Entrepreneurial and Intrapreneurial Propensity of Low-Carbon Technologies in Advanced Materials and Automotive in Central and Eastern Europe

Esin Yoruk[1]

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement "Growth-Innovation-Competitiveness: Fostering Cohesion in Central and Eastern Europe" (GRINCOH)

[1] University College London, e.yoruk@ssees.ucl.ac.uk

Esin Yoruk

University College London

School of Slavonic and East European Studies

P3.10 (T6) Part II: Case studies of low-carbon technologies (in advanced materials and electric vehicles) in CEE and comparative analysis

Final version / 19 January 2015

Entrepreneurial and Intrapreneurial Propensity of Low-Carbon Technologies in Advanced Materials and Automotive in Central and Eastern Europe

Abstract

Building upon the statistically tested and validated conceptual model to examine the propensity of knowledge-intensive entrepreneurship in the innovation systems of EU27 countries (Radosevic and Yoruk, 2013) the methodology paper for this empirical paper was presented in GRINCOH Paper No 3.9 (T6). Based on these, this research explores the role of technology, market and institutions on entrepreneurial and intrapreneurial propensity in low-carbon production activities in the Central and Eastern European (CEE) manufacturing industries. A multiple case study approach is pursued involving entrepreneurial and intrapreneurial ventures operating in advanced materials and electric auto/auto parts technology fields from three CEE countries, namely Poland, Hungary and Czech Republic. The data are collected via an extensive survey questionnaire. An analysis of firms, based on a comparison of type of low-carbon activities in conventional advanced materials technologies (control group), science-based advanced materials technologies and niche technologies in electric auto/auto parts, reveal that CEE region has serious potential for both entrepreneurial ventures and intrapreneurial activities in science-based and niche low-carbon technologies, if elements of institutional framework are enhanced to support these firms to exploit available technological and market opportunities in the innovation system.

1. Introduction

This empirical paper builds on EPIS – Entrepreneurial Propensity of Innovation Systems conceptual framework developed earlier and empirically tested at national level for 27 EU countries in Radosevic and Yoruk (2013). It tests EPIS conceptual framework at emerging high technology sectors (i.e. low-carbon operations in advanced materials and in automotive and automotive parts sectors) in the CEECs and therefore aims to contribute further to EPIS conceptual framework. The conceptual framework and methodology for this empirical research is presented in GRINCOH P3.9 (T6) "Methodology for Assessing Entrepreneurial Propensity of Technology Intensive Sectors". Therefore, this study provides fresh and further insights into the relationship between technologies, markets and institutions in creating the favourable habitat for entrepreneurial activities in firms driven by environmental aspirations.

The methodology for collecting data is based on surveys at firm level. The method of analysis is multiple case study approach.

The paper is organised as follows. Section 2 informs about the low carbon technologies investigated. Section 3 presents the discrepancy between entrepreneurial and intrapreneurial activities in firms. Section 4 informs about the methodology used in this research and finally Section 5 elaborates on case studies from the perspective set within the conceptual framework EPIS in GRINCOH P3.9 (T6) "Methodology for Assessing Entrepreneurial Propensity of Technology Intensive Sectors".

2. Low-carbon technologies in advanced materials and electric vehicle and motor manufacturing

Manufacturing processes and products aiming to generate the least possible greenhouse gas emissions are considered to fall into low-carbon technology category. This can be performed via either:

1. Reducing energy use/requirements in production process (innovation in production process), or

2. Reducing energy use/requirements in product (either end product or intermediate raw material that will be input in another sector (innovation in product which allows it to be used with less material or for longer terms providing efficiency in all aspects, i.e. energy use, performance that indirectly contributes to energy efficiency, etc.).

The advanced materials technologies involve manufacturing of metals, ceramics, composites and polymers. Starting from the 1970s, there has been an accelerating increase in the study and applications of advanced materials in the universities and the industry. These materials started replacing the traditional materials (e.g. iron, standard steel, copper, aluminium, etc.) in mostly high technology applications. Today, it has evolved into a science-based, knowledge intensive and high value-added sector, which delivers products for almost all other industries, from automotive to aerospace, telecommunications, energy, electronics, chemicals, defense, biomedical, machinery and textiles. Thus, the sector distinguishes itself as a sector, which can connect its own dynamism to other related manufacturing sectors. This arises due to increasing cost-effectiveness and high-performance of advanced materials in comparison to traditional materials. Therefore, advanced materials provide indirect but substantial contribution to energy efficiency and conservation in all other sectors of manufacturing.

Based on the kind of product, the materials production can broadly be classified into two:[2]

1. Conventional technology products identified by their structural properties[3] (e.g. powder metallurgy parts, ferrites, laboratory ceramics and porcelains, ceramic refractories) and by the use of medium technology processes in production (e.g. wet/dry/hydraulic pressing, sintering, casting, etc.); and by their application in medium technology sectors, such as ferrous and non-ferrous metal parts for the automotive sector, iron and steel, standard glass and ceramic sectors, standard electronics, etc.

[2] This classification will also prepare the basis for studying and comparing two different segments within the advanced materials technologies, namely conventional technologies and science-based technologies.

[3] Structural properties of a material refer to mechanical properties such as high strength, high-temperature strength, wear resistance and lightweight.

2. Science-based technology products (e.g. technical ceramics such as piezoelectric, sensors, ultra-hard film ceramic coatings), identified by their functional properties[4] and by the use of higher technology processes (e.g. injection moulding, resin transfer moulding, plasma spraying, ion implantation, chemical vapour deposition, magnetron sputtering, plasma enhanced vapour deposition, etc.) and use of R&D; and by their application in high technology sectors such as telecommunications, complicated electronics, defense and aircraft, medical implants, etc.

Advanced materials technology field provides practical and sophisticated solutions for implementation of low-carbon technologies in processes and products. The role of advanced materials in environmental innovations allow for reducing energy use/requirements, material consumption and environmental damage. Many of the most pressing scientific problems currently faced today are due to the limitations of the materials that are currently available and, as a result, breakthroughs in this field are likely to have significant impact on the future of technology. Some recent examples include efficiency from wood to metal and to carbon-impregnated fibre light-weight blades in wind turbines and ceramic thin film coating of photovoltaic modules/cells for better exploitation of solar energy. Particularly high temperature resistance/light weight characteristics of new materials provide opportunities for incremental innovations in the incumbent technologies. This is often preferred by firms since it involves less risky projects and less uncertainty, even though they necessitate planned and continuous investment in research and development. One of industrial examples of advanced materials in this line is surface technologies – i.e. ceramic coating of substrates which improves wear resistance, thermal resistance, chemical stability and corrosion resistance of the materials. This in turn allows for better performance and long term use of products, reducing the cycle of reproduction and thus leading to energy conservation and saving.

Particularly in energy transitions literature, however, more risky and radical innovations are associated with 'niche' technologies –i.e. a product designed for a small part of the technology market (Geels, 2002; Geels and Schot, 2007; Schot and Geels, 2007; Schot and Geels, 2008). Risk and uncertainty the niche innovation faces is not necessarily due to technologically complex nature of the product. In the energy context, it is generally due to fierce competition it faces from the conventional and established products. Recognition of these products by end-users generally requires their first appearance in a local niche market where a set of arrangements are needed to protect novel technologies and to provide them with attention, legitimation and funding (Bakker, Van Lente and Engels, 2012) to allow for the co-evolution of technology, user practices, and regulatory structures (Schot and Geels, 2008). Hybrid, hydrogen and electric cars are analysed widely within this context (Andrews and DeVault, 2009; Bakker, Van Lente and Engels, 2012; Bakker, Van Lente and Meeus, 2012). Schot and Geels (2008) differentiate between the local and global niche markets stating that niche ideas usually first emerge in the local markets. The electric vehicles case in CEE examined in this paper sheds light onto a local niche market. Table 1 provides a brief summary of how the technologies are classified in this study.

[4] Functional properties of an advanced material refer to the physical, chemical, thermochemical and biological functions possessed by the material. These may relate to high thermal conductivity or insulation, high electrical conductivity or resistance, high chemical stability, piezoelectricity, corrosion resistance, biocompatibility, etc.

Table 1. Classification of technologies by product, production process and user types.

Sector	**Technology category**	**Products**	**Product properties**	**Production process**	**User**
Advanced Materials	Conventional technologies	Ceramic parts	Structural (wear resistance, thermal resistance, electrical conductivity/resistance, ferroelectricity)	Powder metallurgy (P/M), hydraulic pressing, injection moulding	Automotive, standard electronics, iron&steel
Advanced Materials	Science-based technologies	Ceramic coating and electro-technical ceramics	Functional (chemical stability, corrosion resistance + all above much improved)	Surface technologies of Laser cladding, HVOF, vacuum deposition technologies of magnetron sputtering, ion implantation, CVD, PVD, etc.	Automotive, telecom, electronics, defense, aerospace
Automotive	Niche technologies	Electric vehicle & engine parts			End users, automotive

3. Entrepreneurial Activities versus Intrapreneurial Activities

Entrepreneurship is about developing, starting a new independent venture. Intrapreneurship, on the other hand, is an internal activity within the existing venture. Whereas most of the recent management literature interprets intrapreneurship as the development of a new venture within an existing organization, to exploit a new opportunity and create economic value and name it as corporate entrepreneurship or corporate venturing; it is also regarded as the development of relatively small and independent units designed to create and expand improved or innovative technologies, methods or services within the organization (Nielsen et al. 1985). Established and old firms during their life time often take a step forward in the direction and implementation of new technologies, processes and products extending their operations. These kind of actions are generally charged to an independent unit in the firm –i.e. in the form of a research project in the R&D unit or within the technical team and then followed by prototyping and production in the production unit. Freeman (1994: 467) states that, for instance, for Schumpeter (1939) a development engineer in the R&D department of a large electrical firm could be an 'entrepreneur' in his sense of the word. A strategically planned and implemented new technology based diversion or extension to the conventional technologies being used in the firm, in that sense, can be considered as an intrapreneurial activity.

This research aims to analyse knowledge-intensive entrepreneurial activities (Malerba, 2010; Malerba and McKelvey, forthcoming) and knowledge-intensive intrapreneurial activities by incorporating science-based and niche technology activities into entrepreneurial and intrapreneurial activities in a 2x2 matrix (Table2).

Table 2. Firms investigated in this research by type of technological and entrepreneurial activity.

Type of entrepreneurial activity / Type of technology	Entrepreneurial activity	Intrapreneurial activity
Science-based	Surface engineering and ceramic coating (Case 3)	Electro-technical ceramic components and ceramic coatings (Case 5)
Niche	Electric vehicle (Case 4)	Electric motors for alternative vehicles (Case 6)
Control Group (established firms)		
Conventional	Laboratory porcelains and ceramics (Case 1) Technical ceramic parts and components (Case2)	

4. Data Collected and Research Method

No data on low carbon activities in firms is published. Indeed, not a list of low carbon activities in manufacturing industries is available, either. Therefore, the main data source in this study has been the survey questionnaire complemented with data from Amadeus database and web pages of the firms.

Amadeus database holds information about firms based on NACE Rev. 2 primary codes. This was our first guide, since it provides information about the main activity and main products of the firms. Since we examine advanced materials and electric vehicles sectors, we gathered the primary information about the below 4-digit sectors in Czech Republic, Hungary and Poland:
2343 - Manufacture of ceramic insulators and insulating fittings,
2344 - Manufacture of other technical ceramic products,
2561 - Treatment and coating of metals,
2910 - Manufacture of motor vehicles, and
2931 - Manufacture of electrical and electronic equipment for motor vehicles.

In the category of ceramic insulators and insulating fittings, there are 29 firms registered as of 2012. Among the 59 firms registered in manufacture of other technical ceramic products category, about 17 are engaged in technical ceramics production. Majority of firms are producers of ceramics tableware or sanitary products.[5] Similarly, treatment and coating of metals category involves firms which employ traditional techniques such as galvanizing, electroplating, spray-painting, heat treatment, anodizing, etc. Among a total of 3000 firms in this category, we specifically looked for

[5] For all technology fields, we checked each firm's website (whenever available) to confirm that the firm is operating in advanced materials field.

firms engaged in 'surface treatment' activities involving science-based techniques of physical or chemical vapour deposition or ion implantation of ceramic nanoparticles. Firms operating in this field amounted to 9. Firms in the technology field of technical ceramics and ceramic coating are mainly SMEs by structure. In total 4 firms in the advanced materials categories responded our survey.

The automotive sector has 243 firms registered, some of them sole traders. Majority of the producers are MNEs and these firms do not conduct any research or production activities on electric vehicles in their CEE subsidiaries.[6] There is quite significant activity in electric bus production in large domestic firms, however their activities are mostly based on assembly where they export the electric engines from abroad. Apart from them, there are three domestic firms engaged in electric vehicle production. We also checked manufacture of electrical and electronic equipment for motor vehicles sector with 290 firms, and identified several firms engaged in motor production for electric vehicles with substantial investment in R&D. One of the three electric vehicle producers and one motor producing firm for electric vehicles responded our survey.

Given the focus on domestic medium and small sized firms, a key informant being the manager/director was targeted.[7] We first contacted firms in the Amadeus database asking them whether they had any low carbon activities in their operations by giving them examples. The majority of responds were negative. A structured questionnaire was then e-mailed during November 2013 to January 2014 period to managers in three waves (i.e. two reminders) followed up by telephone calls. 7 valid questionnaires returns were obtained. Even though information was not available from multiple respondents in each firm, reliability checks were conducted on key firm level indicators, available at Amadeus database and whenever available at firm's website, such as firm age, employment size, turnover and turnover growth rate. The correlations between the Amadeus database and data obtained from the key respondent was stronger than 0.8 in all cases, suggesting that the data obtained by survey questionnaire was reliable.

[6] Upon insisting, Hyundai Czech Republic replied to us stating that their research and development is concentrated in a huge super modern R&D Center in their home country South Korea. They had regional development centers for individual markets located in Japan, China, India, USA and in Germany (Hyundai Motor Europe Technical Center, HME TC). HME TC designed and constructed all models for Europe, currently produced in Czech Republic and in Turkey.

[7] The information on managers is available in Amadeus database. Whenever this was not available, we used the web page of the firm to acquire this information. Whenever this was not possible either, we contacted the firm to direct us to their manager.

Table 3. Indicators used in this research.

Index	Sub-index	Component	Indicators at firm level
Knowledge Intensive Entrepreneurship/Intrapreneurship (KIE)		New enterprise formation	-Factors effecting entrepreneurial activity
		Economic Performance	-Sales growth rate during the last five years -Employment growth rate during the last five years
		New technology, innovation and knowledge intensity	-Number of innovations -Patents granted -Trademarks granted -ISO9001, 14001 certificates -Royalty and license fees receipts (% of turnover)
Knowledge Intensive Entrepreneurial/Intrapreneurial Opportunities **KIEO** = TO + MO + IO	Technological Opportunities **TO** = RND + SKILL + NETWORKS	Knowledge development and diffusion	-R&D expenditures (% in turnover) -Royalty and license fees payments (% of turnover) -Design capability -Production process sophistication -Firm-level technology absorption -FDI and technology transfer -Capacity for innovation
		Competence building in skills	-Number of employees (with PhDs, Master's, Graduates) -R&D personnel (% in total employment) -Quality of the educational system -Local availability of specialized research and training services -Extent of staff training -Brain drain
		Knowledge and value chain networks	-Importance of cooperation partners in innovation activity -Value chain breadth -Local supplier quantity -Local supplier quality -University-industry research collaboration -Availability of scientists and engineers -Quality of scientific research institutions
	Market Opportunities **MO** = DEMAND + FINANCE	Demand side activities	-Share of exports in turnover -Foreign market demand -Domestic market demand -Buyer sophistication: buyer's purchasing decision
		Financing of innovation processes and other activities	-Ease of access to loans (private vs public) -Venture capital availability
	Institutional Opportunities **IO** = REGULATION + SUPPORT	Regulatory environment	-Burden of government regulation -Efficiency of legal framework -Transparency of government policymaking -Strength of auditing and reporting standards -IPR protection
		Public support to incubating & other supporting activities	-State of cluster development -Favouritism in decisions of government officials -Wastefulness of government spending -Government procurement of advanced technology products -Opportunity to sell new products in public tenders

4.1. Data Analysis

We pursue 'comparative' multiple case studies approach for analysis of data in this study. Based on the classification of technologies in Table 1, we make use of firms in the traditional technologies category of advanced materials as the control group. We compare the science-based technology firms and niche technology firms in the advanced materials sector and electric vehicles and parts sector both for their entrepreneurial and intrapreneurial characteristics with this control group. Across each of the three groups, we look for and illustrate literal replication and discrepancies (Yin, 2003).

5. Case descriptions

5.1. Firm characteristics and technologies

Cases are drawn from three CEE countries. Three firms operate in Czech Republic, two in Hungary and one firm in Poland. They all are domestic, small and medium sized firms (see Table 4).

Table 4. Main characteristics of firms.

	Tech	Firm	Country	Tech field	Products	Foundation date	Firm location	Source of funding to start the company	Number of employees (2013)
Established firm	Conventional	1	CZ	Advanced materials	lab porcelain/ceramics	1995	independent location	previous firm	65
		2	CZ	Advanced materials	technical, electrical ceramics	1994	industrial cluster specific to technical ceramics	own savings	114
Entrepreneurial	Sb	3	PL	Advanced materials	Surface engineering and ceramic coating	2004	independent location	own savings	80
	N	4	HU	Auto	Electric vehicle	2004	independent location	bank loan	12
Intrapreneurial	Sb	5	CZ	Auto parts incl. advanced materials	Electro-technical ceramic components and ceramic coating	1996	independent location	bank loan	409
	N	6	HU	Auto parts	Electric motors for alternative vehicles	1992	industrial cluster open to any kind of firm	own savings	14

First two cases represent the control group in this research, which is identified by established firms using conventional production techniques for technical ceramics. Both firms were founded during the mid-1990s as corporate spin-outs of deep-rooted large state-owned firms in Czech Republic. This kind of firm formation has been a typical characteristic for the Czech industry during the transition period. These firms usually accede to the practice and characteristics of the firm that they parted from. In that sense, Case 1 produces laboratory porcelains and ceramics, whereas Case 2 produces technical ceramic parts mainly insulators from steatite and cordierite materials with high levels of thermal resistance. Production of these materials involves powder metallurgy techniques of cold or hot pressing or injection moulding of ceramic powders. Products exhibit structural properties such as mechanical resistance, thermal resistance, electrical conductivity/insulation, wear resistance, etc.

Products are used by automotive, standard electronics, foundry, glass, textile industries or end users.

Case 3 represents the entrepreneurial science-based technology firm and is newly founded in 2004. This firm has started its operations directly in advanced materials sub-field of technical ceramics and ceramic coating field of surface engineering. This process is science-based (chemical or physical) in nature which relies on particle, powder or vapour deposition techniques of ceramic powder onto the metal, glass or ceramic substrates. It provides products with anti-wear, frictionless surfaces, anti-corrosion, high thermal resistance functions desirable in the textile, automotive, defence, aircraft, machinery and cutting tools industries and also bio-medical applications such as hip and knee prostheses, bone joints, medical knives, etc. Case 3, in particular, focuses on laser cladding, laser hardening, high velocity oxy-fuel spraying (HVOF)[8] and plasma spraying as process technologies. These processes allow for coating of nitride or carbide alloys or cermets from cobalt, nickel, chromium, tungsten, titanium and zirconium on substrates. Operationalisation of these processes and production of such complex products necessitate in-depth scientific education and training.

Case 4 stands for the entrepreneurial niche technology firm. This firm produces quite a diverse range of electric vehicles for use in the niche markets. The products are designed and produced for passenger transportation in sports grounds (i.e. golf courses), airports, national parks, historic quarters for tourist zones, castles, zoos, cemeteries, etc. Vehicle capacity of two to fourteen persons are available. Other areas for use are in cargo transportation, mobile catering (i.e. ice cream, coffee, boiled corn, hot-dog, etc.) and also vehicles for specific use such as electric hearses or specially formed ambulance vehicles for hospitals. Electric vehicles are not classified among novel technologies, since electric cars have been around in different forms since the 1880s. But, they certainly can be classified among the niche products today and particularly after internal combustion engine's take over in the car industry. Apart from their extensive environmental contribution,[9] they also are more energy efficient products, since an electric motor can convert the stored energy more efficiently into driving vehicle than an internal combustion engine and it does not consume energy whilst at rest position.

Case 5 characterizes the intrapreneurial science-based technology firm. This Czech firm was established in 1958 as a state-owned firm and started its operations by producing conventional components for motor vehicles industry such as fuses, ignition coils, etc. In 1996 the company was privatised. Several years later, it embarked on the practice of novel, state-of-the-art and complex technologies and products of electrical and electro-technical ceramics such as optoelectronic

[8] During the 1980s, a class of thermal spray processes called high velocity oxy-fuel spraying was developed. A mixture of gaseous or liquid fuel and oxygen is fed into a combustion chamber, where they are ignited and combusted continuously. The stream of hot gas and powder is directed towards the surface to be coated. The powder partially melts in the stream, and deposits upon the substrate. The resulting coating has low porosity and high bond strength. HVOF coatings may be as thick as 12 mm. It is typically used to deposit wear and corrosion resistant coatings on materials, such as ceramic and metallic layers. Common powders include WC-Co, chromium carbide and alumina. The process has been most successful for depositing cermet materials (WC–Co, etc.) and other corrosion-resistant alloys (stainless steels, nickel-based alloys, aluminium, hydroxyapatite for medical implants, etc.

[9] This effect increases if the electricity used in the vehicle is sourced from renewable energy.

devices, ceramic ferrites, thin film resistors, sensors, piezoelectrics and semiconductors. Products are mainly produced for the automotive industry. The firm already achieved the level of OEM supplier for major car brands. Process technology is based on the thick and thin film vacuum deposition techniques (i.e. sputtering).

Finally case 6 represents the intrapreneurial niche technology firm. This firm has been producing conventional products in the form of auto parts and motors since 1992. During the last couple of years it extended its operations into a new technology track comprising the production of electric motors for alternative vehicles.

5.2. Knowledge-Intensive Entrepreneurship

5.2.1. New technology, innovation and knowledge intensity and economic performance

Table 5 informs on the technological outputs and economic performance of the examined firms. Conventional technology firms exhibit very high number of innovations. These are reported due to customized product nature of the operating firms. These firms regard each of their 'customer-oriented'[10] product as innovation, although majority of the changes/additions to the new product might be classified as design alterations or products come in different shapes. The raw materials and

Table 5. Innovation and economic performance in firms.

	Tech	Firm	Country	Innovations (2007-12)	Patents granted (2007-12)	Trademarks (2007-12)	ISO9001/ 14001 (2007-12)	Share of income from licensing (2007-12)	Employee growth from 2007 to 2012 (pa)	Sales growth from 2007 to 2012 (pa)
Established firm	Conventional	1	CZ	50 ntf	0	0	0	0%	0%	slow 1.5%
		2	CZ	150 ntf, 25 ntc	0	0	1	0%	-12%	slow 4%
Entrepreneurial	Sb	3	PL	4 ntw*	12	7	1	0%	16%	very fast 50%
	N	4	HU	5 ntf, 5 ntc	1	1	2	20%	48%	fast 10%
Intrapreneurial	Sb	5	CZ	2 ntf	0	0	1	0	-4%	fast 10%
	N	6	HU	8 ntf	0	1	1	5%	27%	fast 17%

Note: ntf: new to firm; ntc: new to country, ntw: new to world.
*Data for 2012 only.

their formulas would mostly be the same in majority of these products (See findings about the design activities of firms in Section 5.3.1). EBRD (2013) also reports that majority of the firms they

[10] These products are produced based on customer specifications.

surveyed showed signs of difficulty in understanding what 'innovation' actually is –i.e. only a third of self-reported innovations complied with the definition of innovation. All other four firms have also innovated (in the true sense of innovation). Among them, the entrepreneurial science-based technology firm singles out with four new to world innovations, 13 patent applications with 12 of them being granted and 7 trademarks registered during the 2007-12 period. The firm has achieved remarkable sales growth rate of 50% per year along with 16% growth rate of employees. Entrepreneurial niche technology firm has also attained around 10% sales growth and a remarkable 48% employee growth rate based on factors arising from the niche market advantages and also innovation activities. The same trend applies to intrapreneurial niche technology firm, whereas intrapreneurial science-based technology firm shows lower level innovative activity and a fall in employment figures. In contrast to these findings from entrepreneurial and intrapreneurial activities in science based and niche technologies, conventional technology firms show rather poor levels of sales growth (albeit still positive) and no growth or even contraction in employment levels suggesting a bottleneck regarding the engagement in mature technologies and their related products.

5.2.2. Factors affecting entrepreneurial activity

All firms were asked to rate the factors hampering their entrepreneurial activities within a scale of 1 (not at all) to 7 (to a great extent). The results are reported in Table 6. Overall hurdle level was reported well below the average in entrepreneurial niche technology firm, 2.3; and in conventional technology firms, 2.8. All others reported above average with intrapreneurial science-based technology firm the highest, 5. The details are particularly revealing. The technology risk poses the highest hurdle level in science based technology firms. This is due to the nature of pure science based technology they are engaged with. Niche technology firms report very low levels for this indicator, since electric vehicle/motor production is quite a mechanical and mature process. The technical ceramics producing conventional technology firm perceives technology risk higher than that of lab ceramics/porcelain producer firm, since the latter involves a more mature and routine technology level.

Funding constraints for innovation follows more or less the same pattern as the technology risk with entrepreneurial niche technology firm and conventional technology firm (C1) reporting more confidence. One can say that firms which have started operations relying on their own savings (i.e. entrepreneurial science-based technology, intrapreneurial niche technology and conventional technology firm (C2)) find innovation funding as a higher level hurdle for entrepreneurial activity. The significant difference between C1 and C2 might be due to (un)willingness to take action for innovation and whether the firm is aware of available funding opportunities or not, a matter to be discussed further in section 5.4. Market constraints and marketing problems seem to be more a hurdle for intrapreneurial firms than entrepreneurial firms. Conventional technology firms report the lowest level for such hurdles.

Whilst technology risk remains to be quite a hurdle for particularly the science based firms, the hurdle that lack of technological know-how poses is the highest for intrapreneurial science-based technology firm, but not for entrepreneurial science-based technology firm. This is very noteworthy, since it is then related to intrapreneurial science-based technology firm's difficulties in finding and keeping technically skilled employees. Similar level hurdles are reported by entrepreneurial science-based technology firm which may point to chronic skills problem particularly in science based technologies in the CEE region. Science based firms employ a much higher proportion of researchers within their employees compared to other groups. Even higher levels of skills hurdles are reported by intrapreneurial niche technology firm signalling the difficulty in extending operations into a different technological path in the firm which is directly associated with high risk and uncertainty. Many researchers initially may not be ready to take on such a pressure which puts them off from applying to the job. Support to create awareness on this issue by public bodies is essential.

Networking for technological collaboration is not a hurdle for the conventional technology firms. But, the level of this hurdle increases for science based firms and is even more hurdle for intrapreneurial firms. For the latter, this is again due to shifting towards a completely new technological path which necessitates building up of new networks. Conventional technology and science based firms have already established networks mostly with domestic agents (a point further discussed in section 5.3.3).

Finally, competition barriers of entry created by large companies or MNEs increase as the level of technology increases. It is the highest for science based technology firms. These firms have to compete with German multinationals which are engaged in high degree science based activities producing quality products. They don't have any geographical or low labour cost advantages unlike East Asian firms. The niche technology firms have the local niche market advantage, thus they do not face competition from large firms. The significant difference between C1 and C2 arises from the fact that C1 has a more secure market for lab porcelains being an old established firm in this market and C2 faces both internal and external competition because its products are mature less value added products.

Table 6. Factors creating obstacles in entrepreneurial activity of firm (1=not at all, 7=to a great extent)

				A	B	C	D	E	F	G	H	I	Avg (A:J)
	Tech	Firm	Country	Technology risk	Funding constraints	Market constraints	Marketing problems	Lack of technological know-how	Difficulty in finding partners for technological collaboration	Difficulty in finding employees with technical skills	Difficulty in keeping employees with technical skills	Competition and barriers of entry created by large companies (i.e. MNEs)	Assessment of entrepreneurial hurdle level (EH level)
Established	Conventional	1	CZ	2	2	2	2	2	2	2	2	2	2.8
		2	CZ	4	6	4	3	2	2	4	2	5	
Entrepreneurial	Sb	3	PL	5	3	4	4	2	4	5	2	6	3.9
	N	4	HU	2	1	4	2	3	3	1	3	2	2.3
Intrapreneurial	Sb	5	CZ	5	4	6	5	5	4	6	6	4	5
	N	6	HU	2	3	4	6	1	5	7	4	3	3.9

5.3. Technological Opportunities

5.3.1. Knowledge acquisition and development

Table 7 informs about the firms' efforts into development of their own technology. In that sense we compare the level of R&D expenditures, royalty payments, design activity and technology acquisition activities in sample firms. The intensity of effort or commitment for innovation is much higher in entrepreneurial and intrapreneurial firms than that of established conventional technology firms. For that aim, entrepreneurial science-based technology firm invested 30% of its total sales in 2012 in R&D. This figure was 15% for entrepreneurial niche technology firm and 10% for intrapreneurial science-based technology firm. For one of the conventional technology firms, which provided the data, it did not exceed 3%. Royalty payments and receipts seem to have higher rates in niche technology firms compared to science-based technology firms. Being engaged in sophisticated science based activities demand the latter group develop their own technologies more effectively compared to niche technology firms which deal with rather less sophisticated technologies in this sample. Therefore, one can assume that access to more sophisticated technologies would not be easy and also expensive.

Similar pattern repeats itself when main source of design activity in the firm is analysed. There is stark contrast between the conventional technology firms and entrepreneurial and intrapreneurial activity firms. The former largely and almost solely rely on customer designs whereas the latter are engaged in creating their own designs for the products they produce.
Design activities particularly are concentrated on product design in the materials industry. Science-based technology firms are engaged in complicated product design activities given the nature of their field of operation. The science-based technology firms' design activities mostly concentrate on high technology design activities from product to process design, whereas conventional technology firms' design activities mostly concentrate on medium level technology designs in parallel with their products and the mature processes they use. In the science-based segment of the sector, majority of the non-trivial design activities, which result in product or process development and improvement, are the firms' own high-tech design activities. These activities vary from original target design for ceramic coating processes[11] to original ceramic mould design and original powder characterization.[12]

---

[11] Science-based and engineering firms, operating in the field of ceramic coatings, are continuously involved in developing composition (know-how) of different kinds of single layer and multi-layer coatings that provide the materials with different or more reliable properties, especially if they were opting to introduce improved or new products. Such an activity concentrates on the design of raw materials such as compounds of titanium, zirconium, chromium, boron and tungsten to be placed on a target for ionisation in a vacuum chamber and to be deposited on a substrate. The design of a target for a titanium nitride (Ti_xN_y) coating with two elements would be relatively easier than the design of a target for a titanium carbonitride (TiC_xN_y) coating with an added third element. The successful design of a target would yield better results for thickness, hardness and adhesion of the coating.

[12] Especially for the conventional firms operating in laboratory ceramics and porcelains and ceramic parts production for automotive and cutting tools industries, design activities are predominantly concentrated on better performance of the products to meet customer demands. If the firm opts to rely on customer-guided designs, the recipes for powder mixtures for the products and all the drawings for product shape and tolerances are supplied by the client firms. Some firms also perform their own design activities, which are mould design and powder characterization. Such firms have a mould atelier for this aim endowed with lathes and CAD computer supported mould design. Moulds are placed in the dies of extrusion, wet and dry press and injection moulding machines to get the products with desired shapes and cross-sections. They are made of metals or hard ceramics. Successful powder characterization necessitates quantitative data on particle size and its distribution, particle shape and its variation with particle size, surface area, the internal particle friction, flow and packing,

Conversely, the main type of design activity in the conventional segment of the advanced materials sector is customer-guided design activities that largely rely upon customer recipes with little addition from firms. Faulkner and Senker (1995: 106) also observed this kind of behaviour in some of the UK and US ceramics firms[13] they examined. They interpreted firms' preference for low technology design activities by their lack of qualified researchers to carry out the design activities (see Section 5.3.2) and also the concern among firms that their designs were easily copied and imitated by their rivals once the new design was introduced into the market. The former interpretation is largely valid for the conventional technology firms in this research. They do lack the skilled personnel endowed with research and design capabilities. The latter interpretation, however, is more valid for science-based technology firms. They have concerns about their designs being copied and imitated by their rivals; however, this concern do not stop them working on designing new products. Given the fact that their product designs are far too complicated, it is indeed rather difficult for a rival firm to copy a product and introduce it to the market before the original firm. Therefore, it is always the original firm to get its product a trademark or a patent and then others may work on this product as well, but that takes time giving the original developer the first mover advantage. The effects of this is easily noticed for the entrepreneurial science-based technology firm which has the technological capabilities to be able to patent and grow fast both in terms of sales and employment.

Firms were also asked a set of questions with regard to their technology acquisition process in terms of process technologies they used. These involved enquiries about the level of sophistication of process technologies in operation, whether or not actively seeking for state-of-the-art technologies for the renewal of existing technologies, the role of foreign partners in acquiring new technologies and finally whether relying purely on licensing and imitating to launch new products or relying on its own research base. The entrepreneurial science based firm reports considerably higher level of assessment for the above queries compared to other firms. One has to remember that this firm is engaged in purely scientific activity which demands aggressive technological strategy to keep up-to-date with state-of-the-art technologies.

It is very interesting that conventional technology firms report their levels of process technologies as high as 4 or 5. Given the fact that this is already a mature technology field these are plausible answers. These responds need to be interpreted according to the level of technology the firm is operating at. In that sense, conventional technology firms think that they have proper background and base for the level of technology they are operating at, but they do not necessarily go one step further to think that they can embark onto a new higher value added technology in the sense of an intrapreneurial activity that we examine in this paper. They totally ignore the latter point suggesting they are content with the level of their technological activities. Intrapreneurial science based and niche technology firms, on the contrary, show such risk-taking behaviour and embark on available opportunities. Based on this challenge and deviation from routine activities, they report lower levels

internal particle structure, chemical gradients, surface films, admixed materials regarding the powder (German, 1984: 10). Therefore, all of these parameters are important within the entire design activities, since the complete understanding of the powder leads to quality products.

[13] Faulkner and Senker's engineering ceramics firms produced technical ceramics parts by powder pressing techniques.

for their assessment of operational technology and technology acquisition. A more effective institutional policy environment targeting at the needs of these firms would create better results for these firms.

Table 7. Technology acquisition and generation.

								A	B	C	D	**Avg (A:D)**
	Tech	**Firm**	**Country**	**R&D expenditures (% of total sales in 2012)**	**Payments for licensing (% total sales) (2007-2012)**	**Receipts from licensing (% total sales) (2007-2012)**	**Main Source of design activity**	Production process sophistication	Firm level technology absorption	FDI and technology transfer	Capacity for innovation	**Assessment of technology acquisition and generation**
Established firm	**Conventional**	1	CZ	-	0%	0%	Customers' designs, other companies' designs and company's own designs	**4**	**4**	**-**	**4**	**4**
		2	CZ	3%	1%	0%	Customers' designs	**5**	**5**	**2**	**6**	**4.5**
Entrepreneurial	**Sb**	3	PL	30%	0.0015%	0%	Company's own designs	**6**	**6**	**-**	**6**	**6**
	N	4	HU	15%	20%	20%	Company's own designs	**3**	**5**	**3**	**3**	**4**
Intrapreneurial	**Sb**	5	CZ	10%	0.10%	0%	Company's own designs	**3**	**4**	**-**	**5**	**4**
	N	6	HU	-	8%	5%	None	**4**	**4**	**-**	**4**	**4**

Notes:
A. In your firm, production processes used are (1 = labour-intensive methods or previous generations of process technology, 7 = the world's best and most efficient process technologies)
B. Your firm is (1 = not able to absorb new technology, 7 = aggressive in absorbing new technology)
C. If your firm is in a joint venture with a foreign firm or has a foreign partner (i.e. a parent firm, sister firm), your foreign partner (1 = brings little new technology into your firm, 7 = is an important source of new technology for your firm)
D. Your firm obtains technology (1 = exclusively from licensing or imitating foreign companies, 7 = by conducting formal research and pioneering their own new products and processes)

5.3.2 Competence building in skills

Human skills and training is the second crucial determinant of technological opportunities. These can be assessed by indicators such as share of university graduates and post-graduates and R&D personnel in total number of employees in the firm as well as the quality of training and skills environment that the firm can exploit. Table 8 shows that there is stark difference between conventional technology firms and the rest in terms of university graduates and postgraduates employed in the firms. The maximum share of this group in conventional technology firms' total employment is not above 4%; whereas it is not below 9% in the entrepreneurial and intraprenurial activity firms, with the entrepreneurial science-based technology firm having 51% of its employees as university graduates or postgraduates. This pattern repeats itself for share of R&D personnel in total employees. Again, entrepreneurial and intrapreneurial firms are distinguished from conventional technology firms with considerably higher shares of R&D personnel. The reasons for higher levels of research and skilled personnel in science-based firms are self-explanatory, but such high levels in niche technology firms also show that niche category is not at all confined to the traditional firm approach.

In complementarities with the above, we sought information about the firms' approach for preserving the valuable skills within the firm's boundaries. This comprised the assessment of whether the firm invested in extensive training of its workforce and challenged by as minimum brain drain as possible out of the firm. In that sense, science-based technology firms' efforts outperform those of conventional technology and niche technology firms. They invest heavily in training and retaining their employees and their employees almost always remain in the firm. Conventional technology firms also report medium to high level scores on these indicators. Given the fact that, the latter have relatively small proportions of skilled workforce, most of their blue collar workers would feel the security and contentment of staying in a settled establishment and thus would not look

Table 8. Human skills and training

						A	B	C	D	Avg (A:D)
	Tech	Firm	Country	University graduates + postgraduates (% in total employees)	R&D personnel (% in total employees)	Quality of education system in raising skills in your technology field	Local availability of specialized research and training services	Extent of staff training in your firm	Brain drain in your firm	Assessment of human skills and training
Established firm	Conventional	1	CZ	8%	3%	4	4	4	5	4.4
		2	CZ	4%	4%	4	4	4	6	
Entrepreneurial	Sb	3	PL	51%	10%	3	4	6	6	4.8
	N	4	HU	17%	17%	3	1	2	2	2
Intrapreneurial	Sb	5	CZ	9%	8%	4	4	5	6	4.8
	N	6	HU	14%	-	2	1	3	5	2.8

Notes:
A. Educational system /raising skills in your technology field (1 = does not meet the needs of a competitive economy, 7 = meets the needs)
B. Specialized research/ employee training services in your technology field are (1 = not available, 7 = available from world-class local institutions)
C. General approach of your firm to human resources is (1 =little in training and employee development, 7 = invest heavily to attract, train, retain employees)
D. Your firm's talented people (1 = normally leave to pursue opportunities in other firms, 7 = almost always remain in the firm)

elsewhere unless the organization faces major crisis. Niche technology firms, on the other hand, report lower level scores for firm level training. Some elements of why they may not be able to deliver extensive training to their employees might be explained by the skills and employee training environment, when we asked firms to assess the level of the education system in their country with regard to raising skills specifically for their technology field and whether specialized research and employee training services are locally available again specifically for their technology field. Particularly the lack of local availability of specialized research and training services in electric vehicle technology is a major bottleneck for these firms to provide extensive training for their employees. It seems that an intervention from the institutional aspect could widely alleviate the obstacle. Regarding the education system and training services in general, science-based firms and conventional technology firms report medium level skills support. For conventional technology firms, firm level staff training matches with the local training availability. However, science-based technology firms' firm-generated efforts outperform the local support. This is an issue closely linked to developing firm level technological capabilities (Bell and Pavitt 1993, Kim 1997) in which science-based firms can show better capacities (Yoruk 2009; Yoruk 2011). Institutional support regarding skills training can provide a more efficient habitat for science-based technology firms.

5.3.3 Knowledge and value chain networks

Networking and cooperating is a key form of acquiring external knowledge. Edquist (1997: 1) goes as far to state 'No firm can innovate in isolation.' In order to seek information about this dimension, we asked firms to rate their partners and forms of cooperation from the least important to best important for innovation cooperation (Table 9). In the science-based technology firms and the intrapreneurial niche firm local connectedness is more intense than foreign connectedness. Main source of knowledge is domestic university, customers, research institutes and only then suppliers. Among these, R&D agreement and technical support is generally associated with cooperating with the domestic university; licensing agreement and subcontracting are usually associated with foreign research institutes and customers.

Technical support from domestic universities is the most widely used form of cooperation, since firms transfer state-of-the-art process technologies from abroad and seek further guidance from domestic institutes about how to operate and troubleshoot the machines along with using their own knowledge.[14] Also, process modification is always needed to pave the way for product innovations in this technology field. Deeper knowledge flow would comprise joint product innovation in the form of R&D agreement between the science-based technology firm and the university. Therefore, domestic SMEs try to tap into the knowledge sources of domestic universities' materials sciences departments. Ways of interaction can be to the extent that it includes long term skills mobility. Firms employ engineers who conduct their PhDs and MSc at the university. These engineers act as means to transfer knowledge from the university to the firm. Contrary to patterns observed in entrepreneurial science-based, intrapreneurial science-based and intrapreneurial niche technology firms, conventional technology firms show very low level activity regarding the forms of knowledge interactions. Case 1 does not report any particular form of interaction. This is in accordance with it rating the customers as the most important source of knowledge. This can be explained by the use of low and medium level process technologies which do not require further acquisition of complex

[14] Novel and complex production technologies in the field of materials necessitate expertise and tight control of process parameters and applications. Firms, which have imported these technologies from foreign firms, often initially use technical assistance from domestic universities that to some extent could be useful in operating these technologies. Materials science departments of universities could be very helpful to firms regarding such sophisticated techniques at the initial stages of their capability building process – i.e. operational capabilities mainly and process and product improvement capabilities in some cases. However, it seems that for higher-level capabilities of process and product development related to the above complex technologies firms have to also considerably rely on their own intra-firm resources, especially if they aim for further developing such techniques.

knowledge for operation.[15] Case 2 reports only technical support as the form of interaction with university and research institutes as the most important partners. This firm is engaged in slightly higher value added activity – i.e. structural ceramic components which would demand some complex knowledge, compared to that of Case1; thus this would mainly be an interaction for the operation and troubleshooting of processes and their related products, but would not go beyond operational capability acquisition. New product formation would depend on licensing and know-how transfer from abroad.

Among all, the entrepreneurial niche technology firm's knowledge networking is also quite limited to domestic supplier and customers and technical support and licensing agreements. This again highlights the truly unsupportive environment for the niche technology in the local market. All further assessments of this firm for the local networking environment are indication of an unfavourable habitat which points to the necessity of arrangements for the support and protection of the niche in the local market. Indeed, entrepreneurial niche technology firm is the only firm that rates research collaboration with university, quality of scientific institutions, availability of scientists, quantity of local suppliers and own level of value chain activity at the lowest end of the spectrum (see Table 9). The firm does not make use of any of these opportunities and this shows some structural problems for the entrepreneurial niche technology. As stated earlier, conventional technology firms almost do not cooperate for innovation, but they are embedded well within the value chain. However, this is not sufficient for long term and sustainable growth and needs to be complemented with more in-depth forms of knowledge acquisition activities. These indicators, on the other hand, have received much higher scores from entrepreneurial science-based, intrapreneurial science-based and entrepreneurial niche technology firm. These findings should be interpreted in accordance with knowledge development and diffusion and human skills dimensions of technological opportunities. In these firms, these are mostly firm internal commitments which can only be more strengthened by the implementation of accurate policies.

[15]These are simple hot or cold pressing techniques used for production of intricate and small ceramic parts formed from ceramic powders.

Table 9. Knowledge networks and supply chain

						A	B	C	D	E	F	Avg (A:F)
	Tech	Firm	Country	Partner for innovation cooperation*	Form of innovation cooperation*	Research collaboration between the firm and local universities	Quality of scientific research institutions	Availability of scientists and engineers	Local supplier quantity	Local supplier quality	Value chain breadth	Assessment of knowledge and value chain networking
Established firm	Conventional	1	CZ	D. customer (7) D. university (5) D. research ins (3) D. supplier (1)	-	2	2	5	4	6	5	3.8
		2	CZ	University (7) Research ins (7) Customer (5) Supplier (5) Consultant (3)	Technical support (7)	2	3	4	4	4	5	
Entrepreneurial	Sb	3	PL	D. university D&F research ins D&F customer D&F supplier D. consultant	R&D agreement Licensing agr. Research contract-out Technical support Subcontracting	7	6	4	5	5	-	5.4
	N	4	HU	D. supplier (7) Customer (7)	Technical support Licensing agreement	1	2	2	3	4	2	2.3
Intrapreneurial	Sb	5	CZ	D. university (6) D. consultant (6) D. research ins (5) Customer (5) F. university (1)	R&D agr. (6) Research contract-out (5) Technical support (5) Subcontracting (5)	7	4	3	4	4	6	4.7
	N	6	HU	D university Customer Supplier Consultant	R&D agreement Technical support Subcontracting Research contract-out	6	5	5	5	4	-	5.0

Notes: * Numbers in parentheses denote 1=not important, 7=most important. (D=domestic; F=foreign)
A. R&D collaboration between your firm and local universities is (1 = minimal or non-existent, 7 = intensive and ongoing)
B. Scientific research institutions related to your technology field are (1 = non-existent, 7 = the best in their fields internationally)
C. Scientists and engineers related to your technology field in your country are (1 = non-existent or rare, 7 = widely available)
D. Quantity of local suppliers in your technology field in your country are (1 = non-existent, 7 = numerous and include the most important materials, components, equipment, and services)
E. Quality of local suppliers in your technology field in your country is (1 = very poor, 7 = very good)
F. If your firm is exporting, you are (1 = primarily involved in individual steps of the value chain, 7 = present across the entire value chain)

5.4. Market Opportunities

Market opportunities focus on market demand and availability of finance to set up the venture and to fund innovative activity. We differentiated between the public and private funding for the latter since there seems to be interesting disparities between firms' innovation funding practices (Table 10).

Exporting and aiming at foreign markets is an established activity for the conventional technology firms.[16] Their foreign market size is larger than their domestic market size. Given that nature of their production activity is mostly concentrated on subcontracting for EU large firms, this is not surprising finding. However, this means whenever the foreign markets are in trouble, these firms will also fall

[16] One should note that intrapreneurial science-based technology firm's report for share of exports in total turnover (73%) is related to its other conventional products that the firm has already been selling. In a way, this is the same activity as conventional technology firms do. However, intrapreneurial science-based technology firm's rating of foreign market demand for its high technology products is low, because this is related to its new activity in producing science-based products as an extension to its existing conventional products.

into trouble. Indeed, the low rates of sales and employee growth may be interpreted in that sense. On the other hand, it seems that as the degree of technological sophistication of processes and products goes up, firms – i.e. science-based and niche technology firms, target opportunities available within the domestic market. This is due to the fact that foreign market competition with the more advanced western counterparts operating at the technology frontier is fierce and demands better quality products. These firms need to first prove themselves within the domestic market in order to move onto foreign markets. When one closely analyses their assessment of buyer's sophistication – i.e. whether their customers' purchasing decision is based solely on the low price of products or product performance attributes, one can see that entrepreneurial science-based, intrapreneurial science-based and intrapreneurial niche technology firms all report intermediate ratings. This indicates that their high technology products' performances – i.e. structural and functional properties of ceramic products discussed in Section 2, are not yet at the level of a firm's that would be operating at the technology frontier. Thus, until some level of technology is attained these firms would be providing products for price-conscious buyers whether in the domestic or foreign market. These firms need purposefully tailored technology policies in order to move up to the next market to serve performance-conscious buyers. The only exception to the above foreign-domestic market separation is the entrepreneurial niche technology firm, which seems to serve for both markets and to highly performance-conscious buyers despite its relative shortcomings in exploiting technological opportunities as discussed in Section 5.3. This can only be explained by the not very complex nature of the electric vehicle technology.

Ease of access to funds to finance the entrepreneurial or intrapreneurial activity is not more difficult in science-based and niche technology firms than that of conventional firms. Entrepreneurial niche technology firm has some disadvantage in this area because of its risky nature. A major difference between the firms appears to be in how they do fund their innovation activities. Conventional technology firms seem totally unaware of the available public funds such as EU grants and R&D tax incentives. They largely make use of their own funds for innovation purposes. The entrepreneurial niche technology firm shows a similar pattern to that of conventional firms. This may also be due to their relatively not complex nature of innovation activities and thus not fall into the categories required for some specific public funds. This again points to the necessity of arrangements on the policy side specific for niche technologies. Intrapreneurial niche technology firm, on the other hand, seems to be exploiting all the channels publicly available for innovation funding. Science-based technology firms make slightly better use of public funds compared to their own funds. Overall, more efforts are needed on the institutional side to make particularly science-based SMEs to be aware of types of public funding and how to access them.

Table 10. Demand and finance availability for innovation

				Demand				Finance Availability									
								VC	Private Finance				Public Finance				
					A	B	C	D	E	F	G	AVG (E:F)	H	I	J	K	AVG (H:K)
	Tech	Firm	Country	Exports (% in turnover in 2012)	Foreign market demand	Domestic market demand	Buyer sophistication	Ease of access to venture capital	Own financial resources (own savings)	Funding from family member	Funding from a bank	Availability of private finance	Public Loan from national government or local authorities (programs supporting entrepreneurship	Public grant from national government or local authorities (programs supporting entrepreneurship	EU funds (programs supporting SMEs, etc.)	R&D tax incentives	Availability of public finance
Established firm	Conventional	1	CZ	60%	4	3	4	4	7	1	4	4	1	1	1	1	1.4
		2	CZ	80%	7	2	1	4	7	1	4		1	1	4	1	
Entrepreneurial	Sb	3	PL	1%	2	7	4	5	5	4	4	**4.3**	5	6	6	2	**4.5**
	N	4	HU	60%	6	6	7	3	7	2	4	**4.3**	2	4	1	1	**2**
Intrapreneur	Sb	5	CZ	73%	3	4	4	5	5	1	3	**3**	1	6	2	5	**3.5**
	N	6	HU	0	1	5	5	4	7	1	5	**4.3**	7	7	7	7	**7**

Notes:
A. Your firm sells its high technology products in the foreign market (1=none, 7= almost all production)
B. Your firm sells its high technology products in the domestic market (1=none, 7= almost all production)
C. Customers of your firm make purchasing decisions (1 = based solely on the lowest price, 7 = based on a sophisticated analysis of performance attributes)
D. How easy is it in your country for a firm with innovative but risky projects to find venture capital? (1 = impossible, 7 = very easy)
E, F, G, H, I, J, K, L: Availability of funding sources for innovation (1=not at all, 7=to a great extent)

5.5. Institutional Opportunities

An amenable and constructive institutional environment is essential for entre – and intrapreneurial activity. Indeed, well-functioning institutional environment forms a favourable background for better exploitation of available technological and market opportunities by firms (Radosevic and Yoruk, 2013). Furthermore, the quality and effectiveness of institutional framework boost competitiveness and growth (Acemoglu et al. 2001, 2002; Rodrik et al. 2002). Institutional opportunities construct consists of two dimensions, extent of public support to firms and the effectiveness of legal framework and regulations in this research (Table 11).

We measure the extent of public support by asking questions to firms about the support delivered by the government on cluster creation for the specific technology the firm operates in and the purchasing of advanced products that are generated by firms. We also ask about efficiency of the government's spending practices aiming at further improvement of the specific technology field and whether there is any favouritism from government officials for firms well-connected with the politicians. The latter has been an issue in the CEE which creates obstacles for knowledge-based entrepreneurial activities but fail to connect with the dominant governing edifice. The higher the assessment of this indicator, the less is the problem contributing in general to the extent of public support in a positive way.

We measure the legal framework and regulations dimension by several indicators involving the extent of liabilities in administrative requirements, strength of intellectual property protection, strength of auditing with regard to company financial performance, efficiency of legal framework in settling down disputes and transparency of the government in alerting firms about policy changes.

Entrepreneurial firms judge the general environment for public support less encouraging than conventional firms do. But they think that the setting for legal framework and regulation is more effective when compared to that of conventional firms.

Table 11. Public support and legal framework

				Assessment of extent of public support					Assessment of legal framework and regulations					
				A	B	C	D	AVG (A:D)	E	F	G	H	I	AVG (E:I)
	Tech	Firm	Country	State of cluster development	Favouritism in decisions of government	Wastefulness of government spending	Government procurement of advanced technology products	Assessment of public support	Burden of government regulation	IPR protection	Strength of auditing and reporting standards	Efficiency of legal framework	Transparency of government policymaking	Assessment of legal framework and regulations
Established	Conventional	1	CZ	4	4	4	4	**4**	4	4	4	4	4	**4.2**
Established	Conventional	2	CZ	4	4	4	4		4	3	5	4	6	
Entrepreneurial	**Sb**	3	PL	3	3	4	3	**3.3**	2	6	6	5	4	**4.6**
Entrepreneurial	**N**	4	HU	2	3	3	2	**2.5**	7	7	3	5	3	**5**
Intrapreneurial	**Sb**	5	CZ	3	3	4	2	**3**	4	3	4	3	5	**3.8**
Intrapreneurial	N	6	HU	5	1	6	5	**4.3**	3	3	4	3	3	**3.2**

Notes:

A. In your country, how widespread are well-developed and deep clusters with regard to your technology field? (1 = non-existent; 7 = widespread)

B. Do firms in your technology field have contacts with government officials? (1 = yes, officials usually favour well-connected firms and individuals, 7 = no, officials are neutral)

C. Composition of public investment in your technology field (1 = is wasteful, 7 = efficiently provides necessary goods and services not provided by the market)

D. In your technology field, government procurement decisions result in technological innovation (1 = strongly disagree, 7 = strongly agree)

E. Complying with administrative requirements (permits, regulations) issued by the government is (1 = burdensome, 7 = not burdensome)

F. Intellectual property protection and anti-counterfeiting measures in your country are (1 = weak and not enforced, 7 = strong and enforced)

G. Financial auditing and reporting standards regarding company financial performance in your country are (1 = extremely weak, 7 = extremely strong, the best in the world)

H. Legal framework to settle disputes and challenge the legality of government actions and/or regulations in your country is (1 = inefficient and subject to manipulation, 7 = efficient and follows a clear, neutral process)

I. Are firms usually informed clearly by government of changes in policies and regulations affecting your technology field in your country? (1 = never informed; 7 = always informed)

Something very interesting in assessment of institutional opportunities is the respond from conventional technology firms, because they rate almost all indicators at medium level – i.e. 4 on a scale from 1 to 7. There is discrepancy between the intrapreneurial science-based technology firm and niche technology firm in terms of the assessment of public support when benchmarked by conventional technology firms. Intrapreneurial science-based technology firm reasons that the environment in that sense is less favourable. Intrapreneurial niche technology firm reports that it is more favourable, even though it discloses that connections with government officials is a serious issue. Both types of intrapreneurial firms assess the environment for legal framework and regulations as less favourable than entrepreneurial firms and conventional technology firms do.

Lastly, when interpreting institutional factors one must not rule out that regulations vary substantially in various countries, thus producing different constraints on evaluations. Both conventional technology firms are Czech firms and so is the intrapreneurial science-based technology firm. The latter assesses most of the institutional indicators less than that of conventional firms indicating an emphasis on more government support would be favourable. The different opinions of two firms from Hungary (entrepreneurial niche and intrapreneurial niche technology firms) could be attributed to the fact that intrapreneurial niche technology firm is not a new venture, but older than entrepreneurial niche technology firm, thus is more informed and experienced about the institutional structure. It is located at an industrial cluster whereas entrepreneurial niche technology firm is not.

6. Main Conclusions and Policy Implications

Generation of knowledge-based entre- and intraprenurial activity is not a linear process. On the contrary, it is very much a non-linear process shaped by complementarities between technological, market and institutional opportunities. In that context, major conclusions from the above analyses emerge (see Table 12).

Institutional opportunities are effective in creating ‘ordinary’ entrepreneurship when directly used as the sole policy tools. The lower assessment of entrepreneurial hurdles by conventional technology firms is related to their moderately high level assessment of institutional opportunities in general compared to other firms. But slow sales growth rates and stationary/shrinking employment growth figures accompanied with no activity in trademarks and patenting does not exactly match with what an economy with growth aspirations asks for. One must note that for conventional technology firms market and technological opportunities are lower or at most equal to those of the other firms. When used as the only policy tool institutional opportunities are not effective in creating knowledge-based entrepreneurial and intrapreneurial activity. Entrepreneurial niche technology firm seems as an exception to this expressing very low entrepreneurial hurdle. This firm enjoys success in both domestic and foreign markets and also has an exceptionally high level of buyer requests in relation to product characteristics and sophistication. Therefore, the influence of institutional opportunities on knowledge-based niche entrepreneurship is strengthened via the mediating effect of market opportunities in this case.

Analysis of the direct effect of market opportunities on knowledge-based entre- and intrapreneurship suggests even more interesting outcomes for other firms. A careful look into which markets these firms operate in is very revealing. Conventional technology firms exhibit strong presence in foreign markets identified with more or less the mature segment of the market whereby buyers are price-conscious, not quality or performance. In that sense, the contrasts with the other four firms are striking. Entre- and intrapreneurial science-based technology firms and intrapreneurial niche technology firm show presence only in the domestic market but respond to very high level buyer purchasing decisions in terms of performance and quality. Despite their obvious deficiency in the export markets, these firms exhibit higher sales and employee growth rates. A carefully designed and implemented institutional policy framework to help give support to these firms in terms of increasing their chances of access to export markets will act as a catalyst and a mediating factor to elevate further the positive effects of market opportunities and in turn create higher levels of knowledge-based entre-and intrapreneurial activity. Hausmann et al. (2007), at macro level, show that what firms in a country export matters from economic growth point of view –i.e. countries specializing in exportation of high technology products achieve higher growth rates.

Along with the real markets, the role of financial markets is also important in the process. Although ability to access relevant funding for innovation purposes can be closely associated with managerial capabilities in the firm, it is also related to the technological sophistication level. It is generally thought the science-based technology firms may have easy access to such funds on presentation of innovation projects. Yet, it is probably more complicated issue than it seems. Awareness of public funding availability for innovation is a matter of whether the firm is engaged in innovation activities and actively seeks information for channels to fund its innovation activities. This is not much of concern for conventional technology firms which have control over their export markets and invest mostly in product differentiation rather than innovation in its true sense. Further details about the hard data on technological indicators for conventional firms do support this argument. They have very low R&D investment, are engaged in trivial design activities, have low level of skilled labour in the firm and exhibit low or almost absent knowledge network intensity. The intensity of subcontracting activities linked to large western companies paving the way for easy access to export markets inhibits further investment in technological facets in conventional firms to sustain growth. Findings from entre-and intraprenuerial firm activities in this research suggest that technical progress, market control and development of new knowledge-based entre- or intrapreneurial forms of activity proceed in tandem; progress in one field augments progress in the other.

The entrepreneurial niche technology firm invests in R&D, non-trivial design activities and human capital at the firm level. However, its knowledge networking is not at the level of science-based technology firms. It also assesses the human skills and training environment much lower than the latter group. Certain deficiencies at the technological dimension may hold back entrepreneurial niche technology firm from actively seeking information for public funding for its innovation activities along with the deterring effect of full market control both in domestic and foreign markets. This current favourable condition created by mostly full exploitation of market opportunities cause entrepreneurial niche technology firm to assess funding constraints for entrepreneurial activities almost non-existent (see Table 6). This also reflects onto entrepreneurial hurdle assessment in general. Although technological opportunities are not fully exploited, mostly based on full exploitation of real market opportunities, entrepreneurial niche technology firm regards entrepreneurial hurdles are not to a great extent. The sustainability of these conditions is a matter of question if environment for technological opportunities are not improved in the case of entrepreneurial niche technology firm.

In the CEE, access to export markets seem to govern entrepreneurial aspirations greatly. But MO are also closely connected to technological opportunities. Further findings shed more light onto this. For instance, entre- and intrapreneurial science-based technology firms and intrapreneurial niche firm do not have access to foreign markets. But they show superior exploitation of technological opportunities. The entrepreneurial science-based technology firm, in this sense, outperforms the others, but still regards entrepreneurial hurdles as much higher than recorded by entrepreneurial niche firm which enjoys full market exploitation. Intrapreneurial hurdle assessment is even higher for the intrapreneurial science-based technology firm, since it also needs to realign its human skills according to the new line of technological activity. Even though, in CEE region, the levels of graduates in secondary and tertiary education is much higher than most parts of the world, firm-level surveys assessing the quality of labour skills do not match with the former statistics highlighting a mismatch that indicates skills obtained during education do not meet the requirements of businesses or that businesses are not willing to offer sufficient remuneration to attract workers with the skills they need (EBRD, 2013). Approach to this issue necessitates more than basic education policy tools and substantial involvement and re-design of science and technology policy tools particularly if knowledge-intensive entre-and intrapreneurial activities are concerned.

Based on these findings, there is need for carefully tailored institutional support for firms that embark on the challenge to start completely new line of activity in the firm to bring more growth in sales and employment. For the entrepreneurial niche technology firm this would be in improving human capital and knowledge networking in order to sustain growth by raising innovativeness. For intrapreneurial niche technology firm this would be human capital and R&D support along with access to export markets. For entre- and intrapreneurial science-based technology firms, this would be supporting them in joining into export and value chain networks.

The results also show that intrapreneurial activity should be encouraged in traditional firms, since it acts as a driver of growth in the economy. As widely discussed in the energy transitions literature niche technologies need nurturing and support (Bakker, Van Lente and Engels, 2012; Bakker, Van Lente and Meeus, 2012; Schot and Geels, 2008). Whether it is in entrepreneurial or intrapreneurial form it is more beneficial to economy compared to conventional technologies. Investing in and supporting knowledge-based activity is the way out of transition process. This paper shows that emerging market economies, in particular CEE, have the potential, in terms of technological, market and institutional opportunities, to create sustainable growth by investing in and supporting domestic firms and firm activities in science-based and niche technologies.

Table 12. Complementarities between institutional, market and technological opportunities for growth-oriented knowledge-intensive entre-and intrapreneurial activity.

				Firm performance indicators					
	Tech	Firm	Country	Employee growth from 2007 to 2012 (pa)	Sales growth from 2007 to 2012 (pa)	Entrepreneurship hurdle (1 =lowest, 7=highest)	IO→KIE/KII	MO→ KIE/KII IO→MO→ KIE/KII	TO→ KIE/KII IO→TO→ KIE/KII
Established firm	Conventional	1	CZ	0%	1.5%	2.8	IO is effective in sustaining firm activities based on conventional technologies. Since technologies are not very complex or sophisticated institutional framework helps.	Direct effect of MO on sustaining conventional technological activity is solely based on exploitation of foreign markets. Domestic market demand and public financing of innovation are not determining factors for such activity.	None of the TO categories and indicators seem to impose an adverse effect on conventional technological activity. Although hard data shows clear deficiencies in this area, firms' assessment of their own technological levels is above medium apart from knowledge network activities.
		2	CZ	-12%	4%				
Entrepreneurial	Sb	3	PL	16%	50%	3.9	The direct effect of IO on creating knowledge-intensive entrepreneurship is weak. More public support is necessary.	Direct effect of MO on entrepreneurial science-based activity is largely based on exploitation of domestic markets, production of sophisticated products and effective use of public funding. Failing to exploit foreign markets seems to be a major factor in entrepreneurial activity. The indirect effect of IO via MO could focus on support for access to export markets to lower the entrepreneurial hurdles.	ESB singles out with the highest level of TO exploitation. This is confirmed also by hard data on R&D expenditures, design activities, human skills and knowledge networks at firm level. IO can strengthen skilled labour availability by education policy and training programmes as well as providing support for higher level activities in value chain which will greatly enhance access to export markets.
	N	4	HU	48%	10%	2.3	IO is effective in creating knowledge-intensive entrepreneurship in niche technologies, but this is largely indirect effect via favourable market opportunities. More public support is necessary.	Direct effect of MO on entrepreneurial niche activity is largely based on exploitation of both foreign and domestic markets and production of sophisticated products. The indirect effect of IO via MO could raise awareness for availability of public finance for innovation be more accessible to lower the entrepreneurial hurdles even more.	EN has established competences in terms of R&D expenditures, design activities and skilled labour, however there is room for more exploitation of TO in terms of improvement in human skills and training environment and knowledge networks which will positively influence technology acquisition at firm level. IO can strengthen skilled labour availability by education policy and training programmes and supporting EN to connect with research institutes will improve its technological capabilities to sustain exploitation of MO.
Intrapreneurial	Sb	5	CZ	-4%	10%	5	The direct effect of IO on creating knowledge-intensive intrapreneurship is very weak. More public support and legal framework and regulations are necessary.	Direct effect of MO on intrapreneurial science-based activity is largely based on exploitation of domestic markets, production of sophisticated products and effective use of public funding. Failing to exploit foreign markets in relation to its high technology products from the intrapreneurial activity seems to be a major factor. The indirect effect of IO via MO could focus on support for access to export markets specifically for high tech products to lower the entrepreneurial hurdles.	ISB has established competences in terms of R&D expenditures, design activities and skilled labour, however there is room for more exploitation of TO in terms of improvement in human skills and training environment which will positively influence technology acquisition at firm level. IO can strengthen skilled labour availability by education policy and training programmes. This will help ISB to maintain its high tech activities and access export markets.
	N	6	HU	27%	17%	3.9	The direct effect of IO on creating knowledge-intensive intrapreneurship is weak. More support in legal framework and regulations is necessary.	Direct effect of MO on intrapreneurial niche activity is largely based on exploitation of domestic markets, production of sophisticated products and effective use of public funding. Failing to exploit foreign markets seems to be a major factor in intrapreneurial activity. The indirect effect of IO via MO could focus on support for access to export markets to lower the entrepreneurial hurdles.	IN has some deficiencies in full exploitation of TO in terms of R&D expenditures, design activities and skilled labour. Support and improvements in these aspects will positively influence technology acquisition at firm level. IO can strengthen skilled labour availability by education policy and training programmes. This will help IN to maintain its high tech activities and provide much needed access to export markets.

References

Acemoglu, D., Johnson, S. and Robinson, J. (2001) The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review* 91: 1369–401.

Acemoglu, D., Johnson, S. and Robinson, J. (2002) Reversal of Fortune: Geography and Institutions in the Making of the Modern World Distribution of Income. *Quarterly Journal of Economics* 117 (4): 1231–94.

Andrews, C. and DeVault, D. (2009) Green Niche Market Development: A Model with Heterogeneous Agents, *Journal of Industrial Ecology,* 13(2): 326-345

Bakker, S., Van Lente, H., Engels, R. (2012) Competition in a technological niche: the cars of the future, *Technology Analysis & Strategic Management*, 24:5,421-434

Bakker, S., Van Lente, H., Meeus, M.T.H. (2012) Dominance in the prototyping phase—The case of hydrogen passenger cars, *Research Policy*, 41: 871– 883

Bell, M. and K. Pavitt (1993) "Technological Accumulation and Industrial Growth: Contrasts between Developed and Developing Countries", *Industrial and Corporate Change*, Vol. 2, No.2, pp.157-209.

Edquist, C. (1997) "Systems of Innovation Approaches- Their Emergence and Characteristics", in *Systems of Innovation: Technologies, Institutions and Organisations,* C. Edquist (ed.), London, Pinter Publishers.

EBRD (2013) Transition Report 2013: Stuck in Transition? Available at http://tr.ebrd.com Accessed on 18 November 2014.

EBRD (2014) Transition Report 2014: Innovation in Transition. Available at http://tr.ebrd.com Accessed on 18 November 2014.

Faulkner, W. and J. Senker (1995) *Knowledge Frontiers: Public Sector Research and Industrial Innovation in Biotechnology, Engineering Ceramics and Parallel Computing*, Clarendon Press, Oxford.

Freeman, C. (1994) The economics of technical change. *Cambridge Journal of Economics,* 18: 463-514.

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study.Research Policy 31 (8/9), 1257–1274.

Geels, F.W., and J. Schot. 2007. Typology of sociotechnical transition pathways. *Research Policy* 36: 399–417.

German, R. M. (1984) *Powder Metallurgy Science,* Princeton, New Jersey, Metal Powder Industries Federation.

Hausmann, R., Hwang, J. and Rodrik, D. (2007) What you export matters. *J Econ Growth.* 12:1–25.

Kim, L. (1997) *Imitation to Innovation: The Dynamics of Korea's Technological Learning,* Boston, Harvard Business School Press.

Malerba F. (2010), Knowledge-intensive entrepreneurship and innovation systems in Europe, in

Malerba F. (ed.), *Knowledge-Intensive Entrepreneurship and Innovation Systems: Evidence from Europe*.) London & New York: Routledge.

Malerba, F. and McKelvey, M. (forthcoming) Conceptualizing Knowledge Intensive Entrepreneurship: The KIE Model. In Dynamics of Knowledge-Intensive Entrepreneurship: Business Strategy and Public Policy. Yannis Caloghirou, Franco Malerba, Maureen McKelvey, Slavo Radosevic (eds) Routledge.

Nielsen, R.P., Peters, M.P. and Hisrich, R.D. (1985) Intrapreneurship Strategy for Internal Markets-Corporate, Non-Profit and Government Institution Cases. Strategic Management Journal, Vol. 6, No. 2, pp. 181-189.

Radosevic, S. (2007) National Systems of Innovation and Entrepreneurship: In Search of a Missing Link. Economics Working Paper No. 73. UCL-SSEES, Centre for the Study of Economic and Social Change in Europe. UCL School of Slavonic and East European Studies.

Radosevic, S., Yoruk, E. (2013) Entrepreneurial propensity of innovation systems: theory, methodology and evidence. *Research Policy*. 42: 1015–1038.

Rodrik, D., Subramanian, A. and Trebbi, F. (2002) Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development. Mimeo, Harvard University.

Schot, J., and F.W. Geels. 2007. Niches in evolutionary theories of technical change. *Journal of Evolutionary Economics* 17: 605–22.

Schot, J., and F.W. Geels. 2008. Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management* 20: 537–54.

Schumpeter, J. (1939) Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process, 2 vols, New York, McGraw-Hill.

World Economic Forum (2013) Global Competitiveness Report 2013-2014. Geneva. Available at http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf

Yin, R.K. (2003) Case Study Research: Design and Methods. 3rd edition. Sage Publications. London.

Yoruk, E. (2009) Changing Innovation Systems in the Developing Country Context: Technology Transfer and the New Technological Capabilities in the Materials Industry in Turkey. Unpublished DPhil thesis. SPRU – Science and Technology Policy Research, School of Business and Economics, University of Sussex, Brighton, UK. Available at http://sro.sussex.ac.uk/2402/1/Yoruk,_Elif_Esin.pdf

Yoruk, E. (2011) The influence of technological capabilities on the knowledge network component of innovation systems: evidence from advanced materials in Turkey. *International Journal of Technological Learning, Innovation and Development, Vol. 4, No. 4, pp.330-362.*