	9	17

Source: Statistical Office of Estonia, (Eurostat 2004) and author's calculations

Table 4.19. Sources of information considered as very important for innovation in Estonia, 2000-2004

	Within the enterprise or enterprise group	Other enterprises within concern	Suppliers of equipment, materials, components or software	Clients or customers	Competitors and other firms from the same industry	Consultants	Universities and higher schools, their units and institutes	Public and private non-profit R&D institutions	Professional conferences, meetings, journals	Fairs, exhibitions
Manufacturing	17	11	12	6	2	2	1	7	3	1
Machinery	17	10	11	4	0	1	3	4	1	1
Electronics	24	32	22	7	4	0	0,5	12	3	0

Source: Statistical Office of Estonia, (Eurostat 2004) and author's calculations

Education related and public research sources are ranked as not used very often. Less than 2% of enterprises used public information sources as an important source of information. This could be due to that enterprises have not used public sources before and rely more on their internal capabilities, suppliers and customers. Larger enterprises tend to use more outside information sources than small and medium-sized enterprises. Enterprises situated outside of Tallinn area used all sources of information less intensively than enterprises located in Tallinn and in the surrounding area.

Sources of innovation information inside the firms are most natural. Who else than company's own people are aware of customers' wishes and demands. Use of internal resources in sub-sectors of machinery and electronics industry was quite similar to that in total manufacturing (Table 4.20).

Table 4.20. Sources of information within enterprise (% among firms)

	If used, importance			Not used
	High	Medium	Low	
Manufacturing	33	39	9	17
Machinery	42	40	10	6
Electronics	36	31	6	26
2002-2004				
Manufacturing	17	15	5	12
Machinery	17	23	7	6
Electronics	42	21	4	10

Source: Statistical Office of Estonia and author's calculations

Compared to Finland and UK, the intensity of using internal sources for information was lower in Estonia (Statistics Finland): 33% in Estonian manufacturing, 44% in UK and 45% in Finland and Denmark (DTI Statistics 2001, Analyseinstitut for Forskning 2003).

4.9 Problems with implementation of innovation

Not every good idea is implemented. There are several reasons why dreams will not come true. It's the same with innovations. Previous surveys (Hernesniemi 2000; EC Enterprise DG 2001) of innovation have indicated that the main reasons for low level of innovation are the shortage of finances and low development capacity. Innovation process is not always natural for every firm and unit inside the firm. There are several obstacles why the innovation process is not always smooth.

It is a subjective view, but from the author's point of view the main obstacle to innovation is in the minds of people. Motivation and people's empowerment are the main factors not only in the Estonian machinery and electronics industry, but also in all Estonian economy. Better management techniques and changing of economic environment can probably change the situation during the next decade.

Innovation obstacles can be broadly divided into external and internal obstacles. External factors are economic and legislative factors and internal factors are management of resources inside the company. Cost factors were the most cited by Estonian enterprises as obstacles (Table 4.22). In comparison with UK, Denmark and Finland, financing and risk problems were estimated by 10-15 percentage points higher (DTI Statistics 2001, Statistics Finland, Analyseinstitut for Forskning 2003).

Factors hampering innovation and economic life in general are changing. In macro-economic terms, labour is more and more substituted by capital and this enables to pay better salaries and to select and hire better people.

The biggest role among internal factors is played by lack of personnel. The period 1998-2000 was a slowdown period in some machinery and electronics industry branches and the number of available workplaces was not very big. Compared to Germany and Finland, shortage of qualified personnel was not a major obstacle (Janz et.al. 2002, Statistics Finland 2003). However, this is the main obstacle to manufacturing innovation in Germany. Shortage of personnel in Germany does not indicate that the country with one of the best craft skills has lost its biggest resource but it might be more a problem of adaptation and re-learning. Compared with previous period the situation in manufacturing and also in machinery and electronics industry has changed (Table 4.21 and Table 4.22). Lack of qualified personnel has been main obstacle for innovation in electronics industry and serious obstacle in machinery industry in 2002-2004.

Table 4.21. Hampering factors with high importance 1998-2000, % of enterprises

	Economic factors			Internal factors				Other factors	
	Excessive economic risk	High innovation costs	Lack of financing	Organisational rigidity	Lack of competent personnel	Absence of information on technology	Absence of information on market	Insufficient flexibility of legislation	Lack of customer interest
All enterprises	11	22	28	3	10	3	4	6	10
Manufacturing	11	25	32	3	11	4	5	6	9
Machinery	9	23	20	2	11	2	7	3	8
Electronics	12	22	30	0	10	7	8	2	13

Source: Statistical Office of Estonia and author's calculations

Table 4.22. Hampering factors with high importance 2002-2004, % of enterprises

	Economic factors			Internal factors		Market factors		Market factors			
	Internal lack of funds	External lack of funds	Innovation costs too high	Lack of qualified personnel	Lack of information on technology	Lack of information on markets	Difficulty in finding cooperation partners	Market dominated by established fims	Uncertain demand for goods or services	No need due to prior innovations	No need because of no demand
All enterprises	26	18	19	18	4	4	7	15	9	15	15
Machinery	25	12	10	19	1,4	3	4	5	6	19	12
Electronics	21	9	6	23	3	6	11	16	6	8	12

Source: Statistical Office of Estonia and author's calculations

48% of the manufacturing firms faced obstacles during the innovation process (Table 4.23). Due to the above-mentioned obstacles, projects were not started in 20% of the cases after planning and were delayed in 27% of the cases. The level of project abandonment in metal industry was slightly higher than in other manufacturing areas. This trend was caused by a longer innovation cycle and sunk cost nature of investments in process technology.

Table 4.23. Impact of hampering factors, %

	Total	Project delayed	Project was not started	Project was burdened with serious problems
1998-2000				
Manufacturing	42	21	14	21
Machinery	45	27	14	12
Electronics	47	37	15	26
2002-2004				
Manufacturing	48	27	20	10
Machinery	51	32	25,3	10
Electronics	52	45	26	16

Source: Statistical Office of Estonia and author's calculations

Problems related to economic factors are solved in a long term. Not all good innovations were carried out with large resources. We can rather state the opposite: despite the lack of resources, firms found new ways to solve the problems.

Project cancelling can also be seen as a part of development. Even a negative experience acquired in the innovation process can be positive in the long term.

4.10. Conclusions

Estonian machinery and electronic industry firms made more changes than average EU-27 firms in the period 2002-2004 but they are less innovative than Northern European firms. Innovativeness level is greatly influenced by innovation methods. Estonian firms are moving from imitation and implementation stages to the innovation stage. At the current stage of development, technology transfer through acquisition of capital goods is the easiest and fastest way for Estonian firms. Estonian manufacturing firms had a more positive effect from innovation than their counterparts in Europe. This does not mean that the gap in technology and productivity is diminishing rapidly because the share of innovators was smaller than in Nordic countries, but it indicates that enterprises that found ways to innovate had relatively good results both on local and international markets.

Innovation intensity depends on the nature of the industrial sector, maturity of the sector, competition level and other factors. Enterprises size has a strong influence on the firm's innovativeness. Calvert and co-authors (Calvert et al. 1998) showed that there is a positive relationship between the firm size and innovation output. Estonian firms are smaller than firms in EU-15. Large enterprises in Western Europe spend several times more on innovation than large enterprises in Estonia. Innovation creation in Estonia is less concentrated than in the European Union (EU-15).The role of innovative small enterprises is to participate in the creation of innovations and the role of large trans-national firms multiplication and distribution of innovations.

The most commonly used indicator of innovating activities is the share of new products in a company's turnover and in its product portfolio. If to compare the relationship between size of sales and sales of new products, we can see that sales of new products in EU-15 and Northern Europe make up a larger share than sales of new products in Estonia. However share of new products in Estonian firms is increasing. Product innovations are vital for enterprises producing non-standard goods. Dominantly product and process innovations are made by enterprises own efforts.

Innovation expenditures cover the costs of bringing new products to the market and the costs of developing new processes. The most important cost articles are resources spent on machinery and equipment for producing novelties, and research expenses. There is a tendency that more advanced (in GDP terms) industrial countries spend predominantly on research and development and less developed countries on acquisition of machinery and equipment.

Most of research and development activities in Estonian firms were done occasionally. Research and development costs were higher than 1% of the turnover in 5% of the industrial firms. These figures have been underestimated in the surveys due to the fact that surveys in general shows lower than the real level of development of new products in SMEs. Research activities can be integrated into the life of SMEs generally so that their distinction and measuring is impossible.

In the Estonian SMEs, technological innovation does not require basic or even applied research; the idea for new products/services or processes might be taken over or obtained from practical experiences – the important thing is that the new product/service or process is new to the market or to the enterprise itself. The second difference from EU countries is the lack or very low of marketing costs of innovative products in most of the sub-sectors.

At a certain stage of life, every firm is innovative. Estonian firms are young and their innovation potential is high. Protection of intellectual property is one of the preconditions to ensure that the inventor or innovation creator gets paid and can invest into new creations. 32% of the Estonian firms said that they protected or planned to protect their intellectual creation.

The protection level of innovations by patenting is very low in Estonia. The Estonian machinery and electronics industry enterprises make very few patent applications. The difference between patenting by firms of local origin and foreign owned firms indicates that foreign owners are more active patent applicants, medium-sized and large firms also tend to protect their intellectual property more than small firms in legal ways. From the business strategy point of view, relatively expensive patenting is the only way of protecting intellectual property. The general. firm information security methods are also applicable.
Improvement of the quality of products and services was the most important innovation effect both in manufacturing and in the metal industry.

One firm rarely conducts innovations. Today the main innovations are results of cooperation of firms, universities, consultants and other network actors. A bigger web of actors provides access to extra financial resources, information and other resources. Development of innovation networks is an aim of most Estonian enterprises. Enterprises participating in a tight subcontracting process (automobile and telecommunication) tended to have relatively more co-operation contracts than enterprises that serve mostly local clients or produce standard goods.

Estonian enterprises use less most of the outside sources of innovation than EU enterprises. This may be due to the fact that market services and public information sources are not yet on the same level with EU-15 countries. A more important source of information for Estonian firms, compared with EU-15 firms, was suppliers of production equipment and raw materials. Estonian firms have used rarely certain types of information like information about competitors, university research information and conferences. Another difference is the use of information from other enterprises belonging to the same enterprise group (concern). Education related and public research sources are ranked as not used very often. Less than 2% of the enterprises used public information sources as an important source of information. The reason could be that enterprises have not used public sources before and rely more on their internal capabilities, suppliers and customers.

Factors hampering innovation and economic life in general are changing. In macro-economic terms, labour is more and more substituted by capital and this enables to pay better salaries and to select and hire better labour. Some recent trends like more hiring advertisements for engineers indicate the need for growth of development capabilities. Similarly to the older European Union members, the need to control the share of energy, labour and raw material costs will rise in the future. Also innovation efforts move toward this direction and the effects of innovation will be smoother process oriented.

From the author's point of view the main obstacle to innovation is in the minds of people. Motivation and people's empowerment are the main factors not only in the Estonian machinery and electronics industry, but also in the whole Estonian economy. Better management techniques and changing of economic environment can probably change the situation during the next decade.

Innovation obstacles can be broadly divided into external and internal obstacles. External factors are economic and legislative factors and internal factors are management of resources inside the company. Problems related to economic factors will be solved in a long term. Not all good innovations were carried out with large resources. We can rather state the opposite: despite the lack of resources, firms found new ways to solve the problems. Project cancelling can also be seen as a part of development. Even a negative experience acquired in the innovation process can be positive in the long term.

5. CASE STYDY BASED ANALYSIS OF THE INNOVATIVENESS AND NETWORKS IN MACHINERY AND ELECTRONICS INDUSTRY

5.1. Case study research methods for firm research

Case study is a suitable methodology when a holistic, in-depth investigation is needed (Feagin et al 1991). Researchers have used case studies in varied investigations. Well-known case study researchers such has Stake (Stake 1995), Yin (Yin 1993, 1994, 2002), Feagin (Feagin 1991), Tellis (Tellis 1997) and others have written about case study research and suggested techniques for organising and conducting the research successfully.

In the current work case study research is used for several reasons. The first reason is heterogeneous sample of firms. Firms have different size, market structure and path of development. Analysis of innovation methods and mechanisms based on quantitive methods or financial data does not fully disclose the processes of innovation inside the firm. There could also be confidentiality issues or lack of needed data. The second reason for using the case study method is heterogeneity of firm networks. New organizational forms replace traditional, isomorphic supply structures and relationships. In its own way every supply chain and companies network is unique.

We use case study research to understand a complex issue (innovation and networks) and object (electronics and machinery industry) and to strengthen what we already known through previous research. We have used in the current study the specific techniques that are recommended by Yin (Yin 1993, 1994), Stake (Stake 1995), Tellis (Tellis 1997) and others. The case study methodology according the recommendation of Yin (1994) has four stages:

1. Design the case study,
2. Conduct the case study,
3. Analyse the case study evidence, and
4. Develop the conclusions, recommendations and implications.

The goals of this study include examination of the innovation and network aspects of the rapid development of electronics and machinery industry.

Design of the case study

The first stage in the case study methodology recommended by Yin (Yin 1994) is the determination of the required skills and development of the case study protocol. In our research we have a single investigator – the author of this work – who should discover problems in the plans or any phase of the study design. The investigator must able to function as a “senior” investigator (Feagin et al. 1991). The researcher has had about ten years of experience in both academic, administrative and industry. Different engineering and technological factors played an important role in the current study. Most of the persons interviewed were engineers who liked to speak in the terms of technology. Engineers understand several social processes also through technology. Interviewing of them presupposed knowing technological processes used by the firm. To understand technological processes the author studied several materials about electronics and machinery industry technology. Yin (Yin 1994) identified five components of research design that are important for case studies: (1) A study questions, (2) Its propositions, if any, (3) Its unit(s) of analysis, (4) the logic linking the data to the propositions, (5) the criteria for interpreting the findings (Yin 1994).

Case study research generally answers one or more questions, which begin mainly with "how" or "why". In our work the main research questions were:
What are the main innovation goals for firms?
How is product development organized within the firms?
How is process development organized by firms?
What role has technology transfer process for firms?
Who participate in product and process development?
Who are main outside partners and what is their role in innovation?
What kind of networks firm have?

We asked also supportive and background understanding questions:
What is the development path of the company?
What is development path of entrepreneur/manager?
What is the role of the public sector in innovation process?

All companies did not give or have comprehensive answers to all the above questions. Careful definition of questions helped the author to interview entrepreneurs and managers, but the choice of some questions rose also from previous answers.

Conducting the case study

In the study the author used multiple cases; each case was treated as a single case. Cases were carefully selected. Before the selection the author of the thesis had visited approximately 60 Estonian electronics firms and approximately 10 machinery manufacturing firms. In addition to company visits the author visited engineering and IT (information technology) fairs and exhibitions in Tallinn. Among the visited firms the author selected companies with stronger innovation and development potential. The author selected firms in different locations (Tallinn, other regional centres and rural locations), with different ownership (international and local), different size, with different market area and with different product nature. Main characteristics of the selected cases are presented in Table 5.1.

Table 5.1. Characterisation of cases

Firm's name	Size (number of employees)	Ownership	Location	Operations/ market	Market nature
AUDES	medium (71)	local	small city	global	consumer + industrial
IPA	medium (220)	semi-international	capital	international	industrial
Flexenclosure	small (22)	international (part of international firm)	rural	global	industrial
MS TRAFO	medium (120)	semi-local	rural	international	industrial
PNJ	medium (106)	semi-international	capital	international	industrial
Scanfil	big (274)	international (part of international firm)	small city	international	industrial

Source: Compiled by author

Firms are divided into size groups according to usual classification used by Estonian Statistical office. Among the enterprise group are not represented big assembly factories that are not very common in Estonia but play bigger role in Central Europe. Actual size of enterprises is not very precise indicator because enterprise could have close subconractors other firms owned by same owners or other institutions that work very close to main enterprise.

Local ownership means that firm's owners are local residents. International ownership means that firm is owned by international firm(s) who often themselves are owned by institutional investors. Global operational area means that firm sees all world as potential market and is able to operate in most of locations in the world. International operations/ market area means that company is operating mainly in Europe. Most of the enterprises operated in the industrial market i.e. they made products for other enterprises. Their products were used for making other products and offering services.

Data gathered are in large extent qualitative, but also some extent quantitative. Evidence collected included documentation, archival records, interviews, direct observation, participant observations. Typology of evidence is in Table 5.2.

In this survey only last two types were not relevant. In our survey we used: enterprise homepages, business media news, financial records/credit information, interviews and site visits.

Table 5.2. Types of evidence

Source of Evidence	Strengths	Weaknesses
Documentation	• stable - repeated review • unobtrusive - exist prior to case study • exact - names etc. • broad coverage - extended time span	• retrievability - difficult • biased selectivity • reporting bias - reflects author bias • access - may be blocked
Archival Records	Same as above precise and quantitative	Same as above privacy might inhibit access
Interviews	• targeted - focuses on case study topic • insightful - provides perceived causal inferences	• bias due to poor questions • response bias • incomplete recollection • reflexivity - interviewee expresses what interviewer wants to hear
Direct Observation	• reality - covers events in real time • contextual - covers event context	• time-consuming • selectivity - might miss facts • reflexivity - observer's presence might cause change • cost
Participant Observation	• Insightful into interpersonal behavior	• bias due to investigator's actions
Physical Artifacts	• insightful into cultural features • insightful into technical operations	• selectivity • availability

Source: Yin (1994:80) modified by author

Interviews were one of most important sources of case study information. Author used open-ended interviews and asked for the informant’s opinion on events or facts. For formulating the answers author used previously gathered data. Many questions came from the case study protocol. In our cases we used field notes and databases to categorise and reference data so that it was ready for subsequent interpretation.

Analysis of the case study evidence

The author examines data using many interpretations in order to find linkages between the research object and the outcomes. We sought new opportunities and insights. The first problem for author was to select out an analytic strategy that will lead to conclusion. For developing the analysing strategy we used works of King and Kraemer (King and Kraemer 1985), Yin (Yin 1994), Stake (Stake 1995), Tellis (Tellis 1997).

Yin (1994) suggested that every investigation should have a general analytic strategy, so as to guide the decision regarding what will be analysed and for what reason. Yin (1994) presented two strategies for general use: One is to rely on theoretical propositions of the study, and then to analyse the evidence based on those propositions. The other technique is to develop a case description, which would be a framework for organising the case study.

Very useful was Stake's (Stake 1995) recommendation about aggregation as another means of analysis and also a suggestion of developing protocols for this phase of case study to enhance the quality of research. In order to produce an analysis of highest quality Yin (Yin 1994) presented four principles that should attract the researcher's attention:

- Show that the analysis relied on all the relevant evidence
- Include all rival interpretations in the analysis
- Address the most significant aspect of the case study
- Use the researcher's prior, expert knowledge to further the analysis.

The case study analysis author used logical categories developed by King and Kramer (King and Kramer 1985). The categories are: (1) technological development, (2) structural arrangements, (3) socio-technical interface, (4) political economic environment, and (5) benefits/problems. If our case study analysis is priory a descriptive study and we places as Eisner and Peshkin (1990) a priority on direct interpretation of events, and lower on interpretation of measurement data, which was another viable alternative to be considered. Analysis of focused repeat interviews gave possibilities to verify observations and check facts.

Relative importance was given to the background of managers. Introduction of them is important part in every conversation but author analysed also the links between entrepreneurs person and innovation strategy.

Developing the conclusions, recommendations and implications

The conclusions and recommendations part will be most important from the reader and user aspect. This part will explain to the reader results of case study research and give possibility to understand the implication of findings.

During the conclusions and recommendations preparing process author will critically looking for ways to improve the report. He will evaluate and compare data against the using theory. Conclusions will have support or overthrow previous theoretical considerations.

5.2. Interconnect Product Assembly AS case

Interview was made with main shareholder and director Mr. John Ross in Tallinn on 16.07.2005.

The Manager Mr John Ross is a Scottish engineer with twenty years experience in the electronics industry. Of particular relevance here are his origins from Scotland and his connections with Silicon Glen[3]. Among the people of the British Commonwealth, the Scots are often considered to be the best engineers and inventors. Alexander Graham Bell and James Maxwell are just two of the past Scottish giants in the electrical engineering field.

As in the case of several other Western European expatriates now working as managers in Estonia, Mr Ross started his working career as an apprentice. He is active not only in his own business but also in other business-related organisations in Estonia.

Present

In 1997, AMP Estonia began operations in Tallinn, producing cable connections and plastic moulds.In 1999 there was Management Buy Out. IPA now specializes in the production of wire harnesses and electrical assemblies, including high-level assembly and box build. The company is service-oriented and in addition to manufacturing, offers also prototyping, purchasing assistance, supply chain management and design maintenance. The nature of the company's orders requires a flexibility of approach and a commitment to hard work. Flexibility means working in different business areas, with different quantities and different activities in supply chain.

Like many other firms in the rapidly changing electronics sector, IPA has diversified its portfolio of orders. Telecommunication, automotive and industrial electronics are major target markets. More minor markets include fibre optics, medical equipment and consumer electronics. Mr. Ross believes that IPA can achieve steady growth by means of a well-balanced customer portfolio that makes the company less vulnerable to fluctuations in demand within individual sectors. Concentrating on certain key areas does not mean that IPA is not interested in exploiting new market opportunities. The history of the electronics industry is characterised by short product life cycles, new products and changing technologies. IPA continuously improves and invests in up to date automated equipment, information technology and in the training and development of its workforce. 95% of total production goes to customers in UK, Ireland, Sweden, France, Germany and Finland.

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[3] High technology region in Scotland.

In recent years, IPA has been very successful with overall sales values increasing by more than 140% year on year. This growth is a result of favourable market conditions, increased demand from existing customers and the targeting and securing of new business in specific market segments.

The company's initial floor space was 1,800 square meters, but in August 2005, it relocated to a new, purpose-built facility of 5,000 square meters. This new factory is located immediately adjacent to the national airport, Tallinn harbour and in close proximity to major transport companies. IPA currently employs approximately 250 people and plans to expand to more than 300 employees by the end of 2005.

Workers

Despite the existence of several big electronics factories even in the Soviet period, the rapid integration of Estonia into the world electronics community only really began in the mid 1990s. Elcoteq Tallinn, Nokia and Ericsson were all then established in Tallinn, transferred a range of subcontracting activities into Estonia at the same time or subsequently. Foreign investments in the Estonian electronics sector have also contributed towards the development of spill over effects, including the creation of a skilled local labour pool for engineers, workers and suppliers. Current IPA employees, for example include people formerly employed by Elcoteq Tallinn and by other locally based electronics businesses. Similarly, several other Estonia-based electronics firms have benefited from the services of former AMP employees.

In comparison with mass production electronics factories, the nature of the work carried out by IPA requires more creative workers. At the same time, the main accent is not on the high production numbers but quality and reliability.

Industry perspective and business environment

Electronics contract manufacturing is a very competitive business worldwide. Electronics subcontracting was widely employed in US computer manufacturing in the 1990s. Original equipment firms have concentrated on product development and marketing. Electronics Manufacturing Service (EMS) firms also did manufacturing and manufacturing processes development. The development of the contract manufacturing market in Europe was much slower than in US and Asia. This was due to the existence of big integrated electronics producers.

These changes are affecting participants across the electronics manufacturing value chain, and are especially challenging for EMS providers. The EMS segment surfaced in the last decade to provide outsourced services, such as assembly, repair, and design to original equipment manufacturers (OEMs). After the market's sharp ascent and equally sharp decline, EMS vendors in 2004 are repositioning themselves for renewed growth and increased profitability (Price Waterhouse Coopers, 2003).

The development of Estonian-based electronics subcontracting is similar to the pattern exhibited by other emerging countries. Estonia benefited from the transfer of the enterprises from Scandinavia and the British Isles in the 1990s. The first investments were made in close proximity to major infrastructure hubs, Tallinn harbour and Tallinn Airport, and concentrated on assembly operations. The growth of the industry also created demand for services and supplies, including in the latter case, plastic and metal supplier firms. Growing demand also created growing supply and several existing firms adjusted their production to meet the developing needs of the electronics industry, while new, green-field investments were also made. The main local suppliers for the electronics industry are now located outside the metropolitan areas. The third stage of electronics industry development has been accompanied by the growth of engineering services like design, product development, marketing and purchasing.

Innovation processes

Both IPA itself and EMS businesses in general have both manufacturing and service industry features. Innovation processes involve both service and manufacturing industries innovation methods.

The main knowledge created inside the contract service manufacturing firms is practical and essentially related to customers. It is relatively rare for them to generate patents and other types of protected intellectual property rights. In contrast to component and equipment producing firms, contract service firms avoid locking themselves much into long term strategic alliances. Flexibility is for them more important than any advantages that restrictive partnerships might bring.

In electronics manufacturing, the main innovations occur when working with customers and in response to customer requirements and customer interest. The role of EMS firms is, firstly, to develop efficient processes and, secondly, to add know-how from the industrial sectors. Efficient processes development is mainly carried out by multinational EMS firms. The role of the smaller EMS firms (and IPA among them) is to combine technological know-how from different sectors. Accumulating knowledge of different suppliers and their products permits them to give advice and service to customers who may be less involved in the electronics industry business. For car manufacturing, medical apparatus and several other sectors, electronics is an auxiliary activity that is often best to contract to competent suppliers. This niche is filled by EMS firms.

Innovation in the electronics manufacturing field is linked closely to customer needs. In order to secure their future, the smaller EMS firms try to “couple” with the “right” partner firms. Monitoring market trends is essential if they are to find the “right” track.

For IPA, training and testing are the most visible innovation activities. Training is mainly aimed to increase flexible thinking and practical skills, whereas testing is carried out in order to ensure a continued high quality of products.

5.3. PNJ Eesti OÜ case

Case study based on the interview with plant manager Mr. J.Clark. Interview was made in Tallinnoin 17.07.2005.

PNJ Eesti OU started business in Estonia in 2002. The Estonian plant specializes in the manufacturing of high quality metal stampings and welded fabrications for a number of industries, including agricultural vehicles, automotive, leisure and safety. The parent company had transferred the majority of metal processing operations during the period between 2002 and 2003 from UK to Estonia.

The Estonian plant has relatively old press machines ranging from 30T to 300T, made in UK in the 1960s and 1970s and new modern CNC (Computer Numerically Controlled) machining centres, plasma cutter and robotic welding equipment. Older stamping machines processes are also used, although these are relatively labour intensive necessitating a substantial degree of manual work. At the present time PNJ Eesti is one of the leading firms in the field of metal stamping in the Baltic Sea region. The company has both good local technology partners and a number of customers. After staying three years in rented premises, the company has now acquired new production facilities that have twice the floor space - removal to these new premises will take place in the near future.

Industry- perspective

PNJ's final customers have traditionally been tractor and car makers. Most of its customers are first and second tier suppliers. The European tractor and agricultural machinery market has been traditionally protected by legislation. Technical specifications for machines are based on European labour safety and environmental legislation. Financial support under the Common Agricultural Policy is given only for the acquisition of European-made machines. However, tractors made in Belarus-Russia and China are still considerable cheaper to buy, offering a 30-40% price per horsepower discount, compared with tractors made in Western Europe (Karjane 2004). Similar to car manufacturing strong price based competition could hurt in the future both tractor producers and suppliers.

The Estonian company and its resources

The initial task for the company in Estonia was to build up an efficient production organization. The main specialisation at the beginning was the manufacturing of high quality metal stampings and welded fabrications. During its operational history in Estonia, the firm has gained the reputation of being good manufacturer of fabrications and complex assemblies to the off road vehicle market. The main challenge has been to maintain its good reputation while at the same time seeking to adjust its cost bases downward. In the initial period of trading, the Estonian business worked closely with its UK-based sister company.

The transfer of manufacturing and other in-house capabilities to Estonia was accompanied by the creation of a local network of technology contacts. The nature of machine building pre-supposes the use of a large number of different technologies and therefore a number of sub-suppliers. First and second tier suppliers must also coordinate inputs from lower tier suppliers and take responsibility for these inputs. Machine-building companies have mutual dependence; therefore higher tier firms are also interested in the financial health of their suppliers. As one manager said, it is better to pay somewhat premium prices than to look every few month for new sub-suppliers.

The transfer of technical skills that were developed in UK was done mainly by the in-house training of local personnel in Estonia. Gradually, UK suppliers were replaced by suppliers situated in the Baltic Sea region. In 2004, ISO 9002 certification was carried out, and the local company established its own internet homepage in the same year. In the opinion of plant director the new homepage has had the effect of substantially increasing potential customer interest and has also led to the winning of a substantial number of orders. Another sign that PNJ Eesti has become well established in the local business environment is that it has won two new major customers in the past 12 months due solely to its own capabilities.

Production and sales organizing in the firm is done by combining both Estonian and UK technological and organizational capabilities. From the initial period when the main orders were received from traditional UK customers in medium and larger volumes, the company has moved towards lower volume orders and also into prototype component manufacturing (Figure 5.1 and Figure 5.2).

When analyzing the PNJ Eesti performance, we can say that firm has established itself well in the local economy and it has reached next stage in the development ladder when the main task is to build “soft skills” such as design, product development and local marketing. The next developmental stage will now be accompanied by the acquisition of new premises (three time bigger than at present) and by the extension of its technology line.

Relations with other firms

PNJ manufactures a wide range of components destined mainly for heavy agricultural vehicle producers. Among its customers are well known names as Agco, Massey Ferguson and Case New Holland Tractors. Components are shipped to tractor plants all over the world.

In addition to tractor component manufacturing, the company acts as a second-tier supplier to the automotive industry. Components are produced for engine manufacturers such as Cummins and Iveco, along with many other parts destined for end users such as Ford Motors and Land Rover. In addition to its main markets, the company supplies many components to its UK-based distributor, J.H. Yeomans & Sons Ltd. This firm has been supplying components for the safety and leisure industry for many years.

The agricultural machinery market is highly specific due to legal restrictions. Most of the machines sold in Europe are also made in Europe. Plant manager Mr. Clark did not believe that Chinese suppliers yet pose a real threat in the agricultural machines market. This is of course a matter for debate, however. In several EU countries (Estonia among them) Chinese tractors (of between 20 and 40 horsepower) are already sold. Their prices on a horsepower basis are 40-50 % lower than those of European tractors (Karjane 2004). Visible imports of 40 to 100 horsepower tractors are not yet taking place, but it is quite possible that Chinese firms will be attracted in future by this potentially lucrative market sector.

One of the most important reasons for the PNJ's decision to locate in Estonia was its position on the border of three trading zones, Western Europe, Scandinavia and Russia. From Tallinn, it is relatively easy to make shipments and within a few days, Estonian output can be transferred to the company's Birmingham warehouse. The company is trying to take advantage of both traditional customers in UK and a sound cost base in Tallinn.

Among the negative factors linked to the Estonian location is the quality of certain local suppliers. Some exhibit a careless attitude towards customers, and slow delivery times and delivery time slippage also make business in Estonia difficult at times.

PNJ Eesti uses some managers from England. Office personnel and middle managers are recruited locally, but many speak English. Many production-line workers come from Estonia's Russian-speaking minority. 60 % of the company's workers are men and 40% women.

In general, Mr Clark had formed a good impression of Estonian workers. 10% of natural productivity growth was achieved through what he saw as being the good motivation of his labour force. He also saw Estonian workers as being relatively adaptable. One future problem however could be price and wage inflation and the recruitment of new workers. Tallinn is also a service centre and many workers are more attracted to services than to manufacturing, due to the superior wages and working conditions which the former sector offers. It appears likely therefore that a number of manufacturing firms may face recruitment difficulties in future, particularly those who offer less attractive pay levels and working conditions.The Tallinn plant was created in order to save costs. Initially stamping, bending and assembly operations were transferred to Estonia. Production operations at the new Estonian plant had a large, metalworking labour content.

The initial contacts and customers of PNJ were all located in Central England. The company's customers included tractor and car manufacturers.

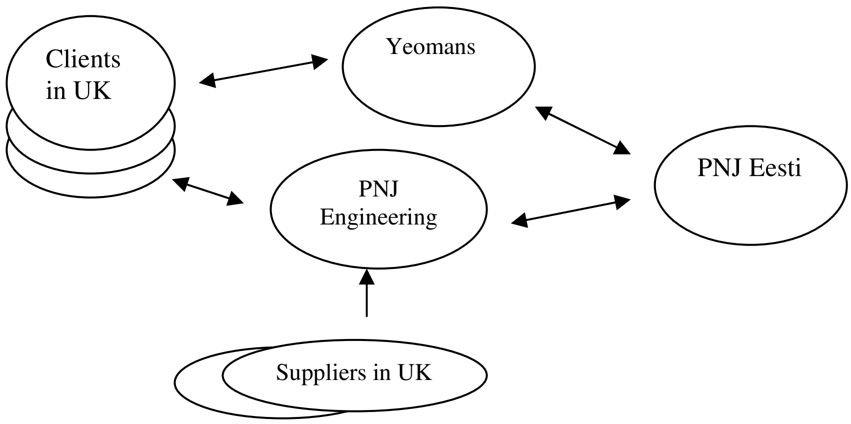

Figure 5.1 Network of PNJ Eesti in 2001

PNJ Engineering in UK continued to operate distribution and warehouse functions. UK distributor, J.H. Yeomans also did more precision work with computer controlled tools, operations that are needed to achiever closer links with the firm's customers. These are also highly productive operations with small labour content and design and quality work.

The main changes which have now occurred in the functions and network of the company are the building of "soft" capabilities in Estonia (run by PNJ Eesti) such as design and prototyping. The development of these capabilities has has helped to begin the creation of a customer base within the neighbouring geographical area. Another big change is the creation of a local supply base in Estonia.

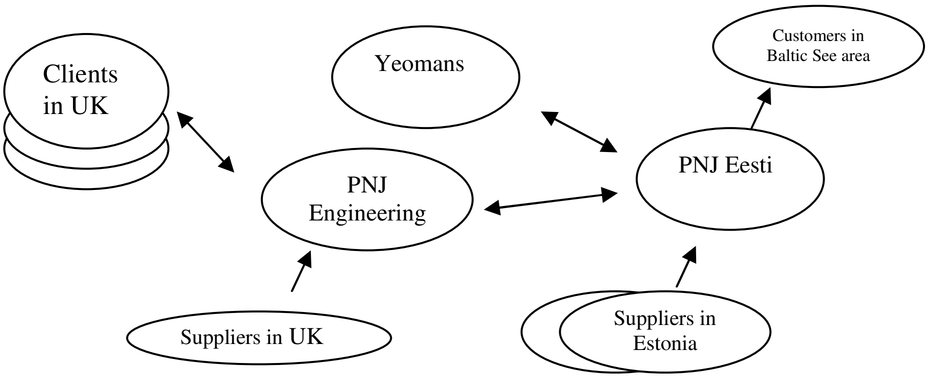

Figure 5.2 Network of PNJ Eesti in 2004

In the case of PNJ Eesti Ltd, most production was transferred to Estonia from the UK, with only small accommodating adjustments being needed. The enterprise has continued to serve essentially the same customers as it did when production was based in England.

The success of technology transfer and the transfer of production activities depends on the speed that these processes take place. First-mover advantages can have a substantial, positive effect. First movers can take the best available resources from the local market. A big threat for transferred enterprises comes however from rising labour costs. These can reduce and eventually eliminate the cost advantages linked to relocation. Future options are therefore to move on to the next, cost-saving location, or to increase capital endowment in the existing location and thus reduce the share of labour in total costs.

Technology transfer typically entails the substantial transfer of technological and organizational culture. Innovation processes that happen during technology transfer are based on adjustments to customer needs. Communication and orders from leading manufacturers help small firms to become suppliers. Perhaps one of the most important aspects in enterprise culture is to encourage self initiative, innovativeness and entrepreneurial skills, on the part of larger and smaller firms alike.

Quick adoption of Western working culture and quality by the Estonian managers and workers gave an opportunity to reach the next development stage (look the Figure 2.2). Estonian firm combined competencies and skills from different sources. Finding right production niches and differentiation of portfolio of products and services, creating of personal and firm's network are guaranteeing success to the firms. On the basis of those networks firms can build up the innovation networks.

5.4. Audes OÜ case

Case study based on the interview with chairman of board Mr. I. Tiurin and OÜ Lavinton laboratory manager A. Vassilkov. Interviews were made at Jõhvi (Ida-Viru County) on 01.02.2006 and on 03.03.2006 in Tallinn.

Entrepreneurs

Mr. Tiurin was educated in Saint Petersburg. He was last the Soviet period chief-engineer of RET. His job in RET was project manager for a new factory that became later Elcoteq Tallinn. Since the middle of the 1990s he is manager of the Kohtla-Järve unit of RET. He was elected to director's position at the beginning of the 1990s. In 1994 he saw the first SMD machine in Finland (Salora factory). He has also music education (piano). This is needed to know the quality. Without such ability it is not possible to make good audio systems. His hobby is also his main business. Tiurin is owner-manager of Audes OÜ.

Alfred Vassilkov works in partner's the firm OÜ Lavinton. Mr Vassilkov graduated from Electrotechnical Institute in Saint Petersburg, Chair of Electro-acoustics and ultrasound. For 2 years after graduation he stayed in the institute. Because of his family background he wanted to return to Estonia. In 1983 he returned and started to work in Pöögelman Factory as designer of ear-aid devices. In 1984 RET started to create a new team for loudspeaker production and mr. Vassilkov was also invited to participate in the team.

Company history

The history of Audes OÜ (that was part of RET Kohtla-Järve unit) starts in 1959. Kohtla-Järve municipality was (and still is) to a large extent a mining and energy production region. There was an abundance of female labour. In the old premises built by German soldiers (prisoners of war) a cables and transformers factory was established. The main production went to the Ministry of Defence. In 1984 began the production of loudspeakers and their parts.

In 1993 Soviet (or Russian) market disappeared almost overnight. Certain small production continued and the management made several attempts to find a market niche. This not-dead, not-alive stage continued until 1997. In 1997 the current management made a buy-out from the bankruptcy trustee. After 1997 the enterprise has shown steady growth at a rate of 15-20% yearly. Within four years, by 2001 main debts were paid. The main strategy in the 1990s was survival. It could be said that the management succeeded in keeping the factory alive. AUDES is a unique enterprise and its structure could not be copied elsewhere. The unique knowledge that existed before was kept alive.

Present

Today Audes has two main production groups (models). One is offering electronics manufacturing services (EMS) and the other is production of loudspeakers. The share of the groups is roughly 50-50. It is planned to add more engineering services to the electronics manufacturing services, subcontracting and transformers production. However, EMS services are not the part that makes Audes unique among Estonian enterprises. Unique is the loudspeakers business. In loudspeakers production Audes peforms the full scale of activities including product development (with Lavinton), brand development, assembly and wholesales. It has also small local sales. We have focused attention on the production of loudspeakers in our case study.

Service activity of Audes is the hand held assembly of the printed circuit boards and the manufacturing of small transformers. In this small assembly niche exists hard competition from Chinese manufacturers. Buyers of small batch assembly services are Scandinavian firms.

The current trend in electronics manufacturing is that there is a second wave of big companies leaving Scandinavia. After the leaving of big firms remain no big buyers in Scandinavia. Only niche firms with 20-40 employees remain in Nordic market.

Audes manufactures transformers in small batches, 20-100 pieces in batch. Batches that are bigger than 1000 pieces are already cheaper to produce in China. Chinese firms have achieved substantial economies of scale. For example by observations of the Audes manager 8 spindle machines were in Sweden are used for transformer manufacturing. In China at the same time 24 spindle machines are quite common.

Personnel and region

Audes gives work to 80 persons (2006). Four of them are engineers in the transformer part and four are engineers in the acoustics systems side. In general the personnel of Audes is relatively young and in local terms very well motivated. Audes pays 30-40% higher salaries than similar manufacturing enterprises in the region. However, there are difficulties in hiring new people to the factory. Especially this concerns engineers. Mr. Tiurin said that Audes could easily hire four engineers and with four more engineers it would be easy to offer jobs for additional 30-40 persons.

Ida-Virumaa region and Jõhvi City, where Audes is situated, is located in the heart of an old mining region. From time to time the region in general has diversified it into other economic activities but social problems related to mining regions are still there. A regional difference is also ethnical composition with a strong majority of Russian speaking people. All those factors have created a less favourable image in Estonia. Often such image is not justified but the image does not change fast. Characteristic is that investors are not very keen to come to Ida-Virumaa, at least not at the same rate as other industrial centres of Estonia. There are several reasons for that. In Ida-Virumaa, like in other locations outside the metropolis, it is hard to find supervisors and managers. Small business is very subjective and a substantial part of it is based on personal contacts, regional special factors that are difficult to copy in other locations.

A positive factor is that there are people in Ida-Virumaa region (Kohtla Järve) who have industrial experience. They have worked for more than 10 years in industrial enterprises. Lack of educated people is a general problem for all regions in Estonia except the capital. Young people do not want to return to their birthplaces. Even Russian speaking people do not want to return to mainly Russian speaking Ida-Virumaa. They prefer either to stay in Tallinn or to go abroad. For example almost 100 students from Ida-Virumaa are studying in London. The probability that the majority of them will come back to Ida-Virumaa is extremely low.

The enterprise has contacts with 20 bigger dealers who sell Audes products. The final sales price can be broken down as follows: manufacturer 30%, distributor 50-55% and retailer 20-15%.

Currently AUDES has 150 clients all over the world. Among them are mostly resellers and big retailers. There are two major markets present: USA and Russia. A few years ago there were also good contacts in Taiwan but due to the difficulties of the reseller they stopped. Russian and US markets are characterized by big economic inequalities. There are many relatively poor people but also there is a big number of millionaires. For example Moscow City, where 10% of Audes production goes has 80% of Russian Federation millionaires. Audes makes loudspeakers of top level. The price of a pair of loudspeakers is 2000-10000 euros. For Estonian market there is also acheaper and smaller model at 200-400 euros. The market for audio-speakers has a shape of a very precipitous mountain (Figure 5.3). The market niche of Audes is marked with a dotted line. An additional $20 to the price of a speakers would reduce the potential market by 50%. “Freaks” are willing to pay but their number reduces sharply with increasing price.

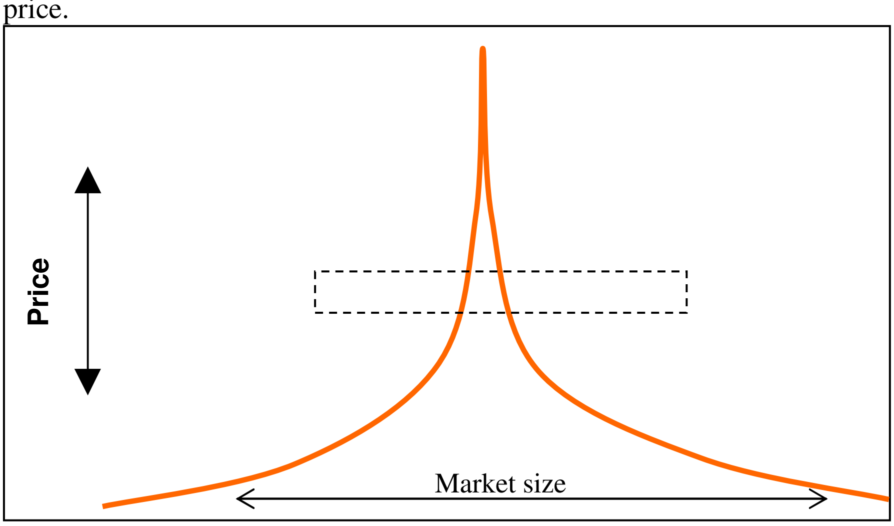

Figure 5.3 Market for audio-speakers. (Lumiste’s interview with Tiurin).

Market of audio devices

People like to hear sounds: music and text. Listening to high quality music from favourite performers is one of the most popular entertainments. The desire to hear authentical or as much as possible authentical performance creates the audience who is willing to pay extra premium for high quality.

There are several types of loudspeakers (Wikipedia Web Encyclopedia). The most common and traditional type is dynamic -loudspeakers. With the distribution of digital electronics analogue signals from life (what is happening naturally) are converted into a digital code. After transfer digital signals are converted back into analogue signals. However during every conversion certain part of data is lost. This process makes perception of different signals psychological. Perception of sound by humans ca not be totally modulated. People perceive signals differently. This factor makes also the buying of a loudspeaker subjective process. People buy what they think is good for them. The pecularity of the audio market is that unlike several other activities only money and big investments do not guarantee success. The listening process is subjective and it depends on concrete persons.

As Mr Tiurin said "*People are buying equipment for music, not for parameters. Often son buys dad's brand. Even analogue technology is coming back and vinyl is coming back. Important is how the ear hearsthe sound. After an hour's concert people must not be tired. All ears are built different. When there is a bad sound (noise) the brain tries to eliminate it. Noise and bad sounds make our brain tired. Also there is difference between males and females. Males have more sensitive ears*".

Mr. Vassilkov added that: "*Men are tending to listen more sound itself and women like to listen rhytm and melody of music*".

Subjective characteristics make loudspeakers unique in the digital world. The loudspeaker is a product that could not be assessed only by quantitative methods. Parameters and sound do not correlate directly. During the Soviet Union period there existed GOST (State Standards) for the initial quality but final tuning was done by acoustics.

Unique characteristics of the product are the reasons why in this sector are also buyers and producers are unique and special people work. Buyers of audio systems are specific buyers. We can even call them freaks. First they have substantial resources. Loudspeakers and audio systems require strong customisation. Audes is able to do all planning and start production within 2 days. There are approximately 500 different models in portfolio. However, only 4-5 models are currently in production.

A loudspeaker and especially a top range loudspeaker is also a visual product. The buyer judges it also visually.

Brand strategy

Buying and sellingloudspeakers involves also psychological effects. It is an extremely hard task to compete against famous names. However the market for leisure goods is never homogeneous and with hard work and luck it is probably possible penetrate to the market. There are discussion groups of audiophiles and the discussion about the analogue sound vs. digital sound helps to raise consumers' awareness about the good qualities of a particular product.

Brand strategy is important in competing in exclusive sectors of audio business. Audiophiles are willing to pay for hi-fi but they want to be confident in quality. Audio business is a long-term business. You must have personnel with good knowledge and craftsmanship. Reputation is built up in he long term. An important role in audio business is played by specialized magazines. There are several strategies in brand-based industries. Buyers' decisions are based on the reputation of the brand and on the confidence that the brand name and the expected quality correlate strongly. Audio business is long-term oriented and buyers are very brand loyal. This makes the entrance for the newcomers very difficult. However, this makes also staying in the club stabile.

The name Audes is derived from the "Audio of Estonia". The image of Audes is also influenced by the countryis image. Estonia is a very small and little known country, which means that the country's image does not support business. To be visible you must also take part in specialized events and fairs. Audes has visited Las-Vegas Consumer Electronics Show (2722 attendees) already 9 years.

Product development and networks

Product development is a challenging process for a small firm. Individual or small batch production gives also good opportunities for small firms to develop customized products. Production of complex goods using several technologies requires also knowledge in different fields and quite often flexible and highly skilled workforce.

A precondition for audio business is that it is a long-term business. Reputation is built up by accumulating both technical knowledge and brand recognition. Initial acoustical knowledge of Audes was acquired during the Soviet Union period from the Soviet Union research institutions. Specific technical knowledge of the company is deeply embedded in the personnel. A problem for the company is that there is no acoustics training in Estonia, although knowledge of physics provides a certain basis for learning acoustics. In general technical education in small countries like Estonia is more general and for specific niches training abroad is needed.

For Audes the Las Vegas Fair is of great importance. It gives many new ideas and facts about the stage of the art. There are approximately 300-500 persons in audio world (producers, developers, retailers, experts) who "make the market". Audes is also a member of the club.

The main development partner of loudspeakers is the acoustics laboratory of the company Lavinton (Tallinn). Mr Tiurin said that Audes and Lavinton's laboratory are like Siamese twins. *"When one dies the other also will die"*. Audes has built up its business networks with partners, suppliers, dealers and clients (Figure 5.4). The firm's managers have used their previous relationships with old fellow students in Russia and other countries and have built up new business contacts.

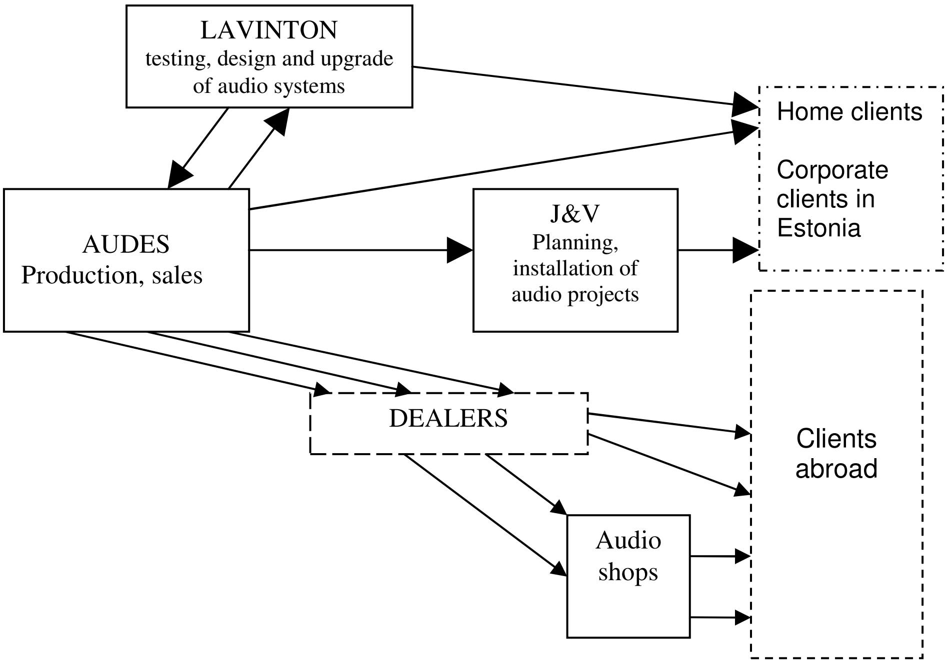

Figure 5.4 Audesis business network (compiled by the author)

Development of a product requires substantial time and efforts. First dealers look at the product and want to be confident that the firm will exist after several years. Then it is possible to start real business. A loudspeaker is a complex product requiring knowledge in different fields. There is a long production tradition of building them in Estonia. Most important feature in small high-tech businesses is psychological interest. Alfred Vassilkov called it interest to learn every day and to discover every day.

Relations with the public sector

The public sector could play a role in supporting regional entrepreneurship. Mr. Tiurin said that the Government could rent empty premises for long term and also offer scholarships for students.

Problems of entrepreneurship and regional development cannot be discussed without tackling ownership issues. Several entrepreneurs/directors sold their enterprises in the 1990s. The main problem was lack of self-confidence, which is the key obstacle in business. Irrespective of globalisation local firms will remain. The government should also respect local firms. Local firms deserve a place under the sun. Relations of Audes with the public sector are relatively limited. Enterprise has received minor assistance from Enterprise Estonia for participation in trade fairs for a few times. There is not much dealing with municipality government.

5.5. Flexenclosure OÜ case

Case study based on the interview with chairman of board Mr. J. Ohlsson. The interview was made at Sõmeru (Lääne-Viru County) on 02.02.2006

History in Estonia

Before the investment into Estonia seven countries were under consideration. The final decision was made between Poland and Estonia. Estonian option was considered more suitable because here starting costs were lower and bureaucracy was smaller and faster. The decision was based on the proximity to companies' Swedish sites and availability of qualified labour at moderate prices. All enterprise units that previously worked in Sweden were relocated to Estonia for lowering personnel expenses. It took 10 months to fully launch the factory. Production started in 2005. The turnover during the first year was approximately 4 million euros and profit around zero. Production space and capacity allow tripling the output.

Mother company

The owner and mother company of Flexenclosure is Pharmadule Emtunga AB, which produces high technology module buildings. The company has three divisions: Pharmadule division produces technical modules for pharmaceutical and biotechnology industries, Emtunga produces modules for oil and gas industry and Flexenclosure division produces shelters for telecommunication industry. The only manufacturing unit in Flexenclosure is Sõmeru plant in Estonia. Concern is market leader in all three product groups. The concern has also another investment in Estonia: Pharmadule manufacturing unit for the production of modular units for pharmaceutical factories. The sale office of Flexenclosure is located in Sweden and sales offices of Pharmadule in Sweden, USA, Ireland and Switzerland. The owner of Pharmadule Emtunga AB is a London-based private equity group 3i, which has multiple investments in several sectors and several regions. The engineering sector investments form a large part of portfolio.

Products

The main products and services of Flexenclosure are design, manufacturing, installation and service of shelters for telecommunication – mobile phone base stations. A shelter is basically a small 2.5*2.5*2.5m house full of equipment. The basic function of the shelter is to protect telecommunication equipment from weather conditions, vandalism, and sabotage; to create work environment for telecommunication devices. In addition to the basic module a client can choose optimal ventilation, cooling, alarm and heating systems. Delivery goes directly from Estonia to the point of destination. The main principle is to offer for clients total system solutions. A low price of the modules is assured with standardized, volume production. The factory has ISO 9001 and ISO 14001 certification for products.

A shelter is a complex product involving different part, subassemblies and devices. The walls of telecom shelter are built on sandwich principle. Between the aluminium lists is polyurethane. Sandwich built shelters are cheaper than steel or concrete shelters.

Main network

The main clients of Flexenclosure include large telecommunication equipment producers Ericsson, Teracom and Siemens AG (among them) (Figure 5.5)

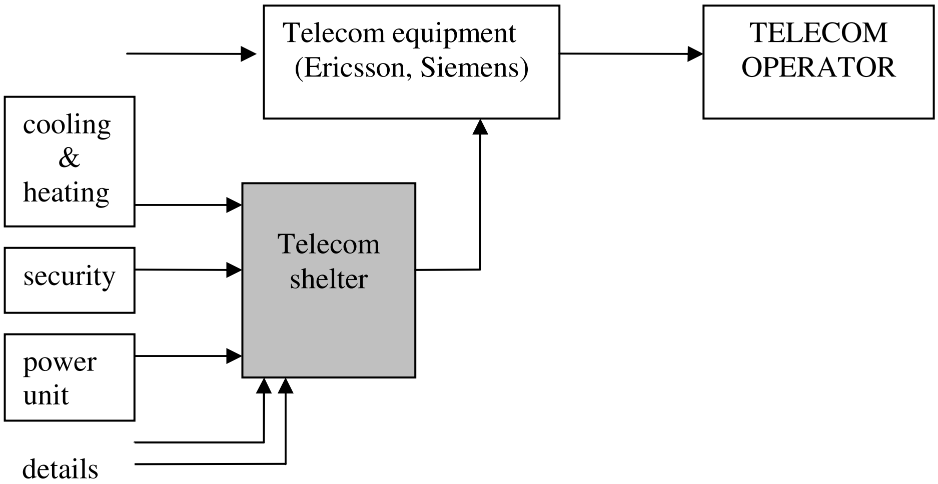

Figure 5.5 Supply chain of Flexenclosure (compiled by author)

Flexenclosure is an example of firms that innovate mainly through other firms. Other firms make breakthrough innovations and Flexenclosure adapts later its products to customer needs. The adaptation process is related to good knowledge about the suppliers, their capabilities and market in general. The small number of key customers assures for Flexenclosure tight contacts with clients and keeps communication costs low.

Location

Sõmeru is located near Tallinn-Narva highway 100 kilometres from Tallinn. The factory is housed in industrial buildings that did not find usage after the collapse of agricultural enterprises that were there before. The owner of the real estate renovated the building according to the customer's needs. Machinery was brought from Sweden. Flexenclosure case also demonstrates the importance of local public institutions in attracting investments. Simple and smooth functioning of public institutions is more important than giving big state aid.

Personnel

The manager came to the factory from Sweden. Workers and middle managers were recruited locally and training was performed in Sweden. In the Swedish factory worked 35 workers. Sõmeru hires currently 22 workers but there are plans to increase employment. Due to the fact that the enterprise is located outside the metropolis area it is hard to find qualified engineers and planners. It took 6 months to find an appropriate engineer. It was much easier to find workers. One difference between Estonian and Swedish workers is relative absence of self-initiative of Estonian workers and need for precise instructions. Where Swedish workers needed half a page of instructions then Estonian counterparts needed four pages. It could be caused by fact that there are few workers who speak and read English. Compared to Sweden there are more coordinating persons. In the future it is planned to reorganize the whole work. The share of labour costs in the total cost is around 2-3%. In Sweden it was 25%.

Outsourcing and market

There is internal an procurement unit in Sweden that negotiates and manages procurement on the basis of price, environment management and safety. The enterprise tries to source as much as possible locally. Half of the inputs by nomenclature are sourced locally in Estonia but it is planned to increase local procurement. Equipment for shelter is bought mostly from Denmark and Sweden. All products are exported. In 2005 products went to Cyprus, Sweden, Trinidad and Tobago and Haiti. In 2006 products went to Cyprus, Pakistan and Sweden. Export destinations are related to the winning of big telecommunication contracts. Relations with local authorities are very good because company offers jobs to local people. The Swedish Investment fund supported investment into Estonia. The Enterprise is a member of the Swedish Chamber of Commerce in Estonia. Design activities are performed in the Swedish mother firm. The design unit tries to find the best solution for every client's needs. It is possible that in the future certain design activities will be transferred to Estonia. The main innovations in shelter fabrication are related to the innovations in partner firms both up and down in the supply chain.

5.6. Scanfil OÜ case

Case study based on the interview with managing director Mr. Pyykönen. *Interview was made in Pärnu on 09.02.2006.*

History of Scanfil

Scanfil OY (Scanfil plc) is an international systems supplier and contract manufacturer to the communications sector and electronic industry. Scanfil OY is listed in Helsinki Stock Exchange. The second generation of the founder of company is actively involved in company management. In global sense Scanfil is a medium sized EMS (Electronics Manufacturing Service) provider with a strong European accent. Initially the company produced different mechanical and electrical parts and assemblies in Northern Finland. In 1990s were the years of rapid growth together with Nokia, Finnish and global telecommunication electronics sector (Haapasalo 2001). A big step forward was acquisition of Wecan Cables in 2002.

Production location has been determined to a large extent by mergers and acquisitions. During its history Scanfil OY had successfully managed a number of mergers. Steadily the production activities have been transferred to lower cost countries.

Table 5.3. Scanfil plc. history

	Start	Transformation
SIEVI Head office (Northern Finland)	1976	
SIEVI (Mechanics)		
SIEVI (Electronics)		
VANTAA (Helsinki Metropolitan Area)	1999	
ÄÄNEKOSKI (Central Finland)	2000 bought from Nokia Networks	
Biatorbagy, Hungary	2001 bought from Tammeron	
PÄRNU, Estonia	2002 (merger with Wecan) 1997	
Suzhou	2002 (merger with Wecan)	
Hangzhou	2003	
OULU	1990	temporary closure announced 2006
Hoboken BELGIUM	2003 (from Alcatel)	ceased 2006
Paimio		2004 transfered to Elektromet Yhtiöt Oy
Tampere (CPS Electronics)	2003 (acquisition from Metso)	2004 ceased
Kiiminki (Masera OY)		1998 transferred to other plants
JES Logistics in UK	1998	2001 striked off
Helsinki	2002 (merger with Wecan)	
Kaustinen	2000 (merger with Botnia Electro)	
Ylivieska	2002 (merger with Wecan)	2002 SMD line transferred to China
Texas	2002 (merger with Wecan)	it seems never fully operational

Source: Compiled by the author

Every acquisition is unique and the motivations are different. Besides the existing plant, technology and machinery there are also personnel skills and customer base. Access to certain customers is quite often the motivation to mergers.

Obtaining new premises raises also the question about the optimisation of company structure. New technology often requires smaller space than older machines. There is also no necessity to keep a large number of factories with separate management and big logistic and coordination costs. Management is better aware of the resources in the acquirer's company and in most cases optimisation happens around the acquirer side.

Another reason for the closure of existing plants is client migration. When big clients relocate their activities also their suppliers and service firms have to relocate their activities.

Scanfil is represented strongly in Europe and there are 2 factories in the fast growing Chinese market. Factories in Finland are located close to major electronics industry and economic centres. Sievi is in the Oulu province. Äänekoski is not far from Tampere. Vantaa is part of Greater Helsinki.

Hungarian and Estonian factories with good logistical location represent lower cost production areas in Europe. In 2005 the difference between salaries in Finland and Estonia was approximately 6 times. In China factories are located at the Yangtze river near Shanghai. The region is called Golden Triangle, because of its successful economic performance.

Every new merger and acquisition has given synergy to the mother company. The competitive advantage of the mother company has been successful management of mergers and acquisitions. The future of regional entity – Scanfil OÜ lies probably in specialization and development of proprietary know-how. Scanfil OÜ has not significantly participated in the R&D and innovation activities of the mother company because has no personnel for such activities.

Scanfil in Estonia (Scanfil OÜ)

Scanfil Estonian plant (Scanfil OÜ) is located in Pärnu. Wecan Cables (Scanfils predecessor) started its Estonian activities in Sindi by obtaining a local small electronics enterprise. Sindi is a 150 years old wool-textile centre approximately 15 kilometres from Pärnu. Several workers in Scanfil Pärnu have textile and clothing industry background. A fish processing factory operated earlier in the old premises.

In 2005 and in spring 2006 the Pärnu factory was in the stage of building big new premises. New vocational education programme and teaching in the local vocational school offer good opportunities to hire skilled personnel for the enterprise.

Pärnu industrial traditions include textile and clothing industry, which has been vanishing under the world market pressure. Last investments (2006) into machinery require higher qualification of workers than the previous technology. It is planned to retrain workers or recruit them from Pärnu vocational training centre that was opened 3 years ago. 274 is the number in Scanfil OÜ Estonian plant. Recruitment of engineers is more problematic than finding blue-collar workers for Scanfil. Regardless of professionals in Estonian electronics industry is very hard to hire engineers in Pärnu. Technical education is concentrated in Tallinn. R&D activities can also be concentrated, but product development is very rapid and demand for highly qualified workers has increased. Pärnu is a small town and to find employees with different skills is hard. Job site training and vocational training are solutions for such challenge.

Outsourcing and markets

Scanfil OÜ outsources 70-90% intermediary products. Purchases from China are not so good as it seems. Sea transport takes more time and air transport is costly. Delivery from China has not time advantage.

The share of Scanfil OÜ exports makes up 99% of the firm's turnover. The aim of the firm is to be competitive on the near markets. The export markets the Scanfil OÜ is responsible: Finland 90%, Sweden 5% and Germany 5%.

5.7. MS Baltic Trafo OÜ case

Case study based on the interview with owner-manager Michael Joachim Schmelzer. Interview was made at Vändra (Pärnu county) on 10.02.2006.

The predecessor or mother of the Estonian firm MS Balti Trafo Ltd. is the German firm Manfred Schmelzer Trafo GmbH, which was established in 1969 in West Germany. The history of MS Balti Trafo started in 1991 when German entrepreneurs made a trip to the Czech Republic. The reason for the trip was increasing labor cost and opening opportunities in Eastern Europe. Czech opportunities were rejected because it seemed too risky to establish business there. The next round of moving East was done in 1996 when owners visited Viljandi (Estonia). The visit made a good impression and the firm started in Vändra. The local municipality gave the company a chance to privatise an industrial building at the end of 1990s and in 2005 a chance to buy some additional land at a good price. In general the local municipality has been very supportive. The initial plan of the owners was to establish a good production unit and to transfer production from Germany to Estonia. However, the German unit received so many orders that it continued at full capacity.

For clarification, there are two distinct enterprises: MS Trafo GmbH located in Freiburg (Baden-Würtenberg) whose 100% owner is Manfred Helmut Schmelzer and MS Balti Trafo OÜ located in Vändra, Estonia. The owners of the later are Manfred Helmut Schmelzer 52%, Michael Joachim Schmelzer 43% and a local shareholder 5%. M.H. Schmelzer is father of M.J Schmelzer.

Production processes in both enterprises are similar. Also both enterprises are of about the same size (in Germany 85 employees and in Estonia 110-120 employees). In management and planning are working 1 manager and 3 full time design engineers in Germany. In Estonia Mr. Schmelzer spends half his time on managerial problems and the other half time on engineering problems. Both companies have family ownership and management links. Their products are almost identical.

Product and market relations with main customers or distributors

The main products of MS Trafo are transformers and inductors. Transformers are devices that must transform voltage of one size into another size. Typically they must transform high voltage into low voltage. Very often they are used in electronics and car industry. Among the main customers of MS Trafo are companies from various sectors. In most cases transformers are not going directly to product producers but to contract manufacturers. By nature a transformer is a relatively standardized product but during its production technological requirements have be followed very strictly.

Being standardized products transformers face quite strong competitive pressure from East-Asian manufacturers. The company constantly compares its prices with competitors. The variable cost structure includes 75% for materials and 25% for labour. China's price for big batches is approximately 30-50% lower (in case of more than 30000 transformers). However, in smaller batches, when the order is smaller than 10000 items, the company is competitive. The manager of the firm said: "Low market time is over in Europe. Only high-market firms will remain in Europe. The same is also true about transformers market".

Of the production of MS Balti Trafo goes 70% to MS Trafo (Germany). The remaining 30% goes to local customers (Northern Europe: Estonia, Finland and Sweden). It is planned to have half of orders portfolio from Northern European customers.

Competition is present not only from Asia but also from local suppliers. In Estonia there are at least five firms that are involved in transformer production. For three (including MS Trafo) transformer business is the main activity. Competitors are present also in Viipuri (Russia) and Latvia.

Workers and learning methods

MS Baltic Trafo OÜ has 120 employees, from whom 7 are white collars; 7-8 employees have a technical education. Relatively fewer employees than in Tallinn can speak foreign languages firms: 4-5 speak German, 3 English and 1 Finnish. The need for language skills comes from following the facts that the majority of technical documentation is in German and more of firm's partners are abroad.

At starting the first thing to do was to teach all people in the factory the proper procedures, manufacturing routines and quality requirements. Vändra is in semiindustrial agricultural settlement with limited industrial traditions. There is experience in textiles and agricultural machinery services.

In general managers considered the workers motivated and disciplined workers. Mr. Schmelzer even said that workers were more motivated to work than East-German workers. Workers are good but it was harder to find middle managers in a small place. The company educated and trained all people in Germany for 3-4 weeks. MS Trafo showed how the firm works. The manager also said that people were willing to learn and hear. Labour costs (9 euros per hour) are considerably lower than in the German mother company (30 euros per hour), but tight competition and high inflation are raising this level rapidly.

Product development and innovation

To develop product development capabilities is a sophisticated task. New products create much better profit opportunities. It is also easier to get better prices for new products. Initial presence in the development process helps also optimise production processes for needs. Principles how a transformer works are known already for more than 150 years. Despite that industrial materials and technologies are changing and clients ask also special customized transformers. Initially all transformers were designed in Germany. The German side managed also all technical documentation and applying for different certificates asked in different sectors. For getting regional customers however “own” product design capabilities were needed. The plan was to create a local design centre-group for inductor and transformer products. For that purpose MS Trafo signed a cooperation contract with Tallinn University of Technology. Until now (2006) cooperation has had limited success. Young engineers are willing to stay during university time practice and for some period longer but not much. They have leaved Vändra probably due to small settlement problems. In the future contracts of supporting students should probably be more tying to the receiving side.

Investment procedures are organized based on orders and perspectives. The company calculates and invests if there is a good market chance. Mr. Schmelzer considered investment conditions in Estonia very good. In Estonia it is possible to invest profit earned from the operations without paying income tax. MS Trafo has considered also various extension plans like adding in the future assembly operations with frames and cable-works. This could extend their product line.

The firm has got aid from the government’s funds: Enterprise Estonia that gave support for the development of business infrastructure and Phare programme supported participation in an international fair.

The start up of the firm occurred under favourable economic climate: the Estonian labour market had sufficiently free labour force and real estate prices were low. In addition to these competitive advantages the firm had possibility of using suppliers’ and consumers’ networks of the mother company. Close connections with the mother company will allow rapid introduction of new products.

The enterprise is ready to move on to the next step of development – to bring part of product development from the mother company to the Vändra plant. The main obstacle is difficulties in hiring high level technical professionals. The Estonian vocational education system has not prepared sufficiently specialists who could work in high technological manufacturing. Estonian vocational schools should prepare more mechanics and mechatronics with up-to-date knowledge.

5.8. Conclusions of case study research

The case study research showed opportunities to use theoretical concepts for analysing the firm's networks. Results of research are presented in Table 5.4. Miettinen et al. (1999) set a good example for composing such tables.

The main conclusions of case study research are:

- The majority of the successful firms started in the 1990s when Estonian business climate was more favourable than now (2007);
- The starting stage firms had a strong support from mother companies and suppliers (transferring networks, technologies, technological and organisational culture, training personnel and so on);
- Technology diffusion has been very rapid;
- Adoption of different innovations has been accompanied with the transfer of habits, attitudes and knowledge from developed countries;
- Firms are moving from simpler methods to more sophisticated ones;
- In addition to implementation and imitation firms have developed their own products;
- The economic position of Estonian enterprises has improved quite a lot during the last decade, but their negotiating power is still relatively weak;
- Asset specificity and skill specificity determine to a great extent the position in networks;
- Several companies try to create a sustainable competitive advantage through the creation of special resources like their own specific know-how and recognized brand.

In the case study research different network innovations were treated by using their classifications (Figures 5.6 and 5.7).

Table 5.4 Using concepts and interpretation of the Network and Innovation Theory

Cases	Network Theory	Innovation Theory
1. Interconnect Product Assembly AS	Participation in different subcontracting networks to diversify risks	Competence from Scotland; innovation manufacturing processes by investments in machines, equipment, information technology and training of workforce; as EMS firm IPA creates innovations with customers and in response to customer requirements and interest
2. PNJ Eesti	Initial contacts and customers' networks derive from England. Great share of English supply and demand network contains risks; increase of turnover has created supply and demand networks in Baltic Sea area; local network reduces operating costs	Competence from England; organisational innovations, transferring innovations and technical skills developed in English based sister company
3. Audes	Central position in loudspeakers manufacturing networks in Estonia; Horizontal and vertical relations with partners in product development create sustainable competitive advantage; risk is diminished by two different product lines: own production, subcontracting	Source of previous core competence was from loudspeakers producing in previous company Punane RET; Development core competence in cooperation with Lavinton laboratory; firm reached innovation stage of development, has own product and modifies it (incremental innovations); innovations are created in area that borders different fields of technology
4. Flexenclosure	Strength of relation – strong relations with mother company, using same networks	Competence from Swedish mother's company; organisational in firm innovations;
5. Scanfil	Strength of relation – strong relations with mother company, using same networks	Using acquisition has given opportunity to transfer competence from Finnish mother company; organisational innovations in enterprise
6. MS Baltic Trafo	Family based network creates strong horizontal relations; firm is using same network as parent company in Germany; new social network in Estonia	Mother firms competence of manufacturing product development; main obstacle to transfering part of product development operations to Vändra is deficiency of engineers and technical skills of workers; organisational and marketing innovations; training workers in Germany

Dominating network or innovation on the figure is dark colour. In our cases technical and organisational networks dominate, social networks are less developed and have not been a special object of our research. Firms were created in an organical way by the mother company or entrepreneur. The majority of firms are flexible SMEs, which will not make far-reaching strategical plans. They perform on regional market. Dominating innovations are incremental innovations of processes and services; new markets need strong market innovations.

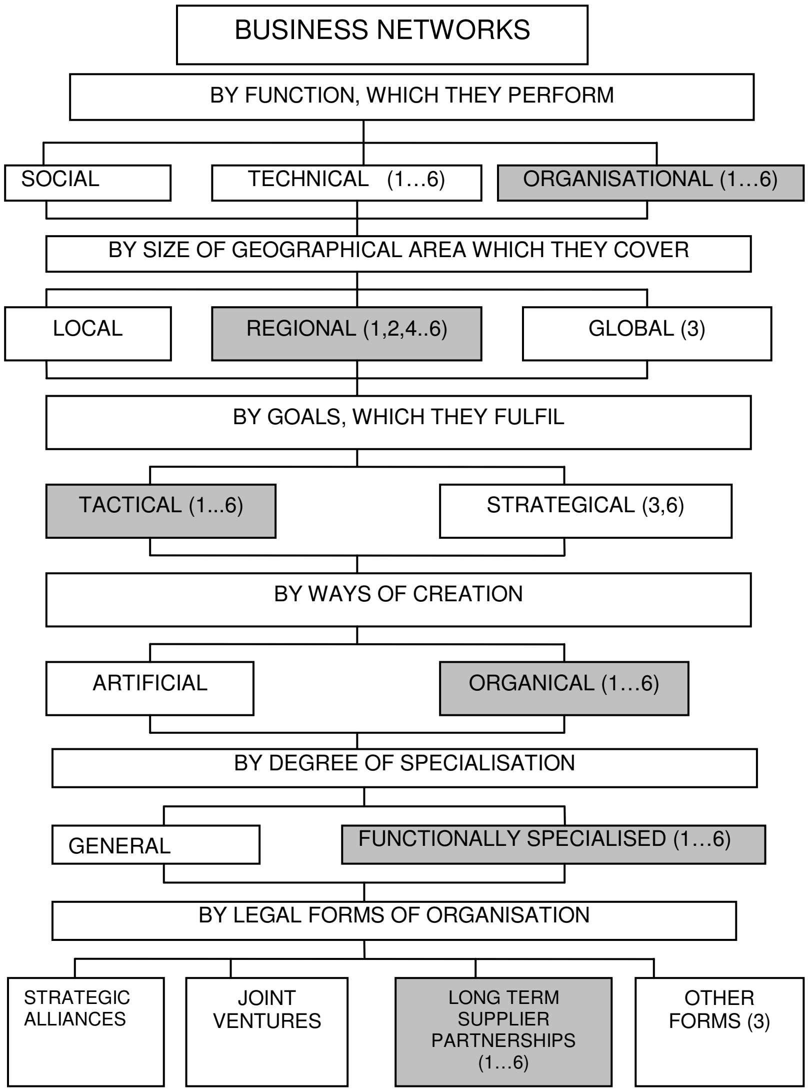

Figure 5.6 Dominating networks in the case study

The figures stand for firms (see Table 5.4). Dark colour shows dominating network or innovation.

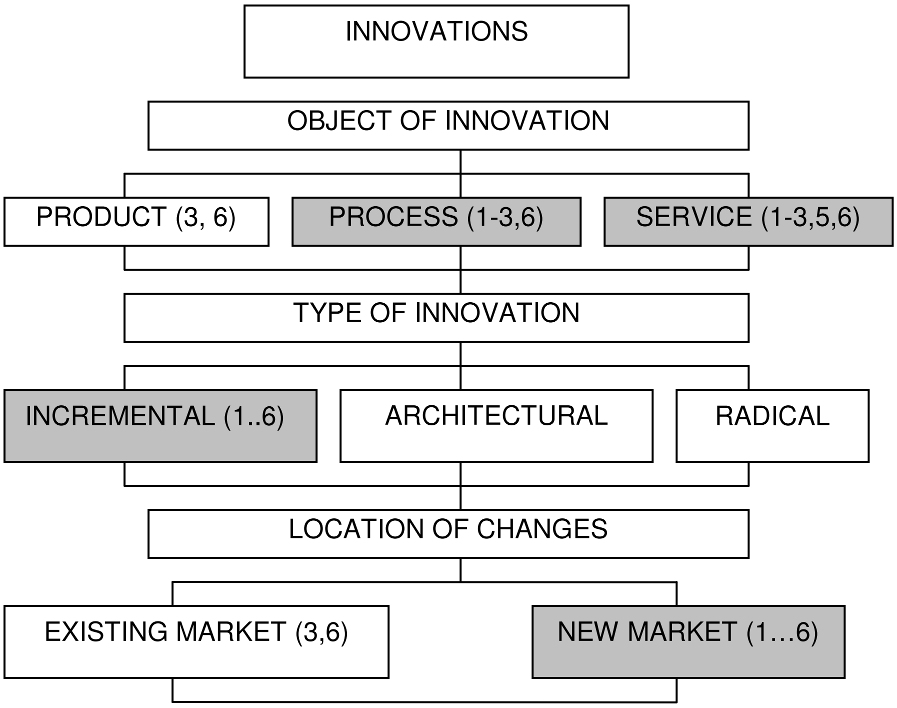

Figure 5.7 Dominating innovations in the case study. Numbers in parentheses stand for firms (see Table 5.4).

Based on the author's previous research (Lumiste 2001) and case study analysis we have made a model of subcontracting in the engineering industry (Figure 5.8). The independent variable is the size of orders. The model assumes that there are 3 different cost level areas (first area in high labour cost countries, second in medium cost level countries (Eastern Europe, Russia, Turkey) and third in very low labour cost areas (East Asia). It is expected that the final customer is situated in the high labour cost region.

A- Are the costs mostly related to the labour: direct labour cost in production, communication cost, transport cost. Also costs of adaptation that is caused by people who could make minor mistakes like imperfect drawings and imperfect specifications. There could be also processes that require additional adaptation (fixing).

B- Are the costs mostly related to the capital: machinery- and buildings cost and overhead cost.

It is definitely sensible to produce components produced in Area 1 in-house closely to the final customer. The only reason for subcontracting could be the lack of appropriate suppliers in the close area.

In Area 2 it is sensible to use suppliers at a medium distance to the buyer and with medium labour costs. Suppliers in Eastern Europe are one possible solution. Another way is to use non-specific machinery if it is possible. In the case of high volumes (Area 3) the decision depends on the share of the labour costs in the total costs of the products. If the production could be automatised the production could be performed in high cost areas. If automation is not possible outsourcing to low labour cost regions to mass producers should be done.

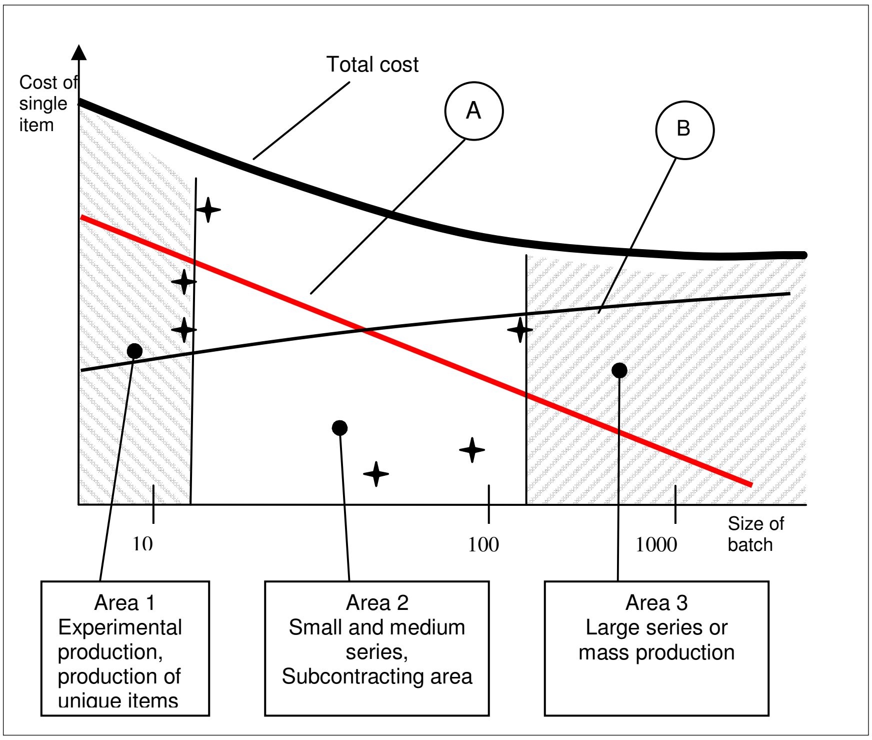

Figure 5.8 Model for subcontracting (based on the author's visits to enterprises)

For the future development the following problems are important:

- Essential task is to maintain flexibility and quality orientation,
- Using the full potential of the workforce. Workers' moving on the career ladder is complicated; they have few opportunities to become a manager or an entrepreneur.
- Bringing services and products to the market and testing them rapidly is essential. The success of technology transfer and the transfer of

production activities depends on the speed at which these processes take place. First mover advantages can have a substantial, positive effect.

- Future options are therefore to move on to the next, cost-saving location, or to increase capital endowment in the existing location and thus reduce the share of labour in total costs.
- One of the most important aspects in enterprise culture is to encourage self-initiative, innovativeness and entrepreneurial skills, on the part of larger and smaller firms alike.
- Finding right production niches and differentiation of the portfolio of products and services, creating personal and firm's network guarantee success to the firms. On the basis of those networks firms can build up in the innovation networks.
- Solving problems of recruiting engineers in the countryside and finding personnel corresponding to R&D and innovation activities.
- Enterprises could prepare to move on the next step of development – to bring part of product development from mother company to Estonian plants.
- Estonian vocational education system has not trained sufficiently specialists who could work in high technological manufacturing. Estonian vocational schools should educate more specialists in different fields of technology.

CONCLUSIONS

The conclusions answer the research questions from the introduction and theoretical chapters, present factors that influence the success of networks and innovation development and summarize important problems to be solved in industry.

Answers to research questions:

- The constructed development model based on the previous research of Gomulko (Gomulko 1971) and Rotwell (Rotwell 1994) and Xu, Chen, Guo (Xu et al. 1998) shows the prevailing connection between development stages, models and methods of innovation and should be used for future research (Figure 2.2);
- Networks and innovation classifications are potential instruments to be used in analysis and they were used in case study analysis (Figures 1.2 and 2.3);
- Only certain types of innovation are present in Estonian enterprises. At the present stage of development enterprises are not able to use all types of innovation and find excellent partners for innovations (Figure 5.7);
- Innovation needs a certain type of networks. Without definite type of networks innovation is not effective;
- Industry development model (Figure 2.1) demonstrates that innovation depends on resources development, technical/technological development, changes in industry and society. The model was used in the following qualitative analysis (chapter 5);
- Case study analysis asserts that innovation processes in Estonian enterprises are more influenced by owners and key managers than a stable economic environment (Cases 1 and 6);
- An enterprise has to choose suitable types of innovations and networks. Innovation methods are greatly influenced by local factors. The cultural context plays a crucial role. Innovation requires more imagination and other qualities that are sometimes difficult to describe, evaluate and that are rather country specific. Small and medium sized enterprises of a small country can no copy the innovation methods of large enterprises.

Factors affecting the development of industry and enterprises through networks and innovation

Based on our research, it was found that the following important problems are facing Estonian MEI and enterprises:

- Joining the European networks for the development of complementary skills and access to the new markets.

- Organic development of networks and obtaining new knowledge and learning from experience.
- Reallocation of enterprises from major urban centres to the periphery.
- Risk sharing between buyers and sellers and ways for the reduction of risk.
- Creation of innovative environment that supports the creation of small high tech firms.
- Development of relationships between big multinationals and small high tech firms.

Even though there are opportunities for practical application, the practical and theoretical proposals can no be a straightforward success for an enterprise if it does not evaluate changes in the economic environment and in economic policy. The author's research confirms the hypotheses formulated in the introduction: Innovation and networks of Estonian electronics and machinery are interdependent. Certain types of networks allow the creation of certain types of innovations and level of innovations.

Topics for future research and recommendation

The current thesis presents two basic development vectors for future research: organization and innovation. The basic question of research is how innovation processes and organizational structures are interlinked in both Estonian and a wider context. Links between the organizational form and ways to renew the enterprise and economic process remain.

Our case studies show that entrepreneurs and their different actions or behaviours were decisive for success. It is estimated that there are other factors that may influence the success of innovation. These factors are presented below for future research and discussion:

- Monitoring different information sources. Information is an important resource for a firm's successful operation. Regular technology auditing and benchmarking with other enterprises of the sector and outside it.
- Developing proprietary know-how and protection of intellectual property, including new products. It should be an integral part of the long-term innovation strategy.
- Constantly engagement in international networks and learning communities that support innovative activities and knowledge transfer. Search for strategic alliances in large-scale innovative activities.
- Co-operation with other companies in developing common marketing and supply procedures in order to create a "win-win" situation.
- Consistent use of different management methods (quality, ISO standards) and the use of corresponding consultations. Systematic use of organisational analysis techniques. Planning of an enterprise's activity should be based on the analysis of the strengths and weaknesses of the organisation.

From the perspective of using the research results the significance of various factors like geographical region, industrial sector and certain time period emerge as limiting factors. The future innovation research should be location, industry-, culture- and time-specific.

KOKKUVÕTE

Võrgustikud ja innovatsioon masina- ja elektroonikatööstuse arendamisel (Eesti juhtumite analüüs)

Uurimistöö peamiseks eesmärgiks on hinnata Eesti masina- ja elektroonikatööstuse arenguvõimet ning leida võimalusi selle tõstmiseks võrgustike ja innovatsiooni võimaluste parema ärakasutamisega. Masina- ja elektroonikatööstuse arengut võib uurida väga erinevatest aspektidest, töös on keskendutud võrgustike ja innovatsiooni mõju hindamisele Eesti masina- ja elektroonikatööstuse arengule. Uuritakse Eesti masina- ja elektroonikatööstuse firmasid ja tööstusharu tervikuna, kuid analüüs hõlmab ka üksikosi (tööjõud, tootearendus, allhanked jm.), tähelepanu pööratakse klastriefektidele ja firmade omavahelistele suhetele.

Töö teoreetilistes peatükkides keskendutakse innovatsiooni ja võrgustike toimimise põhimõtete uurimisele ning konkurentsitegurite määratlemisele. On sünteesitud mitmeid erinevaid teooriaid ja erinevate autorite poolt esitatud seisukohti, uurimaks töö esimeses ja teises peatükis toodud teoreetiliste väidete ja teooriate paikapidavust Eesti empiirilises keskkonnas.

Töö uudsus tuleneb ajalisest aspektist ning objekti spetsiifilisusest ja mis esmajoones tähendab seda, et kompleksselt ei ole Eesti masina- ja elektroonikatööstuse arengut ja uuenemist viimasel kahel kümnendil uuritud. Põhiliselt on keskendutud toimimismeetodite ja kitsamate aspektide uurimisele.

Dissertatsioon koosneb viiest peatükist, milledest kaks on teoreetilist laadi ja kolm viimast käsitlevad empiirilisi uuringuid.

Dissertatsiooni **esimene peatükk** võtab vaatluse alla võrgustikuteooria. Võrgustikuteooria aluseks on lähtekoht, et ettevõtte edukuse määrab ära esmajoones ettevõtete asend võrgustikus ja alles seejärel ettevõtte enda sisemised ressursid. Samal ajal on selge, et ilma sisemiste ressurssideta ei ole võimalik mingit kindlat kohta võrgustikus omandada ja hoida.

Põhiliseks uurimisühikuks võrgustikuteoorias on suhe kahe ettevõtte vahel. Innovatsioon on üks olulisemaid tegevusi, kus ettevõte ja eriti väikeettevõte vajab head koostöövõrgustikku, kuna tänapäeval tehnoloogiline areng nõuab toodete kiirelt turule toomist ja pidevat arendamist, mis aga üksikule ettevõttele võib üle jõu käia.

Teises peatükis innovatsiooni käsitlemisel lähtutakse eelkõige Joseph Schumpeteri (1911), Rogersi (1962, 1976), Davise ja Northi (1971), Freemani (1982), Lundvalli (1992), Nelsoni (1993, 1982), Druckeri (1999), Chuanqi (1999,2000) jt. seisukohtadest ning OECD Oslo (1992) ja Frascati (2002) manuaalides toodud metodoloogiast ja terminoloogiast. Käsitlemist leiavad nii toote, protsessi, turunduse kui ka organisatsioonilised innovatsioonid.

Domineerivaks meetodiks Eesti masina- ja elektroonikatööstuse innovatsioonis on tehnoloogia siire välisinvesteeringute kaudu. Tehnoloogia siire on paljudel juhtudel seotud nii kohalike kui ka imporditud lahenduste kombineerimisega kohalikku keskkonda.

Kolmandas peatükis analüüsitakse Eesti masina- ja elektroonikatööstuse konkurentsipositsiooni, vaadeldakse tööstusharu arengut ja väidetakse, et tõuke Eesti ettevõtete kiireks arenguks andis allhanketellimuste tulek eelmise sajandi 90-ndate aastate keskel.

Neljas peatükk käsitleb innovatsiooni osa konkurentsieeliste loomisel, milles kasutati Euroopa Liidus läbi viidud innovatsiooniuuringute materjale (CIS 3ja CIS 4), millises uuringus ka ise osaleti. Eesti Statistikaameti poolt loodud andmebaasi kasutades on tehtud Eesti masina- ja elektroonikatööstuse ettevõtete detailsema uuring.

Kolmandas ja neljandas peatükis leidis kinnitust seisukoht majanduse astmelisest arengust. Eesti majandus ning masina- ja elektroonikatööstus on arenenud astmeliselt ja on jõudnud viieastmelisel arenguskaalal kolmandale astmele, jõudmine arengu järgmisele astmele sõltub majandusharu innovatsioonipotentsiaali väljaarendamisest.

Viies peatükk käsitleb Eesti masina- ja elektroonikatööstuse ettevõtete hulgas läbi viidud empiirilist uuringut, mille puhul kasutati juhtumite uurimismeetodeid (*case study research methods*), et saada sügavamalt aru nii uuritavast objektist (masina- ja elektroonikatööstuse ettevõtted) kui ka uuritavate probleemidest (võrgustikud, innovatsioon) kvalitatiivse analüüsi abil. Juhtumite analüüsi eesmärk oli kontrollida töö teoreetilises osas püstitatud hüpoteeside paikapidavust ja väljatöötatud mudelite rakendatavust.

Kokkuvõtteks töö olulisemad järeldused:

1. Liberaalne ja avatud majandus on võimaldanud Eesti masina- ja elektroonikatööstuse ettevõtetel kiiresti ja edukalt ümber struktureeruda;
2. Järgmine astmele jõudmine - efektiivselt töötavate innovatsioonivõrgustike ja ettevõttesisese innovatiivse kliima loomine - nõuab suuremat panustamist üleeuroopalistele institutsioonidele ja ettevõtluslikule vaimule;
3. Tõus majandusharu arengu uuele astmele nõuab uut tüüpi innovatsioone ja sellel vastavate võrgustike loomist, millega kaasneb tegutsevate süsteemide järjekordne ümberstruktureerimine ja vajaduse korral ka osaline likvideerimine;
4. Töös välja töötatud võrgustike ja innovatsiooni mudeleid on ja saab kasutada edasistes uuringutes - a)võrgustike klassifikatsiooni mudel ja allhanke mudel; (b)majandusharu arengu mudel seostes tehniliste ja tehnoloogiliiste protsesside arenguga; (c)majanduse ja innovatsiooni astmelise arengu mudel seostes innovatsiooni meetodite ja tüüpidega; (d) (d) innovatsioonide klassifikatsiooni mudel ja (e)mudel, mis kirjeldab ettevõtte ressursside, võrgustike ja innovatsiooni vahelisi seoseid;

5. Võrgustike kvaliteet sõltub kontaktide kvaliteedist neis võrgustikes ja inimkapitali kvaliteedist;
6. Eduka osalemise võrgustikes määrab spetsiifiliste aktivate ja oskuste olemasolu;
7. Omandist sõltub võrgustiku tüüp, omandi struktuur mõjutab innovatsiooni meetodite valikut;
8. Tarnevõrgustikud on olulised ettevõtte arenguks;
9. Erineval innovatsiooni tasemel olevad ettevõtted kasutavad erinevaid innovatsiooni meetodeid ja ressursse, kusjuures keerulisemad innovatsiooni meetodid nõuavad kõrgemat inimkapitali kvaliteeti;
10. Erineva innovatsiooni tasemega ettevõtted on ka erineva innovatsiooni kulude tasemega;
11. Innovatsioon Eesti masinaehituse ja elektroonika ettevõtetes praegusel arengutasemel ei baseeru uurimis- ja arendustegevusel;
12. Riigi poolne toetus märgib väikest osa innovatsiooni protsessis ja on marginaalne praegusel ajaetapil.

Töös välja toodud tähtsamad soovitused innovatiivsuse tõstmiseks on:

- Informatsiooni kui ettevõtete jaoks tähtsa ressursi pidev hankimine ja töötlemine;
- Ettevõtete tehnilise ja tehnoloogilise taseme hindamine läbi tehnoloogia auditite;
- Intellektuaal omandi kaitse korraldamine;
- Koopereerumine ettevõtete, teadusasutuste ja ülikoolide vahel;
- Innovatiivse tehnoloogia, toodete, kvaliteedi- ja juhtimissüsteemide ülevõtmine koostööpartneritelt;
- Kompleksne lähenemine innovatsioonile, hõlmates innovatsiooniga ettevõtte tegevuse erinevaid valdkondi;
- Koostöö arendamine Eestis paiknevate välisomandis olevate ettevõtetega kaasates neid võrgustikessse koos Eesti ettevõtete, teadus- ja uurimisasutuste, ülikoolide ja kohalike omavalitsustega;
- Seada innovatsioonipoliitika eesmärgiks keerukamate ja konkurentsivõimelisemate toodete ja teenuste loomine ja tootmine;
- Ühitada innovatsiooni- ning haridus- ja teaduspoliitika ettevõtete innovatiivsuse toetamiseks.

Käesolev uurimus on üks esimesi nii kompleksselt Eesti tööstusharu arengut käsitlev töö. Järgmistes uuringutes tuleks detailsemalt käsitleda järgmisi üksikküsimusi: erinevate innovatsiooni allikate monitooring, intellektuaalomandi kaitse, personali poliitika sidumine ettevõtte strateegiaga; keskendumine ettevõtjale ja tema isikuomadustele innovatsiooni protsessis, ettevõtete koopereerumine innovatsiooni protsessis ja tehnoloogia siirdamisel, erinevate juhtimismeetodite ja konsultatsiooniteenuste kasutamine innovatsiooni protsessis, sotsiaalsete, geograafiliste ja kultuuriliste tegurite mõju innovatsioonile.

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ABSTRACT

The thesis contains five chapters. The first and second chapter of the thesis will introduce the main theoretical schools (conceptions), explaining the interaction between enterprises. The Network Theory and Innovation Theory were chosen as primary theories because they describe more adequately development processes of industry. The third, fourth and fifth chapters have empirical character. In the third chapter, the author analyses the major indicators of Estonian machinery and electronics industry. The fourth chapter describes and analyses innovation methods in machinery and electronics industry. In the fifth chapter after quantitative analysis of machinery and electronics industry in previous chapter a deeper qualitative analysis of networks and innovation is made by using case study research method.

In the final conclusion we give the information what hypothesis and propositions found evidence and what didn't found. In conclusions we also stress to the most important parts of theory that found evidence in Estonian machinery and electronics industries. The thesis ends with conclusions and recommendations and with the potential further work and suggestions for future studies.

Keywords: Networks, innovation, machinery industry, electronics industry

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Graduated in class of Mathematics and Physics

Employment Experience

2003	Researcher, Tallinn Technical University
2001	researcher Bank of Estonia
1999 - 2000	Deputy Director (Industrial Policy) Confederation of Employers and Industry of Estonia
Nov. 1995 - 1999	Head of Industrial Policy Department Ministry of Economic Affairs, Tallinn, Estonia Ministry of Economic Affairs, Tallinn, Estonia
Aug. 1992 - Aug. 1994	Project Supervisor Estonian State Board of Technical Inspection, Tallinn,
1992	Workshop Instructor Norwegian National Institute of Technology, Stavanger, Norway
1991 - 1992	Computer-operator Pioneer, Tallinn, Estonia

Language skills: Estonian (mother tongue), fluently English and Russian. Able to understand and speak basic issues in German and Finnish.

Training courses

1993-2000 has attended several training courses about economic development, intellectual property rights, sustainable development, quality systems and EU accession.

Elulookirjeldus

Curriculum Vitae

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Töökogemus

2002-	Teadur, Tallinna Tehnikaülikool
Juuli 2001	Eesti Pank külalisuurija, Majandusuuringute osakond
1999-2000	Tegevdirektori asetäitja, Eesti Tööstuse ja Tööandjate Keskliit
Nov. 1995–Veeb.1999	Tööstuspoliitika osakonna juhataja, Majandusministeerium
Jan. 1998	Eesti ja Euroopa Liidu vaheliste läbirääkimiste delegatsiooni liige
Sept. 1994 - Nov. 1995	EUREKA T&A projekti koordinaator Majandusministeerium, Tallinn
Aug. 1992 - Aug. 1994	gaasitehniliste tööde inspektor Eesti Tehnilise Järelevalve Amet, Tallinn

Haridus

2001 Euroopa Doktoriõppe programm (Ettevõtlus ja väikeettevõtete juhtimine) Universitat Autonoma de Barcelona, Växjö Ülikool (Rootsi)

1999- 2005 Tartu Ülikool, Rahanduse ja arvestuse Instituut. doktorant

1997 Tallinna Tehnikaülikool majandusteaduste magister

1992 Tallinna Tehnikaülikool mehaanikainsener (spetsialiseerumine robottehnika)

1985 Pärnu 2. Keskkool. Matemaatika-füüsika eriklass

Lisatööd

Lisaks põhitöökohal töötamisele olen tegev veel ärikonsultatsiooni valdkonnas ja kirjutanud mitmetele väljaannetele artikleid (**Äripäev**, Postimees, Sõnumileht, Ärielu ja Väliskaubanduse Teataja) ja avaldanud teadusartikleid ja raamatuid.

Keeleoskus: Suuteline rääkima, lugema ja kirjutama **eesti, vene** ja **inglise** keeles.
Piiratud keeleoskus **saksa, hispaania ja soome** keeles.

Perekonnaseis: abielus, 2 tütart