CESIS Electronic Working Paper Series

Paper No. 247

Innovation, Technology and Knowledge

Charlie Karlsson, Börje Johansson & Therese Norman

April 2011

The Royal Institute of technology

Centre of Excellence for Science and Innovation Studies (CESIS)

http://www.cesis.se

Innovation, Technology and Knowledge

By Charlie Karlsson, Börje Johansson & Therese Norman

ABSTRACT

This paper outlines a set of fundamental changes in the global economy that have altered the nature of the innovation process, brought about global challenges, and stimulated cross border phenomena and network formation responses. These changes has brought about an increase of the demand for knowledge as well as changed the conditions for knowledge production and innovation. Against the background of a changing global economy, the purpose of the paper is to make an overview over the role and drivers of innovation, technology and knowledge. The role of absorptive capacity and knowledge flows between economic agents from different spatial units for economic growth is further emphasized. Furthermore, it is recognized in the paper that national innovative productivity depends upon the national innovation systems. Multinationals play an increasingly central role for the transfer of knowledge between different parts of the world. This paper thoroughly examines the way multinationals contribute to innovation, technology and knowledge dispersion. The distribution of knowledge investments is uneven across the globe and the occurrence of the "European paradox" highlights where Europe has failed in this context.

Keywords: Innovation, technology, knowledge, globalisation, multinationals, European paradox

JEL codes: O33 - Technological Change: Choices and Consequences; Diffusion Processes

1. Introduction

It is quite common to perceive that the contemporary economy has entered an era of a global knowledge economy. Never before in the history of mankind has so large resources been devoted to the generation of new knowledge and to the diffusion of knowledge by means of education. However, the spatial distribution of these resources over the globe is quite uneven. During most of the 20th century the dominating share of all investments in knowledge production and knowledge generation were made in the industrialized western economies including Japan. Since around 1990, this picture has started to change substantially with rapidly increasing knowledge investments taking place in the BRIC countries[1]. However, from a global perspective one can still claim that these investments retain a very uneven geographical distribution. Disregarding the uneven distribution, it seems appropriate to stress a set of fundamental changes in the global economy that have materialised in recent decades, altering the nature of the innovation process, bringing about global challenges, stimulating cross-border phenomena and network formation responses. These changes have increased the demand for knowledge and at the same time fundamentally changed the conditions for knowledge production and innovation (cf., Archibugi & Coco, 2005) as outlined below under the headings (1) Nature of the innovation process, (2) Global system, (3) Cross-border phenomena, and (4) Network responses.

1.1 Nature of the R&D and innovation process

One can observe in recent time the emergence of new forms for how knowledge generation activities are organised, associated with new approaches to the search for knowledge:

- Many firms have become more motivated and more systematic in searching for, protecting and exploiting scientific, technological and/or entrepreneurial knowledge to increase their competitiveness by means of better products and/or more efficient production processes (Granstrand, 1999; Suarez-Villa, 2000; Karlsson & Johansson, 2006). Firms are changing the way they innovate, while extending their search for access to sources of scientific and technological knowledge outside their national boundaries, building networks of distributed research and development (R&D) including own R&D facilities in foreign locations (Thursby & Thursby, 2006). MNEs' global sourcing of science and technology[2] changes the conditions for research and higher education organizations (Veugelers, 2010).

- The number of knowledge handlers, i.e. people that develop new knowledge or transfer and diffuse knowledge, is rapidly increasing. Since 1950 there has been a global expansion of R&D workers and knowledge handlers in general (Andersson and Beckman, 2009).

- Firms also respond to the fact that R&D as well as innovation itself is changing: (i) the process of transforming knowledge and technology into commercially viable products and services occur more rapidly than before due to reduced geographical barriers and more rapid transport of information and goods, (ii) the innovation process becomes

[1] BRIC = Brazil, Russia, India and China

[2] Technology can be interpreted both in a narrow sense as including production technologies (product and process technologies) and in a broad sense as including production technologies, but also managerial knowledge, marketing skills, and other so-called intangible assets at the firm level (Pavitt, 1999).

gradually more complex and requires collaboration across disciplines and specialities, (iii) the innovation process evolves into more collaborative patterns, requiring collaboration between scientists, engineers and leading end-users, as well as between design, manufacturing, supply and marketing functions, (iv) the development of new products and services gets more expensive, and (v) the innovation process is becoming global in scope, i.e., new knowledge and new technologies are created at centres of excellence around the globe.

1.2 Global system

The world economy is step-wise transformed to a globally interconnected system:

- The phenomenon of globalisation refers to the ongoing expansion of international trade and foreign direct investments. In particular, the emerging new world is characterised by a globally integrated capital market, in which large shares of capital flows find their path outside the control of the banking system and governments.

- International cooperation has become a significant and increasingly important channel for the transfer and diffusion of knowledge in both the public and the private sector (Archibugi & Coco, 2004). One reason behind this is that an increasing share of the research agenda consists of research questions that have a global dimension, such as climate change, energy, safety, and pandemics (Veuglers, 2010).

- An increasing number of players in terms of both nations and firms are able to enter both old and new playing grounds, which implies that the global economic competition has become more intense (Archibugi, Howells & Michie, 1999, Eds.; Mowery & Nelson, 1999, Eds.; Karlsson, Johansson & Stough, 2010).

1.3 Cross-border phenomena

The so-called globalisation of economic and innovation activities are underpinned by a whole set of cross-border phenomena, which comprise interaction of various kinds:

- People with higher education and, in particular, students and researchers have become increasingly more internationally mobile. Thus, firms, research institutes and universities are progressively competing for talent in the global market (Veuglers, 2010). Such knowledge mobility shifts the absorption and creation capacity between places.

- The drivers to extend firms' R&D beyond country borders include the need (i) for adaptation to local markets, (ii) for support to foreign manufacturing, (iii) to reach out globally for new knowledge and technologies, and (iv) to find and attract specific human talent.

- Rapid improvements in the transfer of information and in the transport of goods and people together with substantial deregulation have made the transfer across the globe of commodities, information, human capital and financial resources much easier (Held & McGrew, 1999; Antonelli, 2001; Freeman & Louca, 2001; Karlsson, Johansson & Stough, 2010). In particular, the revolution in information and communication technologies (ICT) and the Internet has reduced the costs of international communication of information and intensified international exchange and communication in R&D and inno-

vation. As a result, the costs of research and scientific activities as well as innovation have decreased drastically (Veuglers, 2010).

1.4 Network responses

The cross-border interaction of the global economy has given rise to efforts to form networks that support and facilitate interaction between firms which belong to the same multinational company group (MNEs) and between firms in general:

- Innovation has in recent decades gone through a globalisation process involving innovation by MNE's overseas subsidiaries, the sourcing of R&D through alliances and joint ventures with foreign firms or universities, and/or the exploitation of foreign technologies through patents and licences (Archibugi & Michie, 1997; Narula & Zanfei, 2005).

- Innovation processes are increasingly characterised by (Gerybadze & Reger, 1999): (i) multiple centres of knowledge in different locations, (ii) a combination of learning through the transfer of knowledge from the parent company and the knowledge created at a given location, and (iii) technology transfers, both between different geographical locations and between organizational units. Thus, the trend in the globalization of technological activities – including knowledge-intensive services – is unambiguously rising since the middle of the1980s following the broader internationalisation of production starting in the 1970s (Cantwell, 1995).

- The knowledge generation process has changed and become more network-dependent (Gibbons, et al., 1994; Meyer-Kramer, 2000). As a consequence, partnerships and collaboration have become more important. International science and technology cooperation has increasingly also become a focus of policy makers, who have become more and more willing to fund programs that stimulate the internationalisation of higher education and R&D (Veuglers, 2010). Collaboration makes it possible to increase the number of agents benefiting from knowledge and provides expanding learning opportunities (Archibugi & Michie, 1995). It allows partners to use each other's expertise and thus enriches the overall accessible know-how (Hagedoorn, Link & Vonortas, 2000).

- The dynamic interplay and the increasing simultaneity of knowledge demand and knowledge supply has become obvious. Multi-disciplinarity and heterogeneity of the actors involved in the knowledge generation process has grown. The increased networking character of knowledge creation and diffusion is evident and has many forms, including increased co-authorships among scientists, intensified university-industry R&D cooperation and the growing number of strategic R&D alliances between firms. However, the generation of knowledge is not defined by clear rules or governed by settled routines. Instead, it is based on a varying mix of theories and practice, of abstraction and aggregation and of coupling of ideas and data from different sources and origins.

Against the above background of globalisation, new forms of innovation, and cross-border and network phenomena, the purpose of this paper is to make a short overview over the state-of-the-art knowledge of the role and drivers of innovation, technology and knowledge in today's global economy.

2. Innovation, technology and knowledge and economic growth

Today, it is generally accepted that knowledge, technology and innovation are major factors contributing to economic growth and development and increased welfare alongside labour and capital (Malecki, 1991; Nelson & Romer, 1996; Lundvall & Foray, 1996; Edquist & McKelvey, 2000). As regards micro phenomena, it is also appreciated that technology factors are critical for the competitiveness of contemporary firms (Kortum & Lerner, 1999; Jaffe, 2000; Shapiro, 2000; Baumol, 2002; van Zeebroeck, et al., 2008). However, the globalization of R&D and innovation is making these relationships more complex and thus more important for scientists and policymakers to analyze and understand. One of the most important insights from recent developments in the new growth and international trade theory has been the recognition of the significant role of knowledge flows between economic agents from different spatial units. For example, the long-term development of export market shares is not driven by price competition but rather by technology and quality competition based upon superior knowledge and technological capability (Soete, 1981 & 1987; Greenhalg, 1990; Greenhalg, Taylor & Wilson, 1994; Maskus & Penubarti, 1995; Wakelin, 1998; Kleinknecht & Oostendorp, 2002; Legler & Krawczyk, 2006; Madsen, 2008).

Knowledge is acknowledged as a critical factor at the micro level, at the regional level, at the national level and at the supra-regional level for preserving and developing competitiveness. In order to stay ahead of competitors in the relevant market niches, firms have to accommodate and develop new knowledge to supply the innovations that are needed to meet the demands of sophisticated as well as price sensitive customers at home as well as abroad to stay ahead of competitors in the relevant market niches. Thus, the competitiveness of a firm is at least partly the result of its capacity to generate but also to find, absorb and assimilate new scientific, technological and entrepreneurial knowledge developed elsewhere, i.e. its absorptive capacity (Cohen and Levinthal, 1990). Major dimensions of this capacity of firms to absorb and to accommodate new knowledge are their stock of human capital and their own investments in scientific and technological research.

At the regional level, competitiveness and thus regional growth, development and welfare is driven by endogenous, decentralized and localized regional factors and here the regional capacity to absorb knowledge developed elsewhere as well as to develop new knowledge plays a central role. Even if the importance of regions has increased substantially, similar factors apply at the national level, and here it is suggested by many that the design of the national innovation systems plays a decisive role (Rosenberg, 1982; Nelson, 1984; Nelson, 1993, Ed.). The idea behind the concept of national innovation systems is that nations provide a milieu for their firms to compete in international markets, and, in particular, that the innovative milieu they offer affect the capacity of their firms to generate and develop innovations.

It is important to observe that the relationships between internationalisation and innovation are both complex and reciprocal. In other words, internationalisation is not only about commercialising technologies developed in a certain country. Depending on the industry, also other motivations, such as resource access and control, technology development, and the development of shared network assets can be of importance. However, while innovation often stimulates internationalisation, there are also considerable evidences of the opposite effect, i.e. that internationalisation itself stimulates learning and innovation within international firms (Andersson and Lööf, 2009; Lööf and Andersson, 2009).

The supra-national level may be illustrated by the triad North America (US) – Europe (EU) – East Asia (Japan). Also on this level the capacity to absorb and to develop new knowledge is critical for competitiveness and for economic growth and development (Ohmae, 1995). Even if each of the triad regions makes very substantial investments in R&D at home, they can never afford to disregard the new knowledge developed in the other two regions, if they in the long run want to preserve their competitiveness in different markets. Thus, it has become a major policy concern within governments and firms in the triad regions how to develop means to promote scientific and technological activities, to absorb knowledge developed elsewhere, to foster innovation within firms and to upgrade the quality of the human capital. Since private R&D is dominated by multinational firms and involves both outward and inward activities, policy-makers are confronted with a two-fold policy challenge: (i) How to stimulate the internationalisation of domestic firms, while ensuring the reinforcement of domestic innovation capabilities?, and (ii) How to attract innovative foreign companies that will strengthen domestic innovation capabilities? The proper response to these two challenges have become more complicated in recent years due to a rapid increase in the location of R&D to developing countries including, India, China and Singapore but also to countries in Eastern and Central Europe.

The changing geography of R&D and innovation is on the one hand the result of efforts from a growing number of countries to increase R&D spending. On the other hand, it is the result of deliberate R&D strategies by firms, where one strategy consideration is to augment innovation resources and results by means of merger and acquisition activities.

3. Innovation, technology and knowledge and national innovation systems

It is important to recognize that innovations which improve productivity and competitiveness do not merely depend on the level of total R&D inputs but also on the way innovation processes are coordinated within and across organizations and countries as stressed in the literature on national systems of innovation (Freeman, 1987; Lundvall, 1992, Ed.; Nelson, 1993, Ed.). This research field developed from the simple observation that nations had different levels of innovation success, measured in terms of the number of patents generated, the share of high-technology goods and services, or the share of trade in high-technology goods and services (Patel & Pavitt, 1987; Mowery, 1992; Mowery & Teece, 1993). In particular, this kind of research was stimulated by concerns in the 1980s among US and European policymakers and scholars that the Japanese system of innovation and manufacturing seemed to create a technology gap, leaving the US and Europe behind. Researchers in the field have studied the influence on the success of these national innovation systems, employing a large number of explanatory variables such as private R&D spending, public R&D spending, antitrust laws, potential market size, the education systems, the quality of the labour force, and the nature of the patent systems[3]. While the perceptions have changed drastically since the 1980s, the questions asked in this research still have their relevance: Are there better systems for generating a larger national innovative output, i.e. to increase the innovative productivity? If so, what should the components be and how should they be related? Above all, which are the variables

[3] A deeper discussion of patents and intellectual property rights is beyond the scope of this report. The economic analysis of patents goes back at least to Plant (1934). There exists since many years a rich literature of "optimal" patent systems and their ability to generate more inventions (quantity) and/or bigger inventions (quality) (Klemperer, 1990; Gilbert & Shapiro, 1990; Scotchmer, 1991).

that properly describe a nation's innovation system, and how do they interface the innovation networks of multinational corporations?

There are, however, today a number of phenomena, and these partly change the focus from the quantity and quality of R&D to the organisation of R&D and innovation. One such phenomenon is the shift from 'closed' to 'open' innovation (Chesbrough, 2003), which has accompanied a broadening of R&D and innovation to include new organizational forms such as outsourcing of R&D, R&D consortia and strategic alliances and the spin-out of firms from incumbents and universities. This growth of "external" R&D indicates a shift away from the traditional in-house R&D-model and the big firm laboratories.

Furthermore, there seems to be a substantial variation between national innovation systems in terms of productivity and efficiency, not least due to organizational and institutional factors (Lehrer, 2007). European R&D has for example lagged significantly behind that of the two other triad regions in terms of commercial productivity (Andreasen, et al., 1995).

Another important aspect is that knowledge spillovers, in particular from academia to industry but also over national borders, are far from automatic (Audretsch & Feldman, 2004). Instead, cross-border flows rely on inter-firm networks which are observed mainly indirectly and hence only documented in fragmented form. This is clearly illustrated by, for example, national differences in the capacity to commercialize biotechnology research (Lehrer & Asakawa, 2004; Cooke, 2006). One problem in this context is the often complex interdependence between basic and applied research.

4. Innovation, technology and knowledge and the role of multinational firms

Globalization and the associated improvements in transportation and communication technologies in recent decades have made it possible for multinational firms (MNE-firms or MNFs) to spread their value-creating activities at a global scale. The geography of the MNFs' innovative activities has evolved along two parallel processes, where the knowledge-creating and knowledge-sourcing activities of MNFs have gradually become more and more international. Even if the internationalisation of the innovative activities of MNFs has lagged behind the internationalisation of their production activities (Dunning & Lundan, 2009), MNFs today play a critical role for the transfer of knowledge between different parts of the world (Breznitz, 2007; Taylor, 2009). One reason is that foreign affiliates today play a much more central role in the knowledge-creating activities of the MNF as a whole by linking the internal innovation network with the regional and national innovation systems in which they are embedded.

Another reason for the stronger role of MNFs is a rapid increase in the number of MNFs, located in a wider range of home countries. This development has made the innovation activities of MNFs much more geographically dispersed. However, the patterns of internationalisation of R&D show a tendency for 'triadisation' rather than globalisation in the sense that the international R&D effort to a high extent is concentrated to the triad regions (Meyer-Krahmer & Reger, 1999; Kuemmerle, 1999b; von Zedtwitz & Gassman, 2002). Most active in internationalising R&D is European firms which carry out 58 % of all internationalized R&D, while the corresponding figure for US and Japanese firms are 33 percent and 10 percent, respec-

tively (Patel & Vega, 1999). Moreover, within the triad, R&D is concentrated within existing agglomerations (Rozenblat & Pumain, 1993; Cantwell & Iammarino, 2000).

The overall effect of these developments is that the international flow of knowledge and technology within each MNF-group has increased substantially as the pertinent subsidiaries have come to play a growing role as centres of learning and R&D (Ghoshal & Bartlett, 1998; Gupta & Govindarajan, 1991; Asakawa, 2001; Iwasa & Odagiri, 2004). This argument applies mainly to MNFs located in developed countries (Dunning, 1998) and in particular to those located in the triad regions (Asakawa, 2001). From a European perspective, it is against this background motivated to ask how Europe is affected by the current trends: To what extent does Europe derive benefits from the presence in Europe of MNFs from the two other triad regions? To what extent do the innovation activities in European MNFs benefit from the presence of their subsidiaries in the two other triad regions? There exist no official data on the knowledge and technology flows within MNFs. To get an idea about the extent of these knowledge flows we are directed to theoretical analyses and empirical studies using various indirect measures.

From an innovation point of view, MNFs can be seen as mechanisms for international knowledge and technology transfers and as knowledge and technology generators. By means of foreign direct investments that exploit an MNF-group's knowledge and other assets, the group will transfer knowledge and technology from the home base to countries that host subsidiaries. This form of transfer comprises both new products and new processes, and can have a spectrum of motives such as market seeking, resource seeking or efficiency seeking, as well as knowledge seeking. Despite the increase in the R&D-efforts that MNF-groups do abroad, these new products and processes is to a large extent the result of R&D investments in the home country of the group (Hennart, 2007). MNF-groups want to internalise such transactions due to imperfections in the markets for knowledge and technology (Buckley & Casson, 1976 & 1985). Multinational company groups make knowledge-seeking and knowledge-augmenting investments outside the home country to expand their knowledge base and to keep themselves up-to-date with preferences of foreign customers and innovation activities of competitors abroad.

Actually, Bresnman, Birkinshaw & Nobel (1999) claim that MNFs maximize their innovative output when they renew their innovative capabilities by transferring, sourcing, combining and integrating innovative knowledge using various strategically advantageous international locations.[4] An underlying motivation for this claim is that due to path dependence and the cumulative nature of innovation, an international strategy striving towards knowledge diversity is a necessary means to avoid the risks of 'lock-in' into technological and institutional cul-de-sacs (Michie, 1998; Redding, 2002). Knowledge diversity increases the pool of know-how a firm can access and combine, which stimulates the innovation process, since innovation to a high extent is based upon the principle novelty by combination (Leonard-Barton, 1995; Glassman, 2001). Furthermore, new innovation strategies unfold when firms have to deal with diverse uncertainties and complexities in their economic milieu (Simon, 1985; Kaufman, 1995; Patel, Kaufman & Madger, 1996; Andriani, 2001).

[4] In earlier research on MNFs' innovative activities it was often claimed that innovation is an activity with limited knowledge flows across borders that is and should be a centralized activity at the parent firm location (Vernon, 1966; Dunning, 1980; Cantwell, 1989; Patel & Pavitt, 1991) due to the need for physical co-location of R&D (Cohen, 1998), the importance of the home market, and the importance of home country competitiveness (Porter, 1990; Sakakibara & Porter, 2001).

To better understand the role of MNFs for international knowledge and technology flows and the effects of these flows, we need to analyse

- the internal knowledge transfers of MNF-groups and how they extend across the borders of regions and countries,
- the extent and the effects of knowledge transfers for the receiving economy when MNF-groups perform asset- or knowledge-exploiting investments, and
- the extent and the effects of knowledge transfers for both host and home country when MNF-groups perform knowledge-seeking investments.

Concerning the impact of MNF's R&D abroad, it is in particular interesting to analyze how an MNF-group's internal knowledge flows affect:

- the home country's technology base ("hollowing out" versus expansion of national capacity), and
- the host country's technology base ("knowledge drain" versus local knowledge development).

Existing economic theory identifies a range of possible spillover channels through which foreign direct investments (FDIs), i.e., MNF-subsidiaries may generate benefits to the receiving economies including benefits for other domestic firms, not least in the form of knowledge spillovers. Such knowledge spillovers may for example lead to higher productivity levels and/or productivity growth in domestic firms. Many governments in developed as well as developing and transition countries also strive to attract MNF-groups to invest in their countries with the belief that knowledge brought by MNF-subsidiaries will spill over to domestic firms and increase their productivity and thus their competitiveness. The literature in the field has identified three potential spillover channels (Saggi, 2002):

- *Demonstration effects*. MNFs introduce new technologies, which are adopted by local firms through imitation or reverse engineering.
- *Labour mobility*. Labour trained by MNFs may bring information, skills and knowledge with them when they become employed by local firms, or when they become entrepreneurs and start their own firms.
- *Vertical linkages*. MNFs may transfer new technologies and knowledge to those local firms which are either suppliers or customers to the MNFs.

In an increasing way, European firms conduct their innovation activities in R&D centres located in the two other triad regions with a strong bias to R&D centres in the US. This behaviour can only partly be explained by a hypothesis a la Vernon (1966), according to which product R&D primarily should be expected to take in the triad economies. It is obvious that the technological endowments and human-capital resources of some regions in the US and Japan are strong attractors for R&D of European MNF-groups (cf. Kuemmerle, 1997 & 1999a; Cantwell & Janne, 1999; Frost, 2001; Le Bas & Sierra, 2002; Chung & Alcacer, 2002). Hedge & Hicks (2008) highlight three different strategic perspectives of R&D performed by MNFs foreign subsidiaries:

- *Foreign R&D focused on customization and modifications*. Foreign R&D is here understood as support to product development and production management in foreign markets along the lines of Vernon (1966 & 1979). The overall motive four such a strategic choice seems to be that early stage innovation is best served by being close to

headquarters, while later and less significant innovations to support overseas markets might be performed locally and close to customers (Teece, 1977; Lall, 1979; Caves, 1996).

- *Foreign R&D focused on absorption from listening posts*. According to Dunning (1994, 75-76), the R&D of overseas subsidiaries of an MNF-group encompasses the following activities: : (i) product, material or process applications or improvements, (ii) basic materials or product research – on immobile subjects, such as tea plants, oil refineries, bauxite mines or agriculture, (iii) rationalized research, i.e. all research on a particular topic conducted in one location, and (iv) research to acquire or gain an insight into foreign innovation activities, i.e. learning and building firm research capability. The last type is "listening post" R&D and it recognizes the existence of high-level R&D capability in other countries and the need for MNFs to absorb foreign know-how in particular from other triad countries.

- *Foreign R&D focused on sourcing knowledge for innovation*. In the last two decades it has become obvious to an increasing number of scholars that MNF-groups have started to adopt a global approach not only in terms of applying their total knowledge base in foreign operations but also to more generally improve their overall innovation capabilities (Bartlett & Ghoshal, 1989; Florida, 1997; Cantwell & Janne, 1999; Zanfei, 2000; Chung & Alacer, 2002; Almeida & Phene, 2004). This strategy seems to be spreading among multinationals. In the literature a distinction has been made between "home-base exploiting" or "asset exploiting" or "production-based" and "home-base augmenting" or "strategic asset augmenting" or "learning-based" investments (Kuemmerle, 1997 and Dunning & Narula, 1995, respectively.[5] In the latter case, R&D is established abroad to access knowledge from local firms and universities. One motivation for such a strategy might be that the home country resources in the form of R&D capabilities are not adequate to meet the firm's requirements. The knowledge absorbed from the local community can be transferred to other R&D units within the MNF-group and/or for local creation of new knowledge. There is evidence that the flow of knowledge between overseas subsidiaries and MNF headquarters is growing and that MNFs may gain more knowledge from their foreign locations than they contribute themselves to these locations (Singh, 2004).

According to a literature that can be traced back to the 1980s, location of R&D in other countries might bring a variety of benefits to MNFs. It gives them an opportunity

- to get advantages from different national systems of innovation (Robinson, 1988; Cantwell, 1992),
- to become acquainted to new lines of technological diversification as reflected in local markets (Cantwell, 1992; Cantwell & Kotecha, 1997; Iwasa & Odagiri, 2004),
- to be exposed to more varied flows of ideas, products, processes and technologies (Håkanson & Nobel, 2001),
- to increase speed and effectiveness of communication and thus reduce development costs (Chiesa, 1996),
- to benefit from location-specific advantages through an international division of labour between foreign R&D locations (Lorenz, 1983),

[5] According to Patel & Vega (1999), 75% of MNFs' technological innovations abroad are being made in fields where MNFs have a home advantage.

- to be more responsive to local needs, in terms of both time and relevance through the access to local supply of goods and services (Caves, 1982; Robinson, 1988; Dunning, 1993; Chiesa, 1996) and to closeness to customers (Casson, Pearce & Singh, 1992), and/or
- to take advantage of what different national innovation systems offer in terms of positive regulatory environments and favourable government incentives (Caves, 1992; Dunning, 1993).

5. Innovation, technology and knowledge – European failures

In Europe, the generation of economic benefits from R&D and not least from publically funded research has become a matter of major concerns among policymakers. The awareness has increased that in Europe there exists a substantial gap between rather high levels of scientific performance based on publicly funded R&D and relatively low levels of scientific contributions to Europe's industrial productivity and competitiveness. This has been described as the "European paradox" (Verbeek, Debackere & Luwel, 2003). It is in this context important to stress, that the application of new knowledge in industrial innovation processes has been identified as a key mechanism for economic growth (Romer, 1990).This impact on growth includes knowledge generated in universities and public research institutes.

This raises different questions (Polt, et al., 2000): Where does the European paradox occur? How does this paradox occur? Why does this paradox occur? Does the European science system fail to develop and to make the kind of contributions upon which modern industrial economies have become increasingly dependent? Does the European industry lack the ability, the absorptive capacity and/or the levels of R&D necessary to effectively use the knowledge produced in the European science sector and in other parts of the world? Authors like Sapir, et al., (2004) and Aghion & Howitt (2006) argue that it is insufficient knowledge investments in industry, which cause the main obstacle to improved competitiveness and growth in Europe. However, other authors stress that it is over-regulated markets in particular in the service sector which limits competitiveness and economic growth in Europe (cf., e.g., Nicoletti & Scarpetta, 2003; Griffith, Redding & Van Reenen, 2004; Bassanini, Nunziata & Venn, 2009). This phenomenon is aggravated by negative effects of administrative burdens to industry and entry barriers across sectors. Actually, this second explanation might partly explain why European industry under-invest in knowledge production. In order to be able to design actions that can change the current situation, it is of course important to understand the reasons for the unsatisfactory performance of Europe.

The European Union (EU) has for many years been concerned with how to strengthen its innovative capability, being an increasingly networked node within the global system (Kale & Little, 2007). One example is the development of a European 'knowledge economy', which has been at the heart of EU's economic policy since the launching of the so-called 'Lisbon strategy' in March 2000. The strategic goal of the Lisbon agenda was that Europe in the coming decade should 'become the most dynamic and competitive knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment'. Later at the European Council meeting in Barcelona in March 2002 it was agreed that the 'overall spending on R&D and innovation in the Union should be increased with the aim of approaching 3% of GDP by 2010. Two-thirds of this new investment should come from the private sector.'[6] These targets were very ambi-

[6] See http://europa.eu.int/comm/lisbon_strategy/index_en.html

tious and at the same time the European summits failed to provide the necessary instruments to reach these targets and left a number of critical questions unanswered. How should the private sector be stimulated to increase its R&D investments? How should the growth of R&D investments be distributed between the different member countries and between different industries? How should the responsibilities to reach the targets be distributed between the individual governments and the EU institutions? Furthermore, the Lisbon strategy neither did nor focus enough on the need to increase the flows of knowledge and technology, in particular, from the two other triad regions. Thus, nobody should be surprised that the Lisbon strategy to a large extent failed.

Thus, Europe still lacks an integrated R&D and innovation strategy with proper instruments to achieve the goals. Europe lacks cohesion and central decision-making regarding R&D and innovation comparable to what exists in the USA and Japan. The individual member states still have a substantial autonomy when it comes to R&D, innovation and higher education. It is far beyond the scope of this paper to try to design a new R&D and innovation strategy for Europe. However, we would like to stress one critical factor for a strategy to be successful, and that is the capacity of Europe to rapidly acquire knowledge developed in the two other triad regions. The importance of such a capacity is well understood as soon as we realise that the gross domestic R&D expenditure in current USD (PPP-adjusted) in the US and Japan taken together is about double of that in the EU, and that researchers in the US and Japan produce approximately the same number of scientific and technical articles as the researchers within the EU (Archibugi & Coco, 2005). The underlying reason why such a capacity is so important is the role of diversity or heterogeneity of knowledge for new combinations to emerge, i.e., for the creation of new knowledge and (technological) innovations (Schumpeter, 1939; Nelson & Winter, 1982; Nonaka, 1994; Nooteboom, 2004). According to this perspective, new knowledge and new technology is assumed to emerge from the combination of existing knowledge bits.

6. Conclusions

This paper has provided an overview of the role and drivers of innovation, technology and knowledge in a global knowledge economy. Four fundamental changes in today's economy are stressed; (1) Nature of the innovation process, (2) Global system, (3) Cross-border phenomena, and (4) Network responses. Knowledge, technology and innovation are major factors contributing to economic growth and development. However, substantial investments in R&D at home will not be sufficient for a leading position in the knowledge economy as nations will lose competitiveness if they disregard knowledge developed in other parts of the world, and especially in the triad. Governments and firms must develop means to increase their absorptive capacity in order to acquire knowledge developed elsewhere.

Differing national innovation systems will impact the innovation productivity of nations differently. The shift from 'closed' to 'open' innovation, e.g. outsourcing of R&D and strategic alliances, has changed the focus from the quantity and quality of R&D to the organisation of R&D and innovation. Furthermore, knowledge-creating and knowledge sourcing activities of MNFs have gradually become more and more international since foreign affiliates play a much more central role in these activities by linking the internal innovation network with the regional and national innovation systems in which they are imbedded. Today, MNFs play a critical role for the transfer of knowledge between different parts of the world. Three potential spillover channels contributing to knowledge and technology diffusion have been identified in the literature; demonstration effects, labour mobility and vertical linkages.

However, Europe has not been able to strengthen its innovative capability in the same manner as the other two triad regions. The "European paradox" describes existence of a substantial gap between rather high levels of scientific performance based on publicly funded R&D and relatively low levels of scientific contributions to Europe's industrial productivity and competitiveness. It has been argued that this is due to insufficient knowledge investments in industry or over-regulated markets which limit competitiveness and economic growth in Europe. One critical factor for an integrated R&D and innovation strategy to be successful, which is stressed in this paper, is the capacity of Europe to rapidly acquire knowledge developed in the two other triad regions.

References

Aghion, P. & P. Howitt (2006), "Joseph Schumpeter Lecture" Appropriate Growth Policy: A unifying Framework, *Journal of the European Economic Association 4*, 269-314

Almeida, P. & A. Phene (2004), Subsidiaries and Knowledge Creation: The Influence of the MNC and Host Country on Innovation, *Strategic Management Journal 25*, 847-864

Andersson, Å.E. & M.J. Beckmann (2009), *Economics of Knowledge: Theory, models and measurement*, Edward Elgar, Cheltenham

Andersson, M and H. Lööf (2009), "Learning-by-Exporting Revisited – the role of intensity and persistence", *Scandinavian Journal of Economics*, 111 (4), 893-916

Andreasen, L., et al., (1995) (Eds.), *Europe's Next Step: Organizational Innovation, Competition and Employment*, Frank Cass, Ilford

Andriani, P. (2001), Diversity, Knowledge and Complexity Theory: Some Introductory Issues, *International Journal of Innovation Management 5*, 257-275

Antonelli, C. (2001), *The Microeconomics of Technological Systems*, Oxford University Press, Oxford

Archibugi, D. & A. Coco (2004), International Partnerships for Knowledge in Business and Academia. A Comparison between Europe and the USA, *Technovation 24*, 517-528

Archibugi, D. & A. Coco (2005), Is Europe Becoming the Most Dynamic Knowledge Economy in the World?, *Journal of Common Market Studies 43*, 433-459

Archibugi, D., J. Howells, & J. Michie (1999) (Eds.), *Innovation Systems in the Global Economy*, Cambridge University Press, Cambridge

Archibugi, D. & J. Michie (1995), The Globalization of Technology: A New Taxonomy, *Cambridge Journal of Economics 19*, 121-140

Archibugi, D. & J. Michie (1997), *Technology, Globalisation and Economic Performance*, Cambridge University Press, Cambridge

Asakawa, K. (2001), Evolving Headquarters-Subsidiary Dynamics in International R&D: The Case of Japanese Multinationals, *R&D Management 31*, 1-14

Audretsch, D.B. & M.P. Feldman (2004), Knowledge Spillovers and the Geography of Innovation, in Henderson, J.V. & J.-F. Thisse (2004) (Eds.), *Handbook of Regional and Urban Economics*, Elsevier, Amsterdam, 2713-2739

Bartlett, C. & S. Ghoshal (1989), *Managing Across Borders: The Transnational Solution*, Harvard Business School Press, Boston, MA

Baumol, W.J. (2002), *The Free-Market Innovation Machine*, Princeton University Press, Princeton, NJ

Bessen, J. (2008), The Value of U.S. Patents by Owner and Patent Characteristics, *Research Policy 37*, 932-945

Bresnman, H., J. Birkinshaw & R. Nobel (1999), Knowledge Transfer in International Acquisitions, *Journal of International Business Studies 30*, 439-462

Breznitz, D. (2007), *Innovation and the State*, Yale University Press, New Haven, CT
Buckley, P.J. & M.C. Casson (1976), *The Future of the Multinational Enterprise*, Macmillan, London
Buckley, P.J. & M.C. Casson (1985), *The Economic Theory of the Multinational Enterprise: Selected Papers*, Macmillan, London
Cantwell, J.A. (1989), *Technological Innovation and Multinational Corporations*, Basil Blackwell, Oxford
Cantwell, J.A. (1992), The Internationalization of Technological Activity and Its Implications for Competitiveness, in Granstrand, O., L. Håkanson & S. Sjölander (1992) (Eds.), *Technology Management and International Business Internationalization of R&D and Technology*, John Wiley & Sons, Chichester, 75-95
Cantwell, J.A. (1995), The Globalization of Technology: What Remains of the Product Cycle Model?, *Cambridge Journal of Economics 19*, 155-174
Cantwell, J.A. & S. Iammarino (2000), Multinational Corporations and the Location of Technological Innovation in the UK Regions, *Regional Studies 34*, ?-?
Cantwell, J.A. & O. Janne (1999), Technological Globalisation and Innovative Centres. The Role of Corporate Technological Leadership and Location Hierarchy, *Research Policy 28*, 119-144
Cantwell, J.A. & U. Kotecha (1997), The Internationalization of Technological Activitity. The French Evidence in a Comparative Setting, in Howells, J. & J. Michie (1997) (Eds.), *Technology, Innovation and Competitiveness*, Edward Elgar, Aldershot, 126-173
Casson, M., R.D. Pearce & S. Singh (1992), Business Culture and International Technology: Research Managers' Perceptions of Recent Changes in Corporate R&D, in Granstrand,O., L. Håkanson & S. Sjölander (1992) (Eds.), *Technology Management and International Business: Internationalization of R&D and Technology*, John Wiley & Sons, New York, 117-135
Caves, R.E. (1982), *Multinational Enterprise and Economic Analysis*, Cambridge University Press, Cambridge
Caves, R.E. (1996), *Economic Analysis of the Multinational Enterprise*, 2nd ed., Cambridge University Press, Cambridge
Chesbrough, H. (2003), *Open Innovation*, Harvard Business Press, Cambridge, MA
Chiesa, V. (1996),Strategies for Global R&D, *Research Technology Management 39*,19-26
Chung, W. & J. Alcacer (2002), Knowledge Seeking and Location Choice of Foreign Direct Investment in the United States, *Management Science 48*, 1534-1554
Cohen, D. (1998), Toward a Knowledge Context: Report on the First Annual UC Berkeley Forum on Knowledge and the Firm, *California Management Review 40*, 22-40
Cohen, W.M. & D.A. Levinthal (1990), Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly 35*, 128-152
Cooke, P. (2006), Global Bioregions: Knowledge Domains, Capabilities and Innovation System Networks, *Industry and Innovation 13*, 437-458
Dunning, J.H. (1980), Towards an Eclectic Theory of International Production: Some Empirical Tests, *Journal of International Business Studies 11*, 9-31
Dunning, J.H. (1993), *Multinational Enterprises and the Global Economy*, Addison-Wesley. Wokingham
Dunning, J.H. (1994), Multinational Enterprises and the Globalization of Innovatory Capacity, *Research Policy 23*, 67-88
Dunning, J.H. (1998), Location and the Multinational Enterprise: A Neglected Factor?, *Journal of International Business Studies 29*, 45-67
Dunning, J.H. & R. Narula (1995), The R&D Activities of Foreign Firms in the United States, *International Studies of Management and Organization 25*, 39-73

Dunning, J.H. & S.M. Lundan (2009), The Internationalization of Corporate R&D: A Review of the Evidence and Some Policy Implications for Home Countries, *Review of Policy Research 26*, 13-33

Edquist, C. & M. McKelvey (2000), *Systems of Innovation. Growth, Competitiveness and Employment*, Edward Elgar, Northampton MA

Florida, R. (1997), The Globalization of R&D: Results of a Survey of Foreign Affiliated R&D Laboratories in the USA, *Research Policy 26*, 85-103

Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, Pinter Publishers, London

Freeman, C. & F. Louca (2001), *As Time Goes by: From the Industrial Revolutions to the Information Revolution*, Oxford University Press, Oxford

Frost, T.S. (2001), The Geographic Sources of Foreign Subsidiaries' Innovations, *Strategic Management Journal, 22*, 101-123

Gerybadze, A. & G. Reger (1999), Globalization of R&D: Recent Changes in the Management of Innovation in Transnational Corporations, *Research Policy 28*, ?-?

Ghoshal, S. & C. Barlett (1988), Creation, Adoption and Diffusion of Innovations by Subsidiaries of Multinational Corporations, *Journal of International Business Studies 19*, 365-388

Gibbons, M., et al., (1994), *The New Production of Knowledge*, Sage, London

Gilbert, R. & C. Shapiro (1990), Optimal Patent Length and Breadth, *RAND Journal of Economics 21*, 87-99

Glassman, O. (2001), Multicultural Teams: Increasing Creativity and Innovation by Diversity, *Creativity and Innovation Management 10*, 88-95

Granstrand, O. (1999), *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*, Edward Elgar, Cheltenham

Greenhalg, C. (1990), Innovation and Trade Performance in the UK, *Economic Journal 100*, 105-118

Greenhalg, C., P. Taylor & R. Wilson (1994), Innovation and Export Volumes and Prices – A Disagggregated Study, *Oxford Economic Papers 46*, 102-134

Griffith, R., S. Redding & J. Van Reenen (2004), Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Countries, *Review of Economics and Statistics 86*, 883-895

Gupta, A.K. & V. Govindarajan (1991), Knowledge Flows and the Structure of Control within Multinational Corporations, *Academy of Management Review 16*, 768-792

Hagedoorn, J., A. Link & N. Vonortas (2000), Research Partnerships, *Research Policy 29*, 567-586

Hedge, D. & D. Hicks (2008), The Maturation of Global Corporate R&D: Evidence from the Activity of U.S. Foreign Subsidiaries, *Research Policy 37*, 390-406

Held, D. & A. McGrew (with D. Goldblatt & J. Perraton) (1999), *Global Flows: Politics, Economics and Culture*, Polity, Cambridge

Hennart, J.-F. (2007), The Theoretical Rationale for a Multi-nationality-Performance Relationship, *Management International Review 47*, 423-452

Hicks, D. & F. Narin (2001), Strategic Research Alliances and 360 Degree Bibliometric Indicators, in Janowski, J.E., A.N. Link & N.S. Vonortas (2001) (Eds.), *Strategic Research Partnerships – Proceedings from a National Science Foundation Workshop*, National Science Foundation, Washington, D.C., 133-145

Håkanson, L. & R. Nobel (2001), Organizational Characteristics and Reverse Technology Transfer, *Management International Review 41*, 395-420

Iwasa, T. & H. Ogadiri (2004), Overseas R&D, Knowledge Sourcing and Patenting: An Empirical Study of Japanese R&D Investment in the US, *Research Policy 33*, 807-828

Jaffe, A.B. (2000), The U.S. Patent System in Transition: Policy Innovation and the Innovation Process, *Research Policy 29*, 531-557

Kale, D. & S.E. Little (2007), Flows and Cohesion: Balancing Capabilities across en Expanded Union, *Mobilities 2*, 99-108

Karlsson, C. & B. Johansson (2006), Dynamics and Entrepreneurship in a Knowledge-Based Economy, in Karlsson, C., B. Johansson & R.R. Stough (2006) (Eds.), *Entrepreneurship and Dynamics in the Knowledge Economy*, Routledge, New York, 12-46

Karlsson, C., B. Johansson & R.R. Stough (2010), Introduction, in Karlsson, C., B. Johansson & R.R. Stough (2010) (Eds.), *Entrepreneurship and Regional Development. Local Processes and Global Patterns*, Edward Elgar, Cheltenham, 1-27

Kaufman, S. (1995), *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*, Oxford University Press, New York

Kleinknecht, A. & R. Oostendorp (2002), R&D and Export Performance: Taking Account of Simultaneity, in Kleinknecht, A. & P. Mohnen (2002) (Eds.), *Innovation and Firm Performance*, ?. New York, 310-320

Klemperer, P. (1990), How Broad Should the Scope of Patent Protection Be?, *RAND Journal of Economics 21*, 113-130

Kortum, S. & J. Lerner (1999), What Is behind the Recent Surge in Patenting?, *Research Policy 28*, 1-22

Kuemmerle, W. (1997), Building Effective R&D Capabilities Abroad, *Harvard Business Review*, (March-April), 61-69

Kuemmerle, W. (1999a), The Drivers of Foreign Direct Investments into Research and Development: An Empirical Investigation, *Journal of International Business Studies 30*, 1-24

Kuemmerle, W. (1999b), Foreign Direct Investment in Industrial Research in the Pharmaceuticals and Electronics Industries – Results from a Survey of Multinational Firms, *Research Policy 28*, ?-?

Lall, S. (1979), The International Allocation of Research Activity by US Multinationals, *Oxford Bulletin of Economics and Statistics 41*, 313-331

Le Bas, C. & C. Sierra (2002), Location versus Home Country Advantages in R&D Activities: Some Further Results on Multinationals' Location Strategies, *Research Policy 31*, 589-609

Legler, H. & O. Krawczyk (2006), The Global Distribution of R&D Activities, in Schmoch, U., C. Rammer & H. Legler (2006) (Eds.), *National Systems of Innovation in Comparison. Structure and Performance Indicators for Knowledge Societies*, Springer, Dordrecht, 31-45

Lehrer, M. (2007), Organizing Knowledge Spillovers When Basic and Applied Research Are Interdependent: German Biotechnology Policy in Historical Perspective, *Journal of Technology Transfer 32*, 277-296

Lehrer, M. & K. Asakawa (2004), Pushing Scientists into the Market Place: Promoting Science Entrepreneurship, *California Management Journal 46*, 55-76

Leonard-Barton, D. (1995), *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*, Harvard Business School Press, Boston, MA

Lorenz, C. (1983), Managing a 1 Billion Dollar R&D Budget, *Europe Profile 32*, 15-17

Lundvall, B.-Å. (1992) (Ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter Publishers, London

Lundvall, B.-Å. & D. Foray (1996), The Knowledge-Based Economy, in OECD (1996) (Ed.), *Employment and Growth in the Knowledge-Based Economy*, OECD, Paris, ?-?

Lööf, H and M. Andersson (2010) "Imports, Productivity and Origin markets – the role of knowledge-intensive economies", *World Economy*, 33 (3), 458-481

Madsen, J.B. (2008), Innovations and Manufacturing Export Performance in the OECD Countries, *Oxford Economic Papers 60*, 143-167

Malecki, E. (1991), *Technology and Economic Development. The Dynamics of Local, Regional and National Change*, Longman, Harlow

Maskus, K.E. & M. Penubarti (1995), How Trade-Related Are Intellectual Property Rights?, *Journal of International Economics 39*, 227-248

Meyer-Krahmer, F. (2000), Increasing Role of Basic Research for Innovation: The Case of Science Based Technologies. Empirical Evidence and Institutional Consequences, Conference paper, ISI Karlsruhe

Meyer-Krahmer, F. & G. Reger (1999), New perspectives on the Innovation Strategies of Multinational Enterprises: Lessons for Technology Policy in Europe, *Research Policy 28*, ?-?

Michie, J. (1998), Introduction: The Internationalization of the Innovation Process, *International Journal of the Economics of Business 5*, 261-278

Mowery, D. (1992), The US National Innovation System: Origins and Prospects for Change, *Research Policy 21*, 125-143

Mowery, D. & R.R. Nelson (1999) (Eds.), *The Sources of Industrial Leadership*, Cambridge University Press, Cambridge

Mowery, D. & D.J. Teece (1993), Japan's Growing Capabilities in Industrial Technology: Implications for US Managers and Policy Makers, *California Management Review 35*, 9-34

Narula, R. & A. Zanfei (2005), Globalization of Innovation: The Role of Multinational Enterprises, in Fagerberg, J., D.C. Mowery & R.R. Nelson (2005) (Eds.), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, ?-?

Nelson, R.R. (1984), *High Technology Policies: A Five-Nation Comparison*, American Enterprise Institute for Public Policy Research, Washington, D.C.

Nelson, R.R (1993) (Ed.), *National Systems of Innovation: A Comparative Analysis*, Oxford University Press, London

Nelson, R.R. & P.M. Romer (1996), Science, Economic Growth, and Public Policy, in Smith, B.L.R. & C.E. Barfield (1996) (Eds.), *Technology, R&D and the Economy*, The Brookings Institution, Washington, D.C., ?-?

Nelson, R.R. & S.G. Winter (1982), *An Evolutionary Theory of Economic Change*, Belknap Press of Harvard University Press, Cambridge, MA

Nicoletti, G. & S. Scarpetta (2003), Regulation, Productivity and Growth: OECD Evidence, *Economic Policy 18*, 9-72

Nonaka, I. (1994), A Dynamic Theory of Organizational Knowledge Creation, *Organization Science 5*, 14-37

Nooteboom, M. (2004), *Inter-Firm Collaboration, Learning and Networks; An Integrated Approach*, Routledge, London

Ohmae, K. (1995), *The End of the Nation State: The Rise of Regional Economies*, ?, New York

Patel, P.& K. Pavitt (1987), Is Western Europe Losing the Technological Race?, in Freeman, C. (1987) (Ed.), *Output Measurement in Science and Technology*, North-Holland, Amsterdam, ?-?

Patel,P & K. Pavitt (1991), Large Firms in the Production of the World's Technology: An Important Case of Non-Globalization, *Journal of International Business Studies 22*, 1-21

Patel, P. & M. Vega (1999), Patterns of Internationalisation of Corporate Technology: Location vs. Home Country Advantages, *Research Policy 28*, ?-?

Patel, V.L., D.R. Kaufman & S.A. Madger (1996), The Acquisition of Medical Expertise in Complex Dynamic Environments, in Ericsson, A. (1996) (Ed.), *The Road to Excellence: The Acquisition of Expert Performance in the Arts and Sciences, Sports and Games*, Lawrence Erlbaum Associates, Mahwah, NJ, 127-165

Pavitt, K. (1999), *Technology, Management and Systems of Innovation*, Edward Elgar, Cheltenham

Plant, A. (1934), The Economic Theory Concerning Patents for Inventions, *Economica ?*, 30-51

Porter, M.E. (1990), *The Competitive Advantage of Nations*, Macmillan, London

Redding, S. (2002), Path Dependence, Endogenous Innovation and Growth, *International Economic Review 43*, 1215-1249

Robinson, R.D. (1988), *The International Transfer of Technology: Theory, Issues and Practice*, Ballinger Publishing Company, Cambridge

Romer, P. (1990), Endogenous Technological Change, *Journal of Political Economy 98*, S71-S102

Rosenberg, N. (1982), *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge

Rozenblat, C. & D. Pumain (1993), The Location of Multinational Firms in the European Urban System, *Urban Studies 30*, ?-?

Saggi, K. (2002), Trade, Foreign Direct Investment, and International Technology Transfer: A Survey, *The World Bank Research Observer 17*, 191-235

Sakakibara, M. & M.E. Porter (2001), Competing at Home to Win Abroad: Evidence from Japanese Industry, *Review of Economics and Statistics 83*, 311-423

Sapir, A., et al., (2004), *An Agenda for Growth in Europe: The Sapir Report*, Oxford University Press, Oxford

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

Scotchmer, S. (1991), Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, *Journal of Economic Perspectives 5*, 29-41

Shapiro, C. (2000), Navigating the Patent Ticket: Cross Licences, Patent Pools, and Standard Setting, in Jaffe, A.B., J. Lerner & S. Stern (2000) (Eds.), *Innovation Policy and the Economy*, The MIT Press, Cambridge, MA, 119-150

Simon, H.A. (1985), What We Know about the Creative Process, in Kuhn, R.L. (1985) (Ed.), *Frontiers in Creative and Innovative Management*, Ballinger, Cambridge, 3-20

Singh, J. (2004), Multinational Firms and Knowledge Diffusion: Evidence Using Patent Citation Data, Working Paper, INSEAD

Soete, L. (1981), A General Test of the Technological Gap Trade Theory, *Weltwirtschaftliches Archiv 117*, 638-660

Soete, L. (1987), The Impact of Technological Innovation on International Trade Patterns, *Research Policy 16*, 101-130

Taylor, M.Z. (2009), International Linkages and National Innovation Rates: An Exploratory Probe, *Review of Policy Research 26*, 127-149

Teece, D.J. (1977), Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-How, *Economic Journal 87*, 242-261

Thursby, J. & M. Thursby (2006), *Here or There? A Survey of Factors in Multinational R&D Location*, The National Academic Press, Washington, D.C.

van Zeebroeck, at al., (2008), Patent Inflation in Europe, *World Patent Information 30*, 43-52

Verbeek, A., K. Debackere & M. Luwel (2003), Science Cited in Patents: A Geographic „Flow" Analysis of Bibliometric Citation Patterns in Patents, *Scientometrics 58*, 241-263

Vernon, R. (1966), International Investment and International Trade in the Product Cycle, *Quarterly Journal of Economics 80*, 190-207

Vernon, R. (1979), The Product Cycle Hypothesis in the New International Environment, *Oxford Bulletin of Economics and Statistics 41*, 255-267

Veugelers, R. (2010), Towards a Multipolar Science World: Trends and Impact, *Scientometrics 82*, 439-456

von Zedtwitz, M. & O. Gassman (2002), Market versus Technology Drive in R&D Internationalisation: Four Different Patterns of managing Research and Development, *Research Policy 31*, ?-?

Wakelin, K. (1998), The Role of Innovation in Bilateral OECD Trade Performance, *Applied Economics 30*, 1335-1346

Zanfei, A. (2000), Transnational Firms and the Changing Organization of Innovative Activities, *Cambridge Journal of Economics 24*, 515-542