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## **Building knowledge base through R&D networking: Enterprises in the Regional University Knowledge Centre for Vehicle Industry**

First draft

### ***Introduction***

The socio-economic importance of networks is nowadays evident and researchers from different disciplines try to shed light on their background, characteristics and impact but there are still a lot do and research. Networks are not new to the economic area (e.g. in the form of guilds or holdings) but since the 1970s and '80s their number and importance has risen sharply. (Hagedoorn, 2000, 2002)

At the beginning of the new century the main engine of economic growth is technology development, research and development (R&D), and innovation all based on new knowledge. Growth is based on increasingly complex, cost- and knowledge intensive activities. This is a situation which enterprises do not want to / cannot cope with alone, therefore innovation is now a collective process where networks play an important, central role. (Özman, 2006) This underlies the importance of getting knowledge on the functioning of networks or understanding the impact of influencing factors on networks, and so the socio-economic impact of networks.

In this paper one case study of my thesis will be presented. The firms have applied for government funding to strengthen their R&D collaboration and they formed – together with the ‘Széchenyi István’ University – the *Regional University Knowledge Centre for Vehicle Industry (JRET)*. However this is not the only collaboration they are engaged therefore the three firms and their *relationships inside and outside of the JRET will be analysed*. The industry has a very important role in the Hungarian economy and it is one of those medium-high tech industries that are very characteristic for the economy. (These knowledge centres also 'help' to get more information on university-industry collaborations.)

The next section shortly overviews some relevant theories concerning R&D collaborations that could be applied in the investigation of the Hungarian situation. The main types of R&D networks, trends and broader socio-economic connections will be mentioned to place Hungary and Hungarian firms into that 'environment'. It is followed by a short overview of the whole research to show the ultimate purpose of the investigation. The fourth section turns to the roots of the investigated case by showing its environment – national, regional sectoral characteristics. This part also gives an insight into the role of some external factors influencing R&D collaborations. The following section provides an overview of the main investigated actors and of the role R&D collaboration plays for them based on some written sources and on the information from the interviewees. The sixth and seventh parts turn to investigate the R&D network of the partners inside and outside of the Regional University Knowledge Centre for Vehicle Industry focusing on the basic structure and characteristics of the whole network and of the bilateral relationships. It also takes into account the impact of the R&D network on the firms themselves and on their environment. The analysis will rely on

methods loaned from social network analysis, like those involved in the PAJEK software. The paper concludes with some emerging findings.

### ***Theoretical background***

During the past 3-4 decades more and more researchers from various disciplines turned towards the investigation of networks. Physicists, mathematicians, sociologists, economists, biologists realized how important role these networks have in their discipline. *R&D networks* become a central feature for evolutionary economists in the past two and a half decades but some theories of sociology and more precisely social network analysis are also relevant for our topic. The next few paragraphs will summarise some of the main statements of these strand of theories.

Since the 1980s more and more economists emphasized the relevance of *interactive, systemic view of innovation* against the traditional linear models. (Nelson and Winter 1982, Kline and Rosenberg 1986) In their view R&D and innovation – which became the main factor of economic growth and competitiveness – is a continuous, 'evolutionary' process which builds on the past experiences and thus resulting in path-dependency (or technological trajectory) which enables higher specialization. On the one hand R&D and innovation become more complex, knowledge intensive, while on the other hand enterprises – to keep up competitiveness – concentrate on more specific areas (which have the higher profit promises for the firm). Therefore there is a growing territory where inter-firm (or even inter-sectoral) collaborations, networks gain on importance. Looking at R&D and innovation activities many economists found that they are best analysed in the framework of national, regional or sectoral *innovation systems* to explain their impact on and differences in national performance and competitiveness. (Lundvall 1992, Nelson 1993, Edquist 1997) They found that the collaboration between the diverse actors in R&D and innovation – enterprises, research institutes, higher education research centres and other direct or indirect participants, institutions - is key to international competitiveness. This view assumes the recognition that there is a very diverse source of new knowledge in the knowledge production process and enterprises are highly interested to get near and access these sources. (It is also found that among the knowledge sources the role of higher education is increasing.) The knowledge involved in R&D and innovation is more complex and specialized than it was 3 or 4 decades ago therefore those regions, where the critical mass of up-to-date knowledge in a cross-fertile interdisciplinary environment is at hand, are becoming more important. This strengthens regionalization against or beside globalization. Another approach to the relationship between the different sectors involved in innovation process is the '*triple helix*' model (Etzkowitz és Lleydesdorff, 1997) which emphasises more the evolutionary character of this phenomena. The "triple helix" is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. (Etzkowitz, 2002, p. 2.) It emphasizes the importance of university-industry-government collaboration in three dimensions: a) the internal transformation in each of the helices, b) the influence of one helix on another and c) the creation of a new overlay of trilateral networks and organisations from the interaction among the three helices.

There are many types and categories of the collaboration among firms and other actors to be found in the literature. Previously most of these collaborations were based on equity agreement but in the last three decades the number of non-equity agreement is constantly growing and become more popular. (Hagedoorn, 2002) Joint ventures belong to the first category while strategic alliances and networks represent the latter. Although the use of these

terms are not solid in the literature for our purposes a network is “a specific organisation form of economic activities directed toward the realisation of competitive advantages. They are characterised by complex-reciprocal cooperative rather than competitive and relatively stable relationships between legally independent corporations.” (Sydow, 1999 in Kreis-Hoyer & Grünberg, 2002, p.2.). One possible categorization of networks are offered by Fischer (2002, p. 8), differentiating five types based on horizontal and vertical collaborations:

- buyer's network,
- supplier's network,
- production network
- technology network and
- research and development network.

The first three types are vertical, the latter two types are horizontal networks. There could be many other possible categorization, e.g. based on the types of partners. The case in this paper is an R&D network in which participants from the industry as well as from the higher education take part.

Independent from the chosen approach or categorisation all author agrees with the view that the investigation of networks could not be separated from its *socio-economic environment*. So far there are only a few studies to systematically investigate this interaction. In such a work economists might 'borrow' theories and methods from *sociology*. (A similar path is followed by Glising, 2005 too.) Since the now seminal work of Granovetter (1973), which investigated the role of weak and strong ties, and after works on the social embeddedness of economic actors there is an increasing strand of sociological literature dealing with networks. A group of scholars emphasize the role and importance of dense networks and strong ties that build up social capital (Coleman, 1988) and trust among partners, while their opponents argue for the importance of structural holes (Burt, 1992) and weak ties enabling the actors to access a wide range of (non-redundant) information. The truth – in practice – is possibly somewhere between the two extremes, that is the actors should maintain a mix of both to maintain a successful network. (Hagedoorn et al., 2005.) *Social network analysis* is one of the increasingly popular fields of sociology that developed own tools for the investigation of complex web of contacts. Its main strength is the investigation of the objectives – individuals, groups, institutions – in their social context. It allows a ‘multi-level’ (micro and macro) analysis to better map not only the features of certain entities but also the quality, quantity, way and extent of the interactions among those entities. This approach is highly relevant if we accept the interdependence of the actors and their activities in the economic field, the importance of the relational ties in innovative activities (technology transfer, diffusion of innovation etc.) and the need for information about the structural environment of the actors. (Wassermann and Faust, 1994.) The case study will rely on the methodologies of social network analysis and use a specialist software to visualize and analyse the R&D network of actors.

### ***Research questions and methodology***

One of the important aims of this research is to investigate the scientific and technological capabilities (and their evolution) of the Hungarian firms participating in R&D networks. In order to achieve real benefits from these collaborations they need to develop their S&T capabilities in knowledge production, diffusion and utilization. The success to acquire and utilize new knowledge is determined by the level of absorptive capacity at and very much depends on the human resources of the enterprise. The result might be new

products, services and processes or – at a more general level - a more competitive organisation.

*This study investigates the pattern of R&D collaborations of a few selected partners from the automotive industry who are also participating in one of the governmental programs enhancing R&D collaboration. It will look at the major characteristics of the R&D network and investigate if it shows any national/regional specificities. It also investigates how and how much could the Hungarian firms benefit from these R&D collaborations and what are the most promising ways to achieve those benefits.*

Hungary put more emphasis on R&D and innovation performance and on the maximization of results obtained from those activities. A good way to improve on the performance is to enhance collaboration and information flow among participants and to additional benefits from resource concentration. The Government in recent years also modified its supporting schemes in order to better respond to these new needs and they put more emphasis on R&D collaborations. However our knowledge on R&D collaborations between the economy and academia (higher education research centres and other governmental research institutes) are rather limited and even so in the case of inter-firm collaborations and networks.

The research concentrates on R&D networks that bring together actors from the different sectors of the national innovation system with the ultimate aim of enhancing the regional economy through increased R&D collaboration. One of the major initiatives of the Government in the past 4 years was the launch of the Regional University Knowledge Centres program (later re-named 'Pázmány Péter' program) targeting the R&D collaboration of a broad variety of actors. In this framework a number of durable (at least in the middle-term) partnerships – aiming a critical mass of human resources for internationally competitive research - were established with state support. The case analysed in the next sections received support from this scheme. These networks require very diverse abilities from the partners but in turn they provide access to a broader variety of complementary competences. They also enable the access to tacit knowledge (Polányi, 1983) which would be difficult to acquire without such a close collaboration. To maximize these advantages it is very important to develop trust and reciprocity among the partners which will also indicate the level of the generated social capital within the network. (Orbán & Szántó, 2005)

According to the type of research questions the empirical approach is based on a case study, which enable to explore and describe the relationships among the partners, the mechanisms and the impacts behind them. The advantage of the case study methodology is opportunity to get in-depth information through semi-structured interviews about the functioning of certain partnerships, insights into the interrelatedness of the activities. Combining this method with social network analysis (SNA) enables not only to draw a picture or map of an R&D network but to understand the reasons behind the structure, the motivations and the results of the collaboration. With SNA the measurement of the strength of linkages, prestige, intermediation, structural equivalence can be done, which might strengthen or weaken the qualitative information gained from the interviews. Thus not only the control of the information is achieved but also the analysis is based on the combination of qualitative and quantitative data. (Although this paper do not utilize it but the final thesis will draw upon the available few statistical data to support the analysis.) In order to understand not only the channels of knowledge flows but also the relevance of the knowledge transmitted through these channels the interviews always reflect the position of the interviewee (and therefore they are not identical in all cases). In the next sections the R&D network of three automotive companies will be analysed. The applied information is drawn from interviews done with:

Imre Czinege (university professor), Károly Kardos (university deputy dean), Péter Tamás Szilasi (director of knowledge centre), Szabolcs Horváth (Borsodi Kft., manager), Károly Szócs (Rába Futómű Kft director), Zoltán Ódor, Péter Stasztny and Ottó Klementis (Sapu Bt, managers).

## ***Origins of collaboration***

### *The environment*

Győr is located in the north-western part of Hungary very near to the Austrian and Slovakian border. It is the major city of Győr-Moson-Sopron county which is the most developed one among the three counties (the other two is Vas and Zala) that together form the West-Transdanubian region. Since the transition the region – and especially Győr city – became a popular location for many foreign direct investors, multinational companies establishing plants in the country and foreign SMEs. This process was supported by the establishment of the “first working industrial park in Central and Eastern Europe” in 1992 (now with 82 firms with owners from 10 different countries). ([www.ipgyor.hu](http://www.ipgyor.hu)) Since that time the number of industrial parks has grown to 18 in the region and 5 in the county. Such industrial parks were an important tool in Hungary for attracting investments and foreign multinationals by providing good infrastructure for enterprises also in less developed regions. Clearly the most important company in the automotive industry is Audi since its settlement in Győr in 1993, becoming one of the largest companies of the country. It is not only manufacture engines and assembly sport cars but in 1999 it established an R&D centre as an extension of its R&D headquarters in Ingolstadt. Another major player in the sector is the Hungarian Rába company which managed to survive the shock of the loss of the eastern markets for its trucks and other products after the transition. Beside them there is a broad list of large and small car-parts manufacturers either Hungarian or foreign-owned companies (e.g. LuK, B.O.S., Borsodi Művek) settled in the industrial park of Győr or established plants in nearby settlements – which was inspired in many cases by tax exemptions or deductions by the local authorities – also to lower the local unemployment.

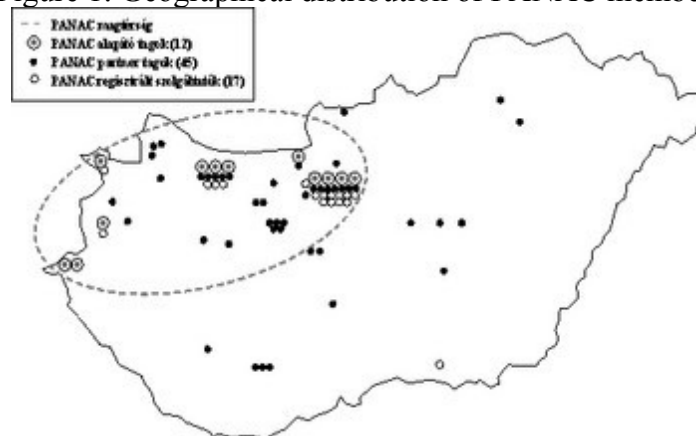
As a result the region became the most industrialized part of Hungary and the size of the industrial output per inhabitants in 2004 was the second largest in the country (following Budapest) and the GDP per capita was 7.6% higher than the national average. *Manufacturing industry* provided the 92% of the industrial output of the region in 2004. An important feature of the region's economy is that 80% of the revenue in the manufacturing industry and 75% of that in the total industry came from export sales in 2004. Ten per cent of all companies with foreign interest in Hungary are located in the region (mainly in Győr-Moson-Sopron) and 88% of them are fully foreign-owned, while this share for total Hungary is only 49%. The vast majority of foreign investments was realized in the internationally competitive manufacturing industry. Within manufacturing industry the *machine industry* (and more specifically the road vehicle production) provides two-thirds of the industrial output and 84% of the industrial export. Almost 70% of the industry sales of the region is realized in Győr-Moson-Sopron county. (KSH, 2005b.) Twenty-four of the 50 largest (by revenue and employees) company in the region is located in the county and 8 of them (overall 14 of the 50) involved in the automotive industry (among others the three overall largest companies). (KSH 2005a) Therefore we can say that majority of the enterprises in the region are concentrated in the same county as SZE and their physical proximity to the university might help to build industry-university linkages. The belief about the importance of university linkages was strengthened during the interview with one of the deputy deans of the SZE who

strengthened that *they have some kind of relationship with the majority of the enterprises at the industrial park. And even many newcomer firms get into contact with them before settling down in the region.*

#### *The local automotive industry*

After the initiative of a few large automotive company the PANAC (Pannon Automotive Cluster) was born to support Hungarian suppliers to latch on to the global supplier chains, to improve their quality and value added, to help the internationalization of the members and to improve their visibility In Hungary and Europe. The founding members were large multinational companies (MNCs): Audi, GM-Opel, LuK and the Rába Holding. Majority of the founding companies and other participants are located in the north-west part of Hungary (near to Austria, Slovakia and to the highway towards Western-Europe). Towards the end of 2001 the region's largest university (SZE) joined the cluster to enrich the knowledge base of PANAC. The geographical position of founding members and other participants of PANAC can be seen in figure 1. The two biggest centres, Budapest and Győr, clearly stands out.

Figure 1: Geographical distribution of PANAC members



Source: [http://autocluster.hu/content\\_2-en.html](http://autocluster.hu/content_2-en.html)

Notes:  
 core territory  
 founding members  
 partners  
 registered service organisations

This was one of the first cluster-initiatives in the country however according to T. Szilasi, who has first-hand information on the functioning of the organization, in Hungary such clusters are *'misconstructed tools'*. *'At the present state of development of firms in Hungary it is difficult to build successful networks. Firms are still searching their position on the market, heavily production-oriented which all act against collaboration. Collaboration could be intensified if these firms became ready to solve problems beyond their present knowledge base but this is only possible once they are 'established organisations'.'* This statement might be the translation into practice of the theoretical observation that only firms who are investing in R&D and able to build proper absorptive capacity can improve to a higher level their R&D and innovation activity. The case of the firms who are participating in the JRET shed some light on the way they became more engaged in collaborative R&D and innovation activity.

### *Government support for collaboration*

When the government launched a new program in 2004 for the establishment of *Regional University Knowledge Centres* (RUKC) there were already established relationships on which a new network could be built.<sup>1</sup> The main aim of this program is to create regional knowledge centres with the collaboration of university, industry and government partners (universities as main actors) for high-level R&D and innovative activities for the benefit of their regional environment. The program targets networks that bring together the whole ‘innovation-chain’ and concentrate a critical mass of financial and human resources. The program would like to achieve the born of long-lasting structures that will exist also beyond the duration of the governmental support. In the first round (2004) HUF 9bn (approx. € 35m) was awarded for 6 consortia to support their operation in their first four years. In the case of industrial partners the requested subsidy should be complemented with at least the same amount from own sources. (Inzelt, 2005.) SZE has applied for support in the second round in 2005 when the framework conditions were slightly modified. In this year 6 consortia received HUF 6bn (approx. EUR 24m) of which HUF 1.1 bn (EUR 4.5m) was awarded for 3 years (2006-2008) for the *University-based Knowledge Centre for Vehicle Industry* (JRET) established at SZE. (It has to be noted that another knowledge centre in the automotive industry received support in the first round but the focus of the two centres are complementary.) The industrial partners have to provide twice as much own financial sources as their governmental support for the project. In our case the participants own contribution amounts to HUF 713m (EUR 2.8m). The government support could be used for basic research (if they lay the foundation of further innovative activities), applied research, and experimental development within defined proportions (e.g. the share experimental development cannot be higher than 50%). The support could be used also for purchasing different equipments as well as for investing in the necessary infrastructure but they all have to be realized at the host university thus securing its future regional utilisation and strengthening the role of the university in knowledge generation and distribution.

### *Regional University Knowledge Centre for Vehicle Industry (JRET)*

The JRET, in accordance with the industrial traditions and development perspectives of the Győr region, specialized itself within the automotive industry to the research of vehicle production technology, component design and development. It is established at the “*Széchenyi István*” University (SZE) in Győr, which was established as a polytechnic institute in 1968 to fulfil the needs for engineers of two main industry: transportation and telecommunication. After 1990 the Hungarian higher education institutions went through on many changes and the previous polytechnic institute has broadened its training to BSc, MSc, and PhD level courses in engineering, social, and life sciences to become a university in 2001.

The JRET targets to support *innovations to Hungary* and the development of the knowledge base in automotive industry and mechatronics. JRET “*operates as a scientific and technology innovation centre, which coordinates a regional R&D network in cooperation with the private sector, thus enhancing the competitiveness of the country as well as the technological and economical development of the region*”; ([www.sze.hu/jret/en/index.htm](http://www.sze.hu/jret/en/index.htm)) of course the latter part of the statement is still have to be realized. The JRET partners have very different backgrounds and thus almost the whole industrial structure is represented in the JRET. This varied content of the consortium have benefits but might generate some (managerial) concerns too. The scientific programme of RUKC consists of three main parts:

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1 In Hungary the government tries to enhance university-industry linkages since the late 1990s. (See more details in Inzelt, 2003.) First they favoured the establishment of consortia within the old-type programs and then the Cooperative Research Centres scheme was the first initiative directly supporting these activities.

1. Complex research of manufacturing processes and tools of highly complicated, high-quality vehicle parts and components
2. Development of complex modules and systems of vehicles and research of their related diagnostic procedures
3. Technology and knowledge transfer activities

*“By generating 6-8 new full-time research positions, and through involving professors, lecturers and PhD students of the University, and by adding top-of-the-art research equipment, the aim of the Knowledge Center is to build up a significant and internationally competitive research capacity on the knowledge-base of the Széchenyi István University. This would support our partners in the Consortium and other partners of the Knowledge Center to develop and produce globally competitive, high value added products.”* ([www.sze.hu/jret/en/index.htm](http://www.sze.hu/jret/en/index.htm)) This aim is in line with the government's target to help the establishment of durable relationships for R&D and innovation activities. Therefore the RUKCs are expected to generate own income in the medium-term to be able to survive without government support. This presumes some entrepreneurial activity from the centre itself and that the research conducted by them is not solely for the current purposes of the partners.

The Regional University Knowledge Centre was established with the participation of the local university and with some important enterprises of the region's economy that are obviously more active in collaborative R&D and generally spend more on R&D than the average enterprises in the region or in the country. Therefore it seems beneficial to look at the collaboration network of these actors and analyse the pattern and other characteristics of their R&D collaborations to gain more knowledge how these relationships affect the firms themselves and their environment. In the investigation a specific consideration is paid to JRET – as the most complex collaboration scheme of the participants - but not constraint exclusively to that scheme. Rather it maps all type of R&D partnerships of the JRET participants to be able to give a more comprehensive and well grounded picture on the extent and relevance of R&D activities at the chosen enterprises.

### ***Overview of main participants***

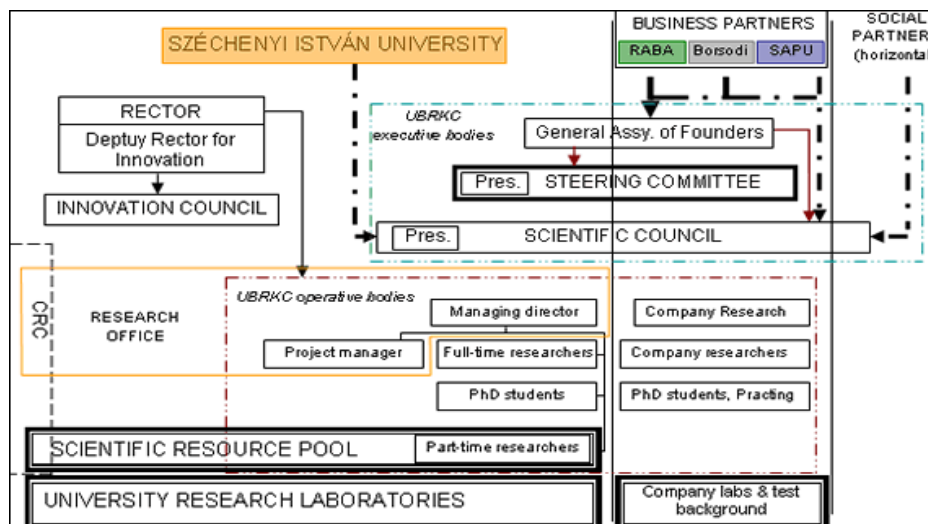
The JRET consortium is made up of four independent partners: the “Széchenyi István” University (SZE), the Rába Axles Ltd (Rába) , Borsodi Műhely Ltd (Borsodi), and the Schefenacker Automotive Parts Ungarn (SAPU) Lp. They all have very different background and focus of interest therefore their collaboration could have been a very fruitful initiative.

The SZE, as required by the supporting scheme, acts as the physical host and leader of the JRET consortium. *“Its main majors rely on the electronic and vehicle industry, which are remarkably strong in the region, moreover on infrastructural development and operation and on the management and international relations of the companies and public institutions working in this field.”* ([www.sze.hu/jret/en/index.htm](http://www.sze.hu/jret/en/index.htm)). To enhance the university-industry collaboration the centre is set up as a new unit at the university with the same rights and responsibilities as the faculties. (The problems of university-industry collaboration within the Regional University Knowledge Centre scheme are discussed in Inzelt, 2004) This also enhances the possibilities of working in a real multi-disciplinary environment as most of the industrially relevant problems to solve are multi-disciplinary in nature. The SZE serves as the main source of young engineers employed by these companies but there are other relationships between university and industry too. SZE has built an internationally recognized knowledge base and laboratory with up-to-date equipment related to research for the automotive industry. They are a useful partner for many automotive company and

furthermore can provide important services for the SMEs who cannot afford and run effectively those expensive equipments that are now available at the university. The Department of Materials- and Vehicle Manufacturing Engineering at SZE generates yearly HUF 100m (approx. EUR 400k) from common projects with industrial partners of which 20% is service-like activities.

JRET has an own full-time management group and employs 5 full-time researchers and a couple of part-time researchers together with PhD and MA students. Interestingly – and different to the similar knowledge centres - the managing director of the JRET comes outside the academic sphere. T. Szilasi was the former manager of the PANAC and he was the promoter to invite the university into that scheme in 2001. His relationship with the university and its representatives dates back to that time. During the preparation of the proposal to establish JRET the same university representatives invited him to become the director of this new initiative. The work of the management is supported by a Steering Committee and a Scientific Council. (A rather complex organisational structure is depicted in Figure 2.) It is self evident that in a university active in such a broad selection of disciplines, not all of the faculties take part in each centre. In the case of JRET researchers form the Department of Materials- and Vehicle Manufacturing Engineering (SZE-MVME), the Department of Machine Design and Mechanics (SZE-MDM), the Department of Mathematics and Computer Science (SZE-MCS), the Department of Automotive and Railway Engineering (SZE-ARE), and the Department of Physics and Chemistry (SZE-PC) participate more or less actively in the scientific programs of JRET. According to the managing director the SZE-MVME is the centre of the collaboration with the most connections to the industrial partners. The other faculties provide their additional special knowledge when it is necessary. Speaking with the managers of the partner firms they mentioned SZE-MVME and SZE-MCS as their relevant university partners.

Figure 2 Organisational diagram of JRET



Source: <http://nkth.gov.hu/main.php?folderID=841&articleID=4599&ctag=articlelist&iid=1>

It has to be noted that the university participates in a previous government program which set up *Cooperative Research Centres* (CRC) for enhancing the university-industry linkages. These CRCs can be seen as a forerunner of the RUKCs (more details about the relationship of the two schemes can be found Inzelt, 2005), but the two schemes have somewhat different focus. From the university point of view the CRC is a useful tool for *commercializing* the knowledge available at the SZE or as one of the enterprise managers put

it '*it is a loose collaboration adequate for mapping common topics*'. It has a rather broad sectoral focus from machine industry through electronics to civil engineering. In fact this is basically a collection of previous bilateral collaborations under one scheme. In this centre 23 companies participate alongside with other higher education faculties and academic research organisation. SAPU is the only partner who is member of both schemes. Although the university has close relationships with Audi, the enterprise is formally participate only in the CRC scheme. The Regional University Knowledge Centre however is a much closer, focused collaboration with the main purpose of *creating new knowledge*. To achieve this aim the university is teamed up with three companies in JRET which all active in different technologies and fields of the machine industry. The theoretical advantages (synergies, cross-fertilization, etc.) of such set-up are not entirely shared by the managing director of JRET because in practice there are hardly any collaboration taking place between the firms and in the present situation the university is the main beneficiary of the work done in the centre.

Among the firms *Rába Axles Ltd.* is part of a large Hungarian holding (Rába Holding Nyrt.) which was formed on the ruins of a once very successful company which had many problems after loosing the less selective and large market of socialist countries. Since the transition the firm has shrank somewhat and its profile time-to-time shifted to meet the market possibilities. Its shares are being handled on the Hungarian Stock Exchange. Rába Axles is the largest member of the holding and manufactures mainly axles and axle components for trucks, buses, military and other special vehicles. It has 1676 employees, sales volume of USD 153,365m in 2006 while the export ratio of the company reached 85% in 2006. The major foreign market for their product is the USA (where they are present since the mid '70s). In 2006 the complete axles made up 34% of the sales while the majority come from axles parts. The company is involved in foundry, forging, tooling, CNC programming (CAM), (cool) processing, heat and surface treatment and machining technologies. There are 18 engineers involved in R&D activities at Rába, working both on product development (e.g. gears) and on process development (e.g. tooling) as well as being involved in integrated development environment, testing activities and software applications.

*Borsodi Műhely Ltd.* is a fully domestic family-owned medium enterprise, its ancestor was established in 1981. The headquarters is in the industrial park of Győr and there are 3 other plants in the country (two in the region one in the Central Great Plain region). The main profile of the company is metal-working, such as cutting, grinding, precision machining, and measurement. It has extensive supplier experiences, among others with GM-Opel, Audi and Epcos. The enterprise is deeply committed to R&D which can be seen also in the desire to continuously entry into new fields and markets, like the present efforts to broaden the activities towards the aircraft-industry. Their desire to enter the aircraft-industry meant that in their common project with the SZE forced also the university to 'adventure' into a new field of knowledge which was not among their capabilities so far.

The third industrial partner of JRET is a subsidiary company of the Schefenacker Group, *SAPU Lp* located in Mosonszolnok (within the commuting area of Győr). Schefenacker Group is a multinational supplier company for car producers present in four continent and focuses on two main groups of car-parts: lighting and mirrors. SAPU is part of the Central European mirror branch of business (together with 3 other plants in Germany) dealing with molding, painting and assembly of diverse mirrors for Audi, BMW, Opel, DaimlerChrysler, Volkswagen, Ford, and Kia. The applied GID technology was adapted from the parent company by the Hungarian managers and the combination /synergy of the activities realised within the plant is still unique in Hungary. The whole group generates approx. EUR 1 billion income in a year with 6000 employees of which approx. 10% generated and employed by the Hungarian plant. Although group-level efficiency measures might influence the decisions of the Hungarian plant, SAPU has the necessary freedom to initiate new steps in

favour of the plant's development and thus of the whole group's. Recently the Hungarian plant arrived at a new stage in its continuous development strategy and set up a research centre in Győr with 17 engineers. (However it will be further expanded soon.) Their own R&D activities concentrate on two big areas: wind-noise tests and image processing for the use of in-built cameras in mirrors. Their contribution within JRET is strongly related to the GID technology they use, to the development of new production technologies and to the strengthening of own R&D capacities.

## ***Network structure***

### *Overall structure and basic characteristics*

The three enterprises and the university introduced in the previous section are in the centre of this analysis. Together they form JRET, a government supported regional university knowledge centre, a network-type scheme for enhanced R&D and innovation activities, but they are also part of a larger network made-up by their more or less regular R&D partnerships. However the three enterprises focus on three different technologies within the JRET: Rába on the construction of complex modules, Borsodi on cutting methodologies and planning/measuring algorithms and SAPU on moulding technologies. As a result the enterprises have practically no common R&D work, each of them execute their tasks in collaboration with university researchers.

Managers at all three enterprises confirmed that the university plays a very important role in the region's knowledge base. They see in SZE (and other universities) a good source of general, background knowledge that might be utilized to solve their special problems. As they formulated they count on the university in doing underlying research or as an information source and they acknowledge their role in providing professional reinforcements. However the physical equipment of a university is just as important as their quality of the researchers. Enterprises (more) often rely on the contribution from universities in cases when their equipment does not prove to be satisfactory or to expensive, ineffective to invest in new machines. As the representatives of the university experienced, they *'had to learn that the university's role have had changed a lot since the transition. Previously the university infrastructure had different role and the specialization typical in Western-European higher education institutes has just started in Hungarian universities.'* They had to invest a lot to bring their laboratories to a competitive level and thus serve the interest of the industry. But managers still find that *'the universities are very narrow-minded. They see only their utensils but not the way how they could help on enterprises.'* In our case SZE continuously try to improve its communication with the economy and apart from their website they prepared different leaflets with the extensive list of their utensils that can be hired or otherwise utilised by enterprises. The clue in this case, too, is the collaboration. To be able to commission an outside partner to solve a certain technological or other problem requires the detailed knowledge on the capabilities of the partner which might require time and common work.

The interviewees found that the Government's idea of the Research and Technological Development and Innovation Fund (RTDIF) does indeed intensified the collaborations between universities and industrial partners but they were not convinced about the quality of the content of these collaborations. As they said *'it does contribute to make R&D expenditures more focused, to the intensifying of university-industry linkages and to enhance the entrepreneurial view within universities'* but *'it still matters more who do you know at the university and would like to do him/her a favour than to get real useful research results'*. In general the importance of personal ties in building R&D networks is determining and only in a few cases enterprises rely on intermediary organisations to find partners. Rába, because of

its own R&D activity, are not really affected by the RTDIF but the manager of Borsodi strengthened, that indeed the fund brought intensification into its relationship with the university. The managers of SAPU emphasized that their decisions are based mainly on the financial possibilities i.e. on the available government support so the introduction of the Innovation Fund made relatively small changes to their relationship with academia.

Outside JRET each enterprise has a number of other R&D partnerships and they show great differences in their approach to collaborations. Rába, which is a large enterprise (medium one on international level) has its own R&D department and able to serve the R&D and innovation needs of the organisation up to a certain level. Therefore there are rather few cases when they rely on outside R&D sources. *'However there are a level beyond which it is worth to establish R&D collaboration. This is the case when we need special knowledge and capabilities or we have to use special equipment without being able to utilize it efficiently on our own. Then it is better to hire it from outside. It's not cheap but still cheaper than buying an equipment to be used once within years.'* In these few cases they prefer to establish long lasting partnerships, because in many cases *'the geographical proximity matters. It is important to know that there is a knowledge centre with the proper knowledge and IT background and whenever we face a problem that we cannot solve with our own resources we can turn to them.'* However these relationships have an ad hoc characteristic because there are no framework contracts or other long-term ties between the parties and it may happen that for 2-3 years there are no collaboration between the enterprises.

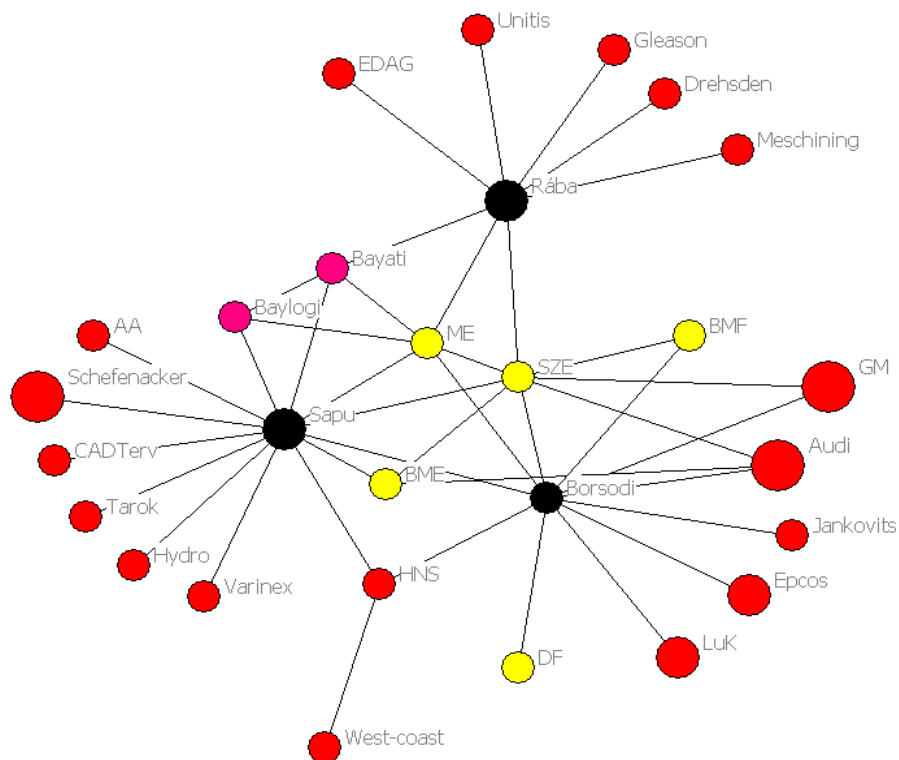
Borsodi seems to be a good example for the development of a once family-run enterprise into a medium enterprise with the help of strong commitment to R&D and innovation. Borsodi's first supplier contract with GM dates back to 1993 and it took a long road till today they can report to collaborate on the development of a new machine-unit as equal partners with GM and SZE. The first five years they have to prove reliability as a production supplier and it happened only after this period that they got the first assignments related to R&D. Since that time innovation and the complexity of tasks they are involved continuously growing. To be able to fulfil the expectations (and to go beyond them) Borsodi has even established an engineering office at the premises of GM. Parallel this process the enterprise arrived at a position where they are not only charged with R&D activities (by large companies as GM, Audi, etc.) but they are also lay charge on other enterprises for R&D and innovation tasks (like HNS, and other small engineering or service offices). Therefore the enterprise has a wide range of partnerships. Actually, as the manager of the enterprise put it, *'practically 100% of our R&D expenditures are spent in collaboration. I think this is similar in all other enterprises of our sort. In Hungary only the large enterprises can afford to do R&D on their own. The SMEs, first tier and lower tier suppliers do it in collaboration.'* This is an interesting view and somewhat contradictory to the available statistical data which records that only 18% of the enterprises are innovative in Hungary (although the share is 37% in transport equipment manufacturing) and only 26% of them collaborate with suppliers, 20% with customers or 15% with higher education institutions (these are the 3 most important partner types). (The number of collaborations decrease with firm size.) (KSH, 2006.)

The difference in the case of SAPU is that the enterprise did not have to start building its technological capabilities from scratch. At the time of establishment and also since that time in any case there are no available knowledge source in Hungary for solving a problem they can turn to the parent company but this was a rare case in the history of the Hungarian plant. So far the enterprise was heavily production oriented but from time to time they had to deal with different problems during the production process or following the kaizen-methodology they were searching for better solutions and improvements of their practice. In these cases they had to rely on outside expertise. In their case the list of R&D partners are longer on the side of academia (higher education institutions, research institutes) than on the

side of enterprises. Specifically they are in contact with bidding companies who are constantly searching for new opportunities of government support, tenders and contribute to writing applications. In the decision to enter an R&D collaboration the most important factor is money. If the internal conditions (demand, human resources) are good they start searching for additional financial sources, i.e. a government program in which they can fit their aims. In JRET although the government support only half of the enterprise's own sources it is sufficient to obtain a new machine 'quasi free of charge'. In some cases they have consultants from international expert firms commissioned by their parent company. However they rely also on their suppliers for *'development and knowledge-tapping integrated to our own products. These collaborations make possible to outsource production in case of lacking capacities while the basic operations remain in-house.'* The management of SAPU was desired to become more than a subsidiary company therefore they started to develop their business which resulted in the establishment of own R&D capacity and they plan to become a Central and Eastern European (CEE) centre for production and marketing within the MNC.

A simple visualisation of the core network by the NetDraw programme is shown in Figure 3.

Figure 3 R&D network of JRET members



Source: own compilation (NetDraw program)

Notes: black – JRET member enterprises; red – R&D partner enterprises; yellow – higher education institutions; purple – research organisations; size of vertices refers to firm size.

Even from this simple figure can be seen that there are three circles of interest around our three enterprises being investigated and these circles are hardly overlapping. However one can identify a couple of interesting characteristics and important nodes on figure 3. First of all, although Borsodi and SAPU representatives told that they have hardly any relationship within JRET, they do have collaboration outside that scheme and they are further indirectly connected through HNS, who provides services for both of them. (Apart from PANAC, where most of the automotive companies in this network are members.) The circle of interest of

Rába is the most insular as it has no direct relationship with either Borsodi or SAPU. In the middle of the picture there are universities and research institutes. Two further colleges are on the rim of the graph connected to Borsodi. For the sake of perspicuity and to keep focus the figure omits the extensive relationships of SZE and included only the most relevant ones but it was clear from the interviews – both at the university and at enterprises – that SZE plays an important role in the region's R&D activities. Beside them the enterprises have contacts with other two major Hungarian universities that have a good reputation in engineering sciences or in the automotive industry. BME is the Budapest University of Technological Sciences, the largest Hungarian university in this field with a very good overall knowledge base and extensive experiences in industrial collaboration. ME is the University of Miskolc, situated in Northern Hungary (near to the north-east borders of the country) which – similarly to SZE – intensively invested to build up and strengthen its specific capabilities. As a result they possess unique equipments and enterprises even from other parts of the country are ready (or have) to travel and collaborate with them. Also in the region of University of Miskolc there are two independent research institutes, Bay Zoltán Foundation for Applied Research - Institute for Matrilas Science and Technology, BAYATI and its sibling organisation the Institute of Logistics and Production Engineering, BAYLOGI who are collaborating with Rába and SAPU. Actually BAYATI (besides SZE) is the only indirect R&D link between Rába and any of the other two enterprises under investigation. Again, here the figure omits a broad set of relationships of BAYLOGI, which is a research centre for logistics, applied information technology, production systems, environmental protection and structural integrity and it turned out from the interviews that it serves as an intellectual 'hub' in certain cases and make possible for enterprises to reach many researchers from different universities (even from those included into the graph) and other research organisations without the need to search for them individually and make separate contracts with each of them.

## *2. Content and specificities of R&D relationships*

This basic picture which is based simple on the presence of any kind of inter-firm R&D relationship can be further modulated if we look at the content and other characteristics (like form, length, intensity, type of work involved, information flow) of the R&D collaborations.

The origins of R&D relations are based on personal ties in the vast majority of the cases. Within this an important channel of finding R&D partners is to look at past working experience and approach previous colleagues or firms who are already a good partner in production and see if this relationship can be upgraded. In many cases the interviewees mentioned the importance of previous relationship at the university either as a researcher-student or as an alumni relation. A third important channel for making new partners is conferences and other professional events. Only at Borsodi was told that they are relying on the services of InnoNet, an incubator and R&D service centre, in partner searching and in offering their services for others. This means that network building are strongly tied on the person who is responsible for developing such activities and this might limit their efficiency by missing out otherwise available possibilities within the innovation system.

Although in the literature there are different types and typologies of the inter-firm R&D relationships (see e.g. Inzelt, 2004) in practice this differentiation is more true for the content than for the form. In the vast majority of the cases R&D collaboration take place in the form of R&D contract assignments between two parties who agree to work together on solving a specific problem. These assignments usually born in case of necessity, e.g. there is a problem to solve in the production process, or a new requirement has to be met. In this sense there is a lack of strategic planning or use of R&D partnerships (e.g. for securing future profitability) at the enterprises though almost all of their partnerships can be regarded as a

durable, periodic one existing for more than 5 years. The reason for this might be that although assignments arise only ad hoc, it is important to know and check the capabilities of the partner. This builds trust (contractual and competence) among the partners and later they are likely to return to these partners who have proven excellence in certain fields.<sup>2</sup> It turned out that many of the R&D relationships are based on previous production cooperation. As for example the manager of Borsodi explained their relationship with GM-Opel developed along an exponential trend. In the first five years they were a simple supplier of GM, then they established an engineering office at GM to be able to provide different measurement service and soon they were involved in an R&D contract with the GM for developing know-how resulting in a new prototype. Based on this project now they are involved in an even larger-scale research project with GM (also some of the MNC affiliates abroad) and the SZE. Of course not all of their relationship reach that level but for any case it is a typical path how R&D relationships evolve in their case. This view was echoed by managers at Rába and SAPU and one of them added, in case of a failure of one of their partners they investigate the reason of failure and it is likely they will not drop forever the enterprise but assign them with less demanding tasks in which they did well previously.

There are only very few cases where the collaboration is more complex. Apart from the JRET only Borsodi is currently engaged in a research project involving more parties. This enterprise also engaged in a large-scale project with SZE in order to broaden its activities from the automotive industry to the aircraft-industry. This collaboration is a great challenge for both partners as they are opening to a field which is quite new for both of them. Most of the R&D contracts involve topics that are strongly related to the core technologies/products of the enterprises and the contracts provide a way to extend their possibilities at hand. In a number of cases these contracts are made to use the university's equipment for different measuring tasks, testing or to run software simulations or calculations. The direct employment of external expert(s) was mentioned only at Rába in case when their own in-house capacities might not be sufficient. An important increment of the collaboration with universities that in some cases enterprises become involved into the education by providing research / practice opportunities for PhD or MA students thus broadening and improving also their own human resources and searching future employees. One of the managers even mentioned that in some cases – mainly in production – it is better worth to employ trainees than researchers because researchers might be too overloaded to keep the deadline and provide a good quality while trainees are keen to provide a good work.

The length of the R&D contracts varies with the tasks and it is judged from very different perspectives by university researchers and by enterprise managers. As researchers formulated managers *'would like to have everything immediately independent from the nature of the problem'* or *'they turn to the university when it is already a very burdening problem'* while managers were complaining that *'the university researchers simply do not feel the pressure of time and very few of them fulfil by the deadline'*. In general the average R&D collaborations last for 6-12 months while the simpler measuring tasks are done within 3-6 months. It is mainly the practice of the large companies (MNCs) to make a framework contract for one or even more years. The Audi or GM offers such framework contracts for the SZE but currently the SAPU also enter into such contract with Borsodi for diverse services (e.g. fault analysis and correction). The only longer research contract in the present practice of the investigated firms is the JRET but in this case the government support is an important modifying factor.

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2 Sako (1992, 1998) has done studies on the role of trust within inter-firm relationships and she is proposing the important role of motivational factors on the efficiency of such collaborations. She compiled evidences that trust significantly contribute to “promote information flows, increase effort exertion, and reduce the need to incur transaction costs associated with curbing opportunistic behaviour” (Sako, 1992, p. 47.).

The budget of the different R&D collaborations are also varying on a broad scale but a few categories can be identified easily. 'Simple' measurement tasks are fall within the HUF 1-10 m (below EUR 40k) category, prototype development projects cost between HUF 10-20 m and 100-200m (between EUR 50k and 500k) and there are only a few more complex projects (like JRET) that goes beyond this and cost even around HUF 1 bn (EUR 4m). Similarly the intensity of the collaborations is very much defined by the nature of the work than any other factors. Within the JRET SAPU has the most intense relationship with the university, which means they have a daily contact. The projects with Borsodi need weekly – on occasion – monthly contact while again Rába is the most insular partner with fairly separate research project where the university has rather a consultant role with monthly or even less intense contact. In general the measurement tasks or the solution of other production related projects require the most intense contacts because in many cases they work in an iterative process with constant feedback and modifications at the partners. Longer projects follow a general 'life cycle' in their intensity too. At the beginning they are more burdening and the partners have to keep daily contact to define the roles but this later rarefy and settle down on a weekly/monthly basis. Towards the end of the project the contacts become once more intense to ensure that the final results are satisfactory for all partners.

From the interviews it became clear that most of the R&D collaborations are experimental development that result in a prototype or a new/modified machine and they are closely relate to the enterprises' core products/technologies. The second largest group can be formed from services and consultation. It is only a very small share of the projects where enterprises become involved in activities with broader scope, like applied research. As it emerged from the interviews enterprises would like to see ready-made products out from the R&D collaboration and they are not likely to be engaged in projects which future outcome is questionable or takes too long time. The Hungarian SMEs are simply underfinanced and a large share of them could not develop a good idea into market product on their own. Therefore they need results with almost immediate returns.

It is a little bit more difficult to assess the information and knowledge flows realised in the different kind of R&D relationships. Of course during the common work both partner learns a lot about each other but enterprises are naturally cautious in disclosing any specific knowledge. As managers told in their field of the automotive industry patents are rare so enterprises have to keep their interest by other tools, like secrecy agreements. Only at Rába was mentioned that since the share of proper axles in the production is rising again against axle-components they turn back to patent observation by commissioning an external expert. As the manager formulated *'...since we are strengthened in certain market segments, as actors, we are getting interested if, e.g. we can block others. Obviously a patent is important for an enterprise, whether it can develop special solutions and monopolise and say, for at least a portion of time it can block from others.'* None of the other enterprises were patents a major topic. For universities this means that although they might learn from the projects they are involved in with industrial partners they can utilize this knowledge (e.g. publication) only in generalized form.

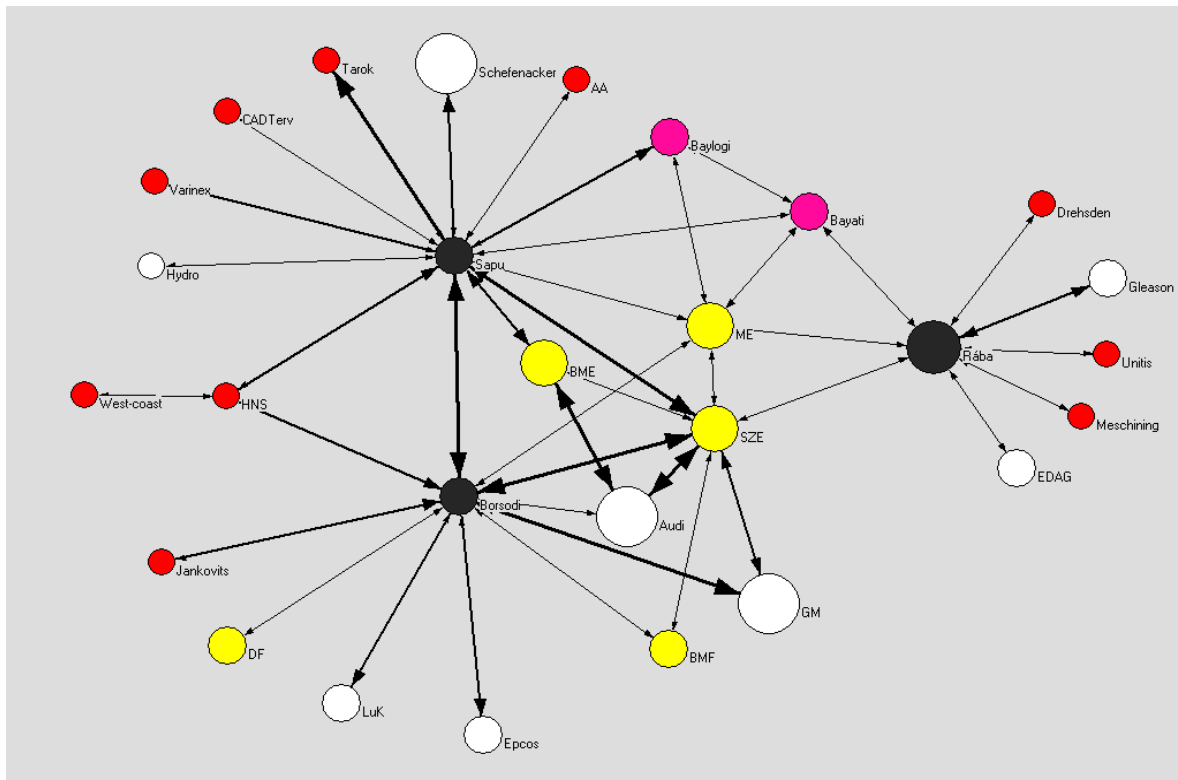
Enterprises are usually the initiators of R&D collaboration, usually they come up with special requests or order a new product or maybe an existing product with significantly improved attributes. Usually the enterprises who initiated such collaborations see this step as an important element in helping developing the partner's business. They are requesting new products, processes or new combination of the existing knowledge which requires significant R&D efforts from the partner to be able to meet the challenge. As the Rába manager formulated *'we are big and complex and interesting enough to be learnt by us.'*

If we attempt to visualize the network with approximate tie strengths, the picture would look like as in Figure 4. The ties are simply grouped into 3 basic categories:

- the weakest being largely based on engineering service or infrequent collaboration,
- the medium-strong ties usually targeted towards product/process innovations, and
- the strongest ties are the most frequent, multi-tiered ones often based on framework contracts.

It is even more obvious than on Figure 3 that although Rába is the biggest enterprise from the 3 JRET partners it follows a very different strategy than the two other companies. Its R&D collaborations are less intensive and less dense than those of the Borsodi and Sapu that are very much in the middle of a dense and intensive part of the network.

Figure 4 R&D network of JRET partners



Source: Own compilation

Notes: Black: core organisations, yellow: higher education institutes, white: foreign owned enterprises, purple: research organisations; red: Hungarian enterprises; size of vertices and boldness of lines refers to firm size and strength of relationships.

Overall the network of R&D collaborations of the three enterprises seems to be based on thorough knowledge about the partners' capabilities and thus on durable contacts but the use of these relationships are rather incidental and lacks the necessary strategical view to be able to develop into a real useful local system. R&D collaborations are mainly seen as a necessary solution when some problems cannot be solved in house or they need expert opinion but they are not regarded as a tool for opening up new fields and new business opportunities. Therefore the network cannot be as powerful tool as it could be but its impact on the development of the enterprises' capabilities is undisputed.

## *Network impact*

The different technologies that the 3 enterprises concentrate on mean that the main beneficiary of the JRET is so far the university where the researchers can benefit from the synergy of the projects they participate in. On the side of the enterprises such synergy are non-existent, they benefit only from the R&D collaboration in the preliminary agreed tasks but any other complementary gains are hardly come forward. It can be said that the network is built up by too many weak ties and the cognitive distance (Nooteboom, 1999) between firms are too big to create a coherent unit from the participating enterprises. If we exclude only one or two major actors (or linkages among them) from the network the whole set of relationships would fall apart.

A very important influence of SZE that they strongly recommend to each of their industrial partners not to simply commission them with a task and after it use the results but to establish a 'mirror-project' within their organisation for the task and continuously interact with the researchers about the progress of the project. As an illustration of how important is this step for Hungarian enterprises, one of the university representatives mentioned it already happened that *one of their industrial partners just because of this common R&D project took up R&D into the range of its activities*. This means that Hungarian firms have to familiarize themselves with the fact that R&D results have different nature than their products: it is not enough to pay for it and start using but it needs a constant commitment. Firms who already have done this – like the three enterprise investigated here – have better chances on the (global) market. The manager of Rába mentioned the example of optimisation tasks that are often 'outsourced'. But *'we will not simply commission an external company to do the optimisation work but we will work with this company to become capable of doing this task with the otherwise available capabilities at the enterprise next time. So, first, I try to learn it and then at the second, third, fourth time I will be able to do it alone, without external help.'* However this view might also give (part of the) explanation of why networking activity is lower in Hungary. The level of trust towards the partner (goodwill trust) or rather towards the business environment as a whole keep enterprises back from relying on external sources in important fields or for longer time periods. Nevertheless these collaborations contain a lot of learning not only about the problem but also about how to collaborate. Enterprise managers told that usually the same person is reliable for the collaboration on each side through more projects. Thus the partners get acquainted with each others' operations and with time partnerships become smoother and more effective.

Of course there are more quantitative answers to the benefits of R&D collaborations because enterprises get involved into such relationships only after thorough economic considerations. R&D projects mean significant amount in the enterprises' budget therefore they start the planning period with cost-calculations and they set the amount of the expected benefits too. This might be a certain level of cost reduction, additional sales volume, or other benefits from the enhanced characteristics of machinery. Therefore R&D collaborations (contracts) are handled as a specific project and after finishing them they are measured by how they met the initial financial targets. The first year of JRET brought already significant results for the participating firms: among others Rába were able to launch a new product, SAPU reduced by 10% its production costs and Borsodi achieved HUF 30 m additional returns and the latter two enterprises employed additional researchers too. Altogether the first year of operation of JRET resulted in 27 new products, services and technology, 22 prototypes, additional HUF 182 m income (of which HUF 75 m from export) and HUF 140 m cost-reduction was achieved. (Szilasi, 2007.) Besides these financial measures, the partners benefit from the upgrade of their research infrastructure (test labs etc.) and of their human resources (at the firms 6 new jobs were created of which 3 for researchers, 2 PhD and 3 MA students were involved into the research).

Answers were similar to a question regarding what is the most important output of R&D collaborations in the sense that they mentioned multiple output. R&D collaborations ultimately contribute to the competitiveness of the firms through cost reduction, solving temporary employment problems, developing the business, and in general through the enhancement of the knowledge base. The technology observation and the creation of new (highly skilled) jobs were also mentioned. However looking at the general situation of the R&D network of these enterprises it is clear that managers do not consider it as a new entity for doing business rather it is a simple 'portfolio' of partners who can be mobilized in need. From the successful collaborations does not emerge a tighter coordination of efforts, sharing of ideas and information or framework contracts of mutual benefits. Rather they remain loose relationships which become more intense in need but latent otherwise.

## ***Conclusions***

The enterprises, who set up the University-based Regional Knowledge Centre for Vehicle Industry (JRET) together with the 'Széchenyi István' University are a good example that irrespective to firm size and ownership structure R&D capabilities can be built and strengthened over time. During those efforts enterprises have to rely on external sources of knowledge and capabilities, which means they have to be involved in R&D collaborations. In Hungary the level of collaborative activities supporting R&D and innovation seems to be lower than in many Western European economies. One important source of problems is the national innovation system itself in which enterprises exist: it is too centralized in terms of governance and financial support but way too fragmented in terms of efforts, actors and coordination.

The even more important source of problems is the way managers think about the role and usefulness of R&D and especially R&D collaborations. The majority of Hungarian automotive firms still too production oriented and if they are involved in R&D they try to keep their results in secret as they do not try to (cannot) protect their rights by other means. Therefore a large share of collaborations remains in the realm of marketing or involve simple R&D services. It is only a small share of the collaborations that realise complex R&D, like the JRET. But even the case of enterprises participating in the JRET showed that large firms (be they owned by domestic or foreign owners) can afford to build intramural R&D capacities and will collaborate with complementary character. Smaller enterprises have to rely more on external sources in R&D but it is a long time to be accepted as an R&D partner not only a simple supplier. Only a minor share of Hungarian enterprises devotes enough resources to R&D collaborations and achieves significant results from them. It is partly because enterprises try to keep their knowledge and collaborate in areas of lesser importance and partly because enterprises do not have the necessary resources and capabilities to assess and utilize applied research (or any research far from pre-market development).

Of course a single case cannot provide for generic statements valid for a whole country or industry but it provide useful insights into the structure and functioning of R&D networks. However this case provided some evidences that those firms nearer to the centre of the network – because of the higher number of contacts – could benefit more from the collaboration than those firms who have only one or two collaborative ties. It is also more likely that the central firms have a mix of 'outreaching' and 'inreaching' relationship while the peripheral firms have mainly 'inreaching' relationships, i.e. they only play the role of service- and knowledge-providers. The importance of absorptive capacity are highlighted by the tendency that those firms more deeply involved in R&D activities are likely to create their own in-house R&D department or strengthen otherwise their R&D capacities. The case does

not supported the belief that the good experiences enhance the number/intensity/complexity of collaborative activities it turned out that such decisions are driven by economic necessities. The uncertainty of the overall economic environment and their competitive positions leaves R&D among the lesser priorities for firms.

The JRET partners choose to build up a network with broad technological focus thus weak ties dominate among them with a few bilateral strong ties e.g. between the SZE and each of the firms. The detachment of the existing halos of the three enterprises does not seem to diminish with collaboration thus presuming there are no real big opportunities arising for upgrading the scale and/or scope of R&D collaborations within the broad network. However the network capable to provide a relatively stable environment for R&D which enable firms, who are providing only simple R&D services at present, to develop their own business and with time they also may become principal in R&D collaborations. In this sense the network creates and makes available new knowledge in the automotive industry which may raise the awareness of other enterprises thus improving the overall level of R&D expenditures and broadening R&D collaborations which in turn may help to overcome system fragmentation. Yet, this has to be seen.

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