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Abstract

Changes through technological innovations are the principle driving forces for economic development and progress. On the other hand, economic development and progress are essential for economic prosperity of firms and of the economy as a whole.

Technological innovation is a continues and endogenous process, developing within the firm. The firm is the main source of innovations, not some exogenous factors, like the market for example. Because of their cumulative nature, technological innovations, which are aimed to improve the production process of a firm, are developed over longer period of time. Moreover, improvements in the production systems of firms are incremental. Nowadays, we are rarely witnessing radical innovations that can change the fundamental basis of the established production systems. Innovations are becoming more of a culture (more of a routine) in successful companies.

By analyzing the evolutionary progress of successful multinational companies, we can see that innovations in general and technological innovations in particular, were the key to their success. Firms with long innovation traditions were and still are the most successful firms in their respective industries. Creating firm's specific technological competence is a continuous and cumulative process which takes time. Generally, the competence creation is only exceptionally an outcome of some breakthrough innovation. Furthermore, even the breakthrough innovations mostly occur in firms with strong technological competences and long innovation traditions.

Technological innovations are fundamental for the firm's long-term existence, growth and success. They help the firm to create innovative profits, which differ from the traditional kind of profits realized by adapting prices and quantities to the current market conditions, and which are more stable than the traditional ones.

Zusammenfassung

Veränderungen durch technologische Innovationen sind die entscheidenden Triebkräfte für die wirtschaftliche Entwicklung und den Fortschritt. Andererseits, sind die wirtschaftliche Entwicklung und den Fortschritt unerlässlich für den wirtschaftlichen Wohlstand der Unternehmen und der Wirtschaft als Ganzes.

Die technologische Innovation ist einen fortlaufenden und innen entstehenden Prozess, der sich innerhalb des Unternehmens entwickelt. Das Unternehmen ist die Hauptquelle der Innovationen, nicht irgendwelche sonstige exogene Faktoren, wie zum Beispiel der Markt. Aufgrund ihrer kumulativen Natur werden technologische Innovationen, die den Produktionsprozess eines Unternehmens verbessern sollen, über einen längeren Zeitraum entwickelt. Darüber hinaus sind Verbesserungen in den Produktionssystemen der Unternehmen inkrementell. Heutzutage, sehen wir selten radikale Innovationen, die die fundamentale Basis der etablierten Produktionssysteme verändern können. In erfolgreichen Unternehmen werden Innovationen als eine Unternehmenskultur (als eine Routine) etabliert.

Durch die Analyse des evolutionären Fortschritts erfolgreicher multinationalen Unternehmen können wir sehen, dass die Innovationen allgemein und die technologische Innovationen insbesondere der Schlüssel zum Erfolg dieser Unternehmen waren. Unternehmen mit langen Innovationstraditionen waren und noch sind die erfolgreichsten Unternehmen in ihren jeweiligen Branchen. Um das Unternehmen eine spezifische technologische Kompetenz zu entwickeln, braucht es Zeit, weil die Kompetenzentwicklung einen zeitaufwändigen, kontinuierlichen und kumulativen Prozess ist. Grundsätzlich erfolgt die Kompetenzschöpfung eines Unternehmens nur ausnahmsweise aufgrund bahnbrechender Innovationen. Darüber hinaus kommen sogar die bahnbrechenden Innovationen meist in Unternehmen mit starken technologischen Kompetenzen und langen Innovationstraditionen vor.

Die technologischen Innovationen sind für die langfristige Existenz, das Wachstum und den Erfolg des Unternehmens von grundlegender Bedeutung. Sie helfen dem Unternehmen, innovative Gewinne zu schaffen, die sich deutlich von den traditionellen Gewinnen unterscheiden. Der so genannte traditionelle Gewinn wird durch die Anpassung der Preise und

Mengen an die aktuellen Marktbedingungen realisiert, während der innovative Gewinn durch die ständige gewinnsuchende Aktivitäten verwirklicht wird. Außerdem sind die innovativen Gewinne stabiler als die traditionellen.

Acknowledgments

It has always been in my perceptions profoundly that knowledge is the most precious of all values, accompanied by learning as the greatest virtue. Being able to learn is a fortuitous union of possessing abilities and a good luck. In a context of such values, I would first want to express my unreserved gratitude to professor Josef Windsperger for his wholehearted acceptance of my thesis, and his precious advices in the topic of concern, which I would hardly think of a possible parallel. I will be always indebted to all my professors in the Faculty of Business, Economics and Statistics at the University of Vienna for giving me a unique basic framework for my future activities. In particular, I would like to emphasize the importance of the basic support and suggestions given to me by the professor Samuel Sadikario-Kolonomos. He gave me very valuable and interesting ideas and hints and was my biggest support during the process of writing the thesis.

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List of Abbreviations

C.E. - Consumer Expenditure

EEC - European Economic Community

GDP - Gross Domestic Product

GNP - Gross National Product

ICT - Information and Communication Technology

MNCs - Multinational Corporations

M&As - Mergers and Acquisitions

PCM - Product Cycle Model

R&D - Research and Development

WWII - World War II

W. - Wages

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Introduction

In this master's thesis I will elaborate on MNCs in the context of technological innovation. As the title suggests, the primary focus will be on the economic development of MNCs through technological innovation. The main research areas are technological innovations and international business strategies.

Change is as fundamental as existing, because change means improvement. Innovation is a combination of new ideas and change, and as such is the essence of existence. The purpose of this work is to emphasize the importance of innovation, especially technological innovation, for a firm's profit and growth and for the economy as a whole. This work is intended to be a highlight of the technological innovation as a continuous and cumulative process which determines the future.

I will try to achieve this purpose through secondary analysis of existing literature elaborating the topic of concern. I will start by analyzing one of the most influential economists of the 20th century, J.A. Schumpeter and his Mark I and Mark II. His very progressive thinking, especially for that time, expressed in his work (*"The Theory of Economic Development"*, 1934 and *"Capitalism, Socialism and Democracy"*, 1943) has enormously contributed to the understanding of economic development in general. He gave special importance to the innovation and was among the first economists, who recognized the great significance of change.

I will continue the analysis with another *"creative thinker"*, as referred to by the economist Sir Alec Cairncross, Edith Penrose. She also stressed the importance of innovation for the firm's growth and was the first economist who introduced the Resource-Based View of the firm (RBV is fundamental for creating firm-specific competitive advantage through effective use of the firm's tangible and intangible assets). She classified the human resource (especially the management) as the most important among the intangible assets of the firm.

Reaching the purpose of this work would be impossible without analyzing the work of the British and American economist, professor John Cantwell. His contribution to the topic is quite extensive. His work *"Technological Innovation and Multinational Corporations"* published in

1989 is used as the basis for my analysis. Many of his more recent individual works and collaborations with other authors are included in my research as well.

Besides the above mentioned remarkable economists, the research includes other important authors who were of interest and have also researched the topic.

The theory presented in this work is supported by some empirical findings in order to show its reliability and its possible practical implications.

The text is conveyed in the following seven chapters:

1. Analyzing the MNCs through the prism of innovation:
Framing the very essential principles of economic progress through innovations
2. Technological innovation
3. The importance of internationalization and the concept of multi-nationality for large MNCs
4. The theory of technological accumulation
5. The evolutionary development of technological competition since the 1950s
6. M&As as technological strategy for greater technological diversification
7. Conclusions and critical overview of the Cantwell's model (1989) and the technological accumulation theory

Chapter 1: The first chapter will elaborate the importance of innovation for MNCs in general. In this section, the most significant aspects of Schumpeter's theory of profit will be considered. Schumpeter's monopolistic practices will be analyzed. Penrose's perspective on profit and firm's growth will be also part of this section.

Chapter 2: The importance of technological innovation for MNCs' long-term survival and success will be emphasized in the second chapter. Of main interest in this section will be the question why technological innovation, rather than other types of innovation, is essential for MNCs?

Chapter 3: In this chapter the internationalization of large firms will be discussed. This part will also consider the concept of multi-nationality and will try to show that the nationality and the multi-nationality are not conflicting trends, but complementary parts of a common process (Cantwell and Santangelo, 1998, p.138). The evolution of foreign subsidiaries of large MNCs will be also part of this chapter.

Chapter 4: The fourth chapter will examine the theory of technological accumulation, elaborated in great details by Cantwell (1989) in his book *"Technological Innovation and Multinational Corporations"*, but also articulated by some authors before him, like Pavitt (1987), Rosenberg (1982), Dosi (1984) and others. An extensive number of recently published research papers on the topic will be considered in my analyses to check the consistency of the theory in question.

Chapter 5: The fifth chapter analyzes the internationalization of large manufacturing firms and the international technological competition since the 1950s. This chapter is divided in two subparts - the first part examines the internationalization of manufacturing firms and the international technological competition since the 1950s through Vernon's PCM, while the second part analyzes the same phenomena, but using a different model based on the theory of technological accumulation, which was first proposed and used by Cantwell (1989) to analyze the same problem.

Chapter 6: M&As as a possible technological strategy for greater technological diversification will be of principle concern in this section.

Chapter 7: This last chapter brings together all important aspects discussed in this work and tries to summarize and evaluate the accumulation theory in general and Cantwell's model (1989) in particular. The major contributions, as well as the major limitations of the theory and the model will be highlighted. The current status of the theory will be evaluated too. Main conclusions will be drawn.

1. Analyzing the MNCs through the prism of innovation:

Framing the very essential principles of economic progress through innovations

The essential conditions for technological development and economic progress of firms in a particular socio-economic environment will be discussed in this chapter. A MNC can be analyzed only within the structure of a particular socio-economic environment, not separately. Thus, for deeper understanding of the functioning of a MNC we should firstly understand the very basic principles of how the environment in which the MNC operates functions.

Today, we can say that we are living in some advanced form of capitalistic society. Since the big corporations are becoming more and more influential and dictate not only the economic, but also the political and the social rules, many critics will say that today is the time of corporatism, not capitalism. However, the corporatism is only a form of organizing the economy and it is not a complex socio-economic system which gives priority to individuals and their rights. In this sense, the corporatism is a collectivistic form of economy which represents the interests of corporations, not the interests of individuals. Nowadays, we can see that both capitalism and corporatism not only exist, but they can even co-exists. Such hybrid forms of capitalism and corporatism are supported as an idea by many politicians around the world.

Since capitalism is well supportive of change through innovations, especially through technological innovations, and to constant technological development and economic progress, in this work I will focus solely on the functioning principles of capitalism and I will analyze MNCs only within a capitalistic structure and a capitalistic form of organizing the economy. The capitalistic society is a dynamic one. The capitalistic dynamism is what Schumpeter defined as a *"necessary evil inseparable from economic progress"* (Schumpeter, 1943, p. 106). It would be impossible to analyze technological innovations in capitalism without considering the ideas of the brilliant theorist of innovations in capitalistic society, Josef A. Schumpeter. Schumpeter was among the firsts who understood the modern industrial conditions and who addressed the need of innovations for profit creation, a firm's growth and a firm's long-term existence.

Another important aspect of the capitalism is certainly its inconsistency with the functioning principles of a perfectly competitive market. The most important condition for economic development and progress is surely the "destruction" of the perfectly competitive market. Under perfectly competitive conditions, where all agents involved are in a state of equilibrium, there is neither the need for the introduction of new, more efficient methods of production nor new products. There exists no incentive for firms to create and innovate, since there is no possibility to earn "higher profits" (profits higher than zero). If perfect competition is "destroyed", firms will have the opportunity to earn positive profits which can compensate their high investments during the innovation process. The creation of such positive profits through innovations is what I will term later as "*innovative profits*". The innovative profits are the key for technological development and economic progress.

1.1. Schumpeter's theory of profit through innovations: Innovative profits

Schumpeter was among the firsts who recognized the importance of innovations for a firm's growth and its long term existence. He enriched the economic literature with two highly valuable works, "*The theory of economic development*" (1934) and "*Capitalism, socialism and democracy*" (1943). In these two works he has spoken about innovations, but in different time periods and under different economic conditions and developments, so the economic critique distinguishes nowadays between Mark I and Mark II model of innovation.

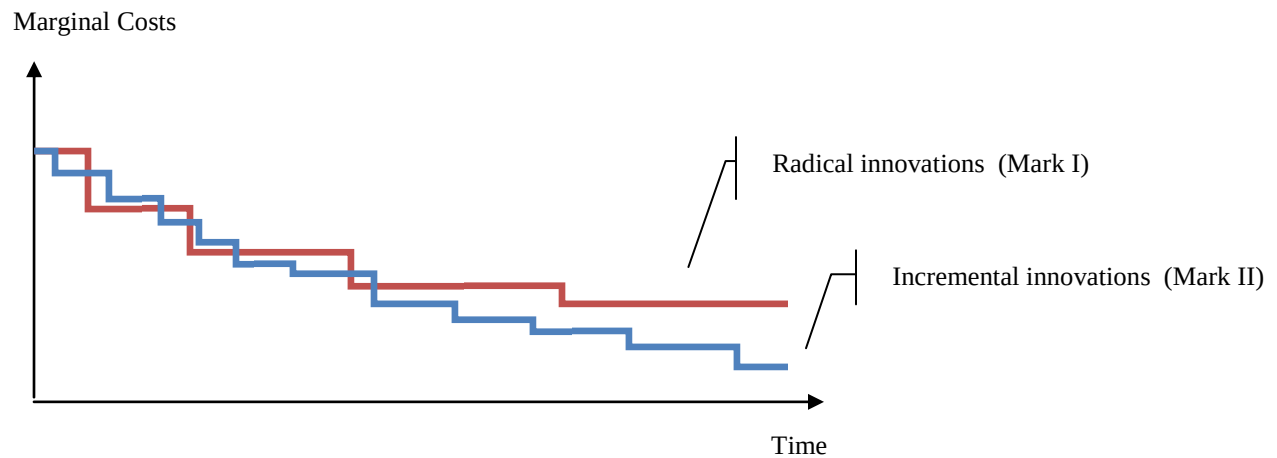
In his first work from 1934 (originally published in 1911) Schumpeter writes about profit as a result of radical innovations. In this work, known as Mark I, Schumpeter distinguishes between invention and innovation, where invention was related mainly to independent inventors and innovation with entrepreneurial firms and commercialization. At that time it was common practice for independent inventors to offer their inventions to entrepreneurial firms, which were responsible for their commercialization.

During the twentieth century the situation changed and in-door research and development became common practice. Schumpeter in his later work known as Mark II (1943) put the focus

on large oligopolistic firms as the main source of innovation. Some authors heavily disagree with this idea that only large firms should be perceived as a source of innovation, addressing that firm's size does not affect much the firm's innovation potential and innovation capability (Pavitt, Robson and Townsend, 1987; Audretsch, 1995). I, personally agree that small firms can also be quite innovative, but the focus here is on large firms because they are constantly creating new technological improvements through their continuous problem-solving activities (Loasby, 1998), which can be regarded as a source of further technological development and a source of innovations for smaller firms. Therefore, large firms should be perceived as a source of innovation and as a valuable resource for smaller firms with which they co-operate. In Mark II, Schumpeter shifted his attention from profit creation through radical innovations to profit creation through incremental innovations, as innovation creation became a continuous process developing mainly within the firms.

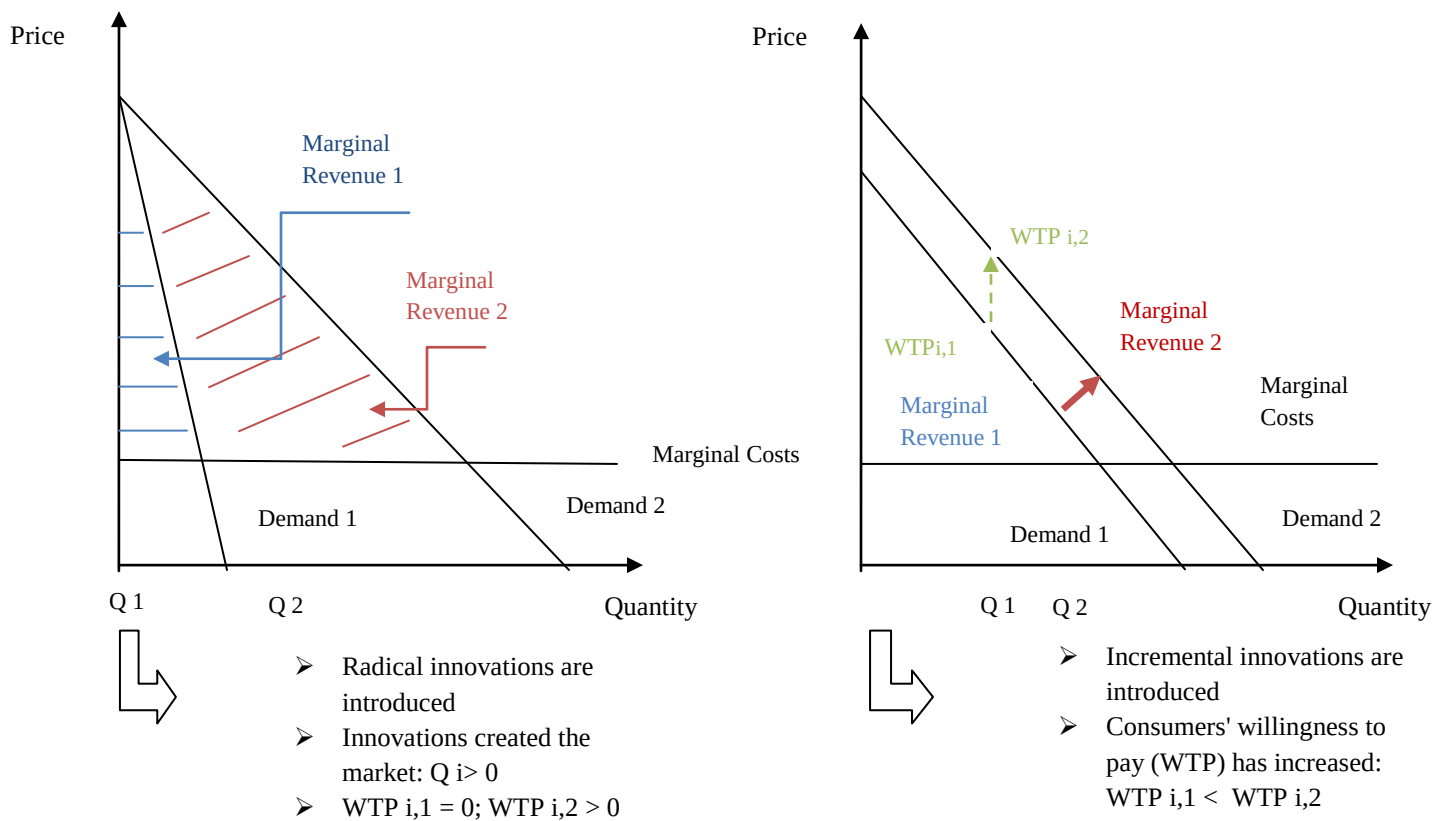
During the nineteenth century most of the newly introduced innovations were radical, thereby creating completely new firms and establishing new industries. During the twentieth century the focus shifted from radical towards incremental innovations and the so called "routinized regime" became a popular term. In Figure 1, the so called "entrepreneurial regime", characteristic for the nineteenth century and related to Schumpeter's Mark I, and the "routinized regime", characteristic for the twentieth century and related to Schumpeter's Mark II are graphically presented. The red line, denoted as radical innovations (Mark I), shows that the marginal costs decline while the time interval between each following introduction of innovation increases. This suggests that during the nineteenth century radical innovations were discovered at relatively low costs. The blue line, denoted as incremental innovations (Mark II), shows that during the twentieth century the innovative process has become more of a routine, resulting in smoother cost reduction. The newly introduced innovations didn't completely eliminate and displace the old ones, but quite the opposite, they improved them. In this case we speak about incremental changes or incremental innovations.

Figure 1. Schumpeter's Mark I vs. Mark II



Source: own representation based on Puetzl, 2016, p. 53

Figure 2. Mark I vs. Mark II



Source: own representation based on Puetzl, 2016, p. 54

In the first chapter of his book *"The theory of economic development"* known as Mark I, Schumpeter describes the economic life from a standpoint of the circular flow of money. The circular flow of money is an economic system which tends towards equilibrium, thereby creating the opportunity for the determination of prices and quantities.

The principle features of the theory of circular flow are: 1. The production processes follow similar routine and there is no product differentiation, 2. There is no room for asymmetric information, namely all suppliers know the exact demand and adjust the quantity supplied accordingly, 3. There is no possibility of wastage of resources, since the economy is able to produce the optimal level of quantity, 4. All firms cohabit in competitive equilibrium, and 5. The prices are equal to the average costs. All these characteristics create a picture of perfect competition and equilibrium.

If we consider these main features of the circular flow theory, we can easily conclude that this concept is used in the context of static rather than dynamic settings. The transformation of the model into a dynamic one requires changes. These changes can be created through innovations. Introduction of innovations into the established channels of the income-flow disrupts the well settled structure of this circular flow of money and whereby the process of economic development begins. Innovations represent the foundation of economic development and progress. The Schumpeterian model of innovation represents exactly that, the disruption of the established economic structure of the circular flow of income.

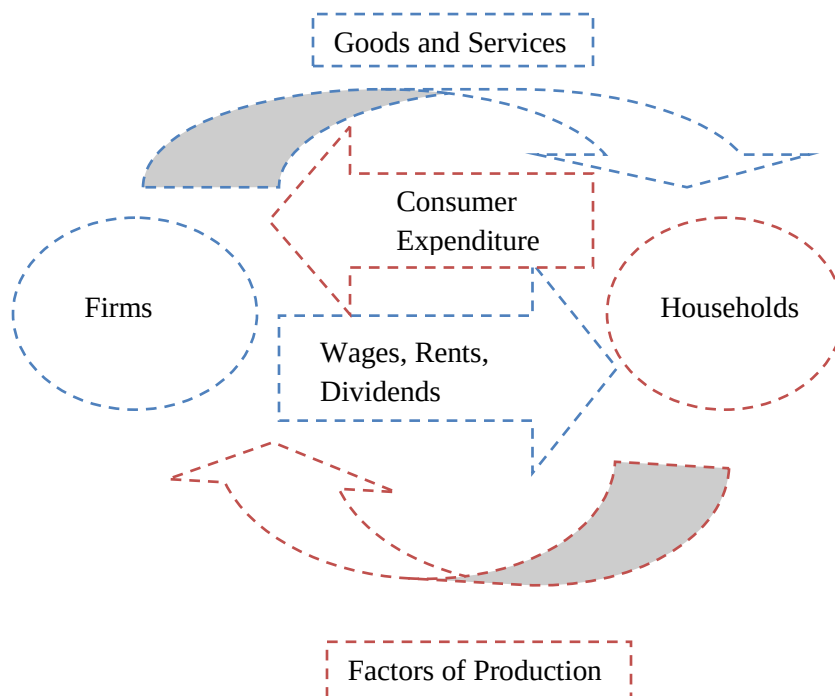
Schumpeter understands economic development as a *"spontaneous and discontinuous change in the channels of the flow, disturbance of equilibrium, which forever alters and displaces the equilibrium state previously existing"* (Schumpeter, 1934, p. 64). Innovations responsible for inducing the process of economic development do not arise from the consumers' needs, but they are initiated from the producer. The producer is the one that starts the economic change, which will eventually lead to economic development (Schumpeter, 1934, p. 65). Using the modern economic terminology, we term these type of changes as technology-push innovations. One important characteristic of technology-push innovations is that, first the innovation is introduced and then the market for that innovation is created. Of course, this is mainly true in the theoretical sense, because in reality the economic logic always prevails over the technological one (Schumpeter, 1934, pp. 14-15).

Schumpeter defines innovations as "new combinations" in the production process of a firm. Improvements in the production process arise from the producer's ability to combine the existing materials and existing methods of production differently. In this sense, economic development comes as a result of such new combinations in the production process (Schumpeter, 1934, p. 66). Schumpeter distinguishes between the following five categories of innovations which can break the established circular flow of money: 1. Introduction of a new good or new quality of an existing good (product innovation), 2. Introduction of a new method of production, which needs to by no means be founded upon a new scientific discovery but can also exist in a new way of handling a commodity commercially (process innovation), 3. Opening up of a new market, in which the particular manufacturing branch of the country in question has not previously been entered, whether or not this market existed before 4. Conquest of a new source of supply of raw materials of half-manufactured goods, whether or not this source already existed, and 5. The carrying out of the new organization of any industry, like the creation of a monopoly position or the breaking up of the monopoly position (Schumpeter, 1934, p. 66).

As long as the circular flow is static, perfect competition can be secured. When this concept is extended to include innovations as well, perfect competition can no longer exist. The destruction of the perfect competition should not always be interpreted as a negative event, thereby highlighting the argument that in a market with anomalies one agent can benefit only at the expense of some other agent (the so called zero sum game) (Hens and Rieger, 2010, p. 120). On the contrary, in my opinion this destruction should be regarded as a motivator for firms to become more innovative. The innovative firm will surely benefit at the expense of some other less innovative firm, which I perceive as a very natural event. In markets with certain anomalies (imperfect markets) firms get the chance to introduce new, value-added products which will differ from the products of their competitors and to charge higher prices for them. Using the imperfect conditions in the marketplace firms can yield profits, which otherwise could not be obtained. Moreover, firms will also satisfy the specific needs and requirements of the consumers, which were formerly unsatisfied. This surely can be perceived as a trigger which drives firms to act. Changes introduced through innovations are highly uncertain and innovators will always ask to be compensated for the undertaken risk. The higher this risk, the higher would be the compensation that the innovator will expect. Therefore, the innovators will always look for higher returns. As long as firms coexist in perfect competition, there is no need for further

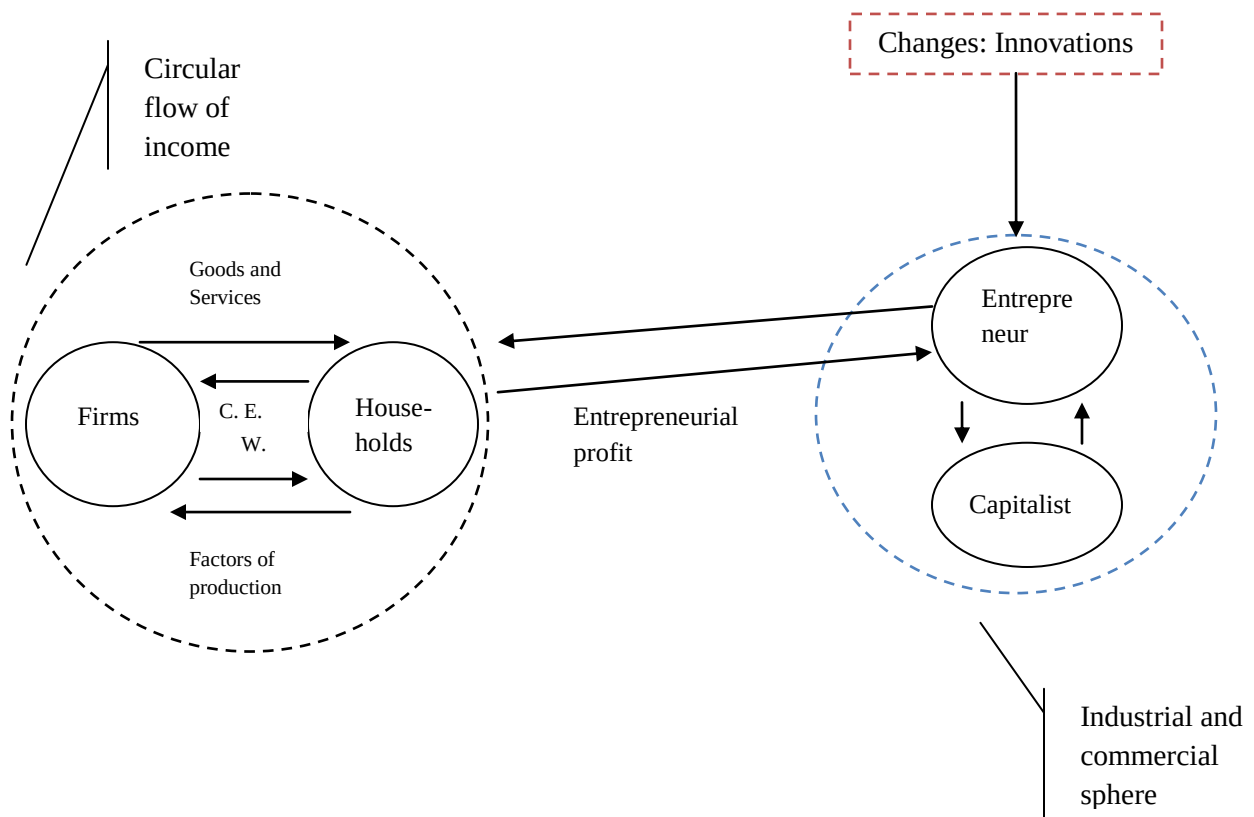
economic development. When the circular flow of income is disrupted by innovations and the perfect competition is destroyed, the process of economic development starts. The concept of circular flow of economic life and Schumpeter's model of economic development are visualized in Figures 3 and 4. As we can see from Figure 3, changes (innovations) appear in the area of industrial and commercial life and not in the sphere of consumers' needs, which confirms Schumpeter's proposition that innovations (and economic development) are initiated by producers and not by customers (Schumpeter, 1934, p. 65).

Figure 3. Circular flow of economic life



Source: own representation based on Daraban, 2010

Figure 4. Schumpeter's economic development model



Source: own representation based on Chandradas and Vishnu, 2012, p. 14

According to Schumpeter (1934), there are two ways of creating profit, the traditional one which is related to adapting prices and quantities to market conditions in order to create profit, and the new one which is related to profit creation through novelty-creating economic activities (Cantwell, 2000/2001, p. 6). Therefore, we distinguish between the traditional or standard kind of profits and innovative profits. In the traditional context of profit creation, a firm should have a certain degree of market power in order to impose prices and quantities in a way that would be beneficial for it. In this sense, profits are created through adjustment of prices and quantities in the market by firms that have enough market power to conduct such adjustments (Cantwell, 2000/2001, p. 6). According to this traditional way of creating profits, an innovative firm is focused simply on profit maximization rather than on innovation.

In a novelty-creating economic environment the attention shifts from using the market power to create profits towards a constant search for new value-adding activities that will secure higher profits. These profit-seeking activities disrupt the circular flow of income (Cantwell, 2000/2001, p. 6). According to Cantwell (2000/2001), Schumpeter in his later work *"Capitalism, Socialism and Democracy"* (1943) termed the disruption of the established circular flow of money as a *"creative destruction"*. This term is often misunderstood, since *"creative destruction"* refers to the creative process and not to the circular flow of income (Cantwell, 2000/2001, p. 6). Profits created through value-adding activities significantly differ from the profits derived from using the market power. Using the market power at a given point in time can help the firm to increase its profit rates, but only in that particular point in time. The innovative profits are a result of a continuous creative process and can raise the firm's profits for a longer period of time. They are more constant and stable profits, securing long term existence of the firm. These profits are not created by exercising the market power of the firm. Furthermore, the firm's increased market power comes as a result of innovations, which create the innovative profits.

Either by using the standard analytical tool grounded on the traditional economic theory of circular flow of income or by using the new one which is based on the continuous creation of new value-adding activities to analyze the origins of profits, we come to the conclusion that in both cases Schumpeter speaks about earning profits higher than zero, only using different economic mechanisms. In accordance with the traditional way of profit creation, we discuss the pure profit maximization, while according to the new way, we speak about constant *"search for higher profits"* (Nelson and Winter, 1982). Such higher profits can be acquired only if perfect competition is destroyed and the firm starts to compete in more aggressive economic environment. In the eighth chapter of his second book *"Capitalism, Socialism and Democracy"* (1943), Schumpeter discusses the monopolistic practices and explains why the concept of perfect competition and a perfectly competitive market is inconsistent with innovation and economic development. His viewpoints expressed in this chapter are often misinterpreted, as he speaks about monopolistic positions not as a source of innovative profits but just as an incidental by-product (viewed from the perspective of the income circulation) (Cantwell, 2000/2001, p. 7). This misinterpretation of Schumpeter's monopolistic practices in the context of profit creation is known as the *"Schumpeterian hypothesis"*, which claims that the market power is the main source of innovation, thereby providing resources and safeguarding against the potential

downside of risk-taking activities (Cantwell, 2000/2001, p. 8). In the very same chapter, he clearly makes a difference between innovative profits and profits that come as a result of increased market power, claiming that the latter are coincidental source of profits. The following quotation demonstrates very clearly that Schumpeter is misinterpreted by many authors trying to analyze his monopolistic practices and it also disputes the *"Schumpeterian hypothesis"*: *"Thus it is true that there is or may be an element of genuine monopoly gain in those entrepreneurial profits which are the prizes offered by capitalist society to the successful innovator. But the quantitative importance of that element, its volatile nature and its function in the process in which it emerges put it in a class by itself. The main value to a concern of a single seller position that is secured by patent or monopolistic strategy does not consist so much in the opportunity to behave temporarily according to the monopolistic schema, as in the protection it affords against temporary disorganization of the market and the space it secures long-range planning."* (Schumpeter, 1943, pp. 102-103). The only logical answer to the question why Schumpeter is so often misinterpreted and even criticized with regard to the monopolistic practices, is probably because his ideas were too progressive for his time to be understood appropriately.

Schumpeter, as many modern evolutionary economists after him and many classical authors like Smith and Marx before him, also insisted on the priority of innovative profits over the standard ones. The relative importance of innovative profits continues to increase and it is expected to increase further in the future, with the growing internationalization of firms (Cantwell and Santangelo, 1998, p. 132). Cantwell and Santangelo (1998) claimed that the creation of innovative profits is encouraged by new, more flexible forms of organizations. Thus, they believe that in the future more flexible forms of organizations are to be expected (Cantwell and Santangelo, 1998, pp. 131-132). Another important reason for the increasing importance of innovative profits is the internationalization of firms. Strong international competition has decreased the possibility for using market power to maximize profits. Innovative profits also gained priority with the increasing significance of the international knowledge flow, which enables easier creation of "new combinations" and creation of innovations. The establishment of international corporate networks smoothes the knowledge transfers between firms and accelerates the learning process, which is an essential condition for the creation of innovations and for the creation of innovative profits. When analyzing MNCs in the context of technological innovations, innovative profits have a prevalent role.

Besides the fact that Schumpeter made a clear distinction between innovative profits and profits generated with help of market power, he also distinguished between innovation and imitation in order to determine the allocation of innovative profits (Cantwell, 2000/2001, p. 11). Schumpeter held the opinion that initial innovators, compared to imitators, should earn a higher share of the innovative profits. Other economists, like Cantwell for example, do not share the same opinion with Schumpeter about profit distribution. Cantwell (2000/2001) characterizes Schumpeter's perspective on innovative profit allocation as a drawback, because in his opinion the initial innovator of a successful innovation is not necessarily the one that performs the best in the market (Cantwell, 2000/2001, p. 11) and therefore, should not always receive the highest share of the profit. Very often we are witnessing how "followers" (or "imitators") are becoming technological leaders and not necessarily the "first movers" (or "innovators"). Thus, in the actual socio-economic environment Schumpeter's distinction between innovation and imitation blurs. I personally understand Schumpeter's idea of profit distribution, especially from a standpoint of social fairness; "first movers" should be rewarded for their courage to involve themselves in innovative processes, which are highly uncertain, risky and highly demanding. However, from a standpoint of the fast technological and economic progress, I think that the distinction between innovation and imitation should not be of great importance, since both innovations and imitations accelerate the overall process of technological development and economic progress. I believe that not only the initial innovators, but all firms operating in a certain industry should have access to the advanced knowledge and information in order to innovate. Only if they have such an access, the knowledge transfer between firms in the industry will be effective, fast and continuous, enabling rapid technological development and encouraging innovation. Nowadays, MNCs are aware of the importance to have access to the existing international knowledge flow in order to innovate. Therefore, they are actively building international corporate networks which help them to obtain such access.

1.2. Schumpeter's monopolistic practices

Schumpeter strongly believed that such a thing as a perfect competition and perfectly competitive markets had never existed and would never exist. Perfect competition is simply not an attractive economic environment for innovators, since it secures zero profit. Therefore, it is not a suitable environment for technological development and economic progress. Innovators will always look for higher profits (positive profits) in order to justify the high risk they are facing during the innovative process. Therefore, in my work I analyze MNCs under imperfect market conditions and in imperfect competition.

After briefly explaining the difference between innovative and standard profits, the discussion may continue to the second important topic for my analysis here, namely the Schumpeterian monopolistic practices. In the previous section I clearly emphasized that the primary source of Schumpeter's innovative profits is not market power and the monopolistic practices arising from that power, but innovation. However, the fact that an innovative firm may enjoy greater market power after successful introduction of an innovation is undeniable. Still, this great market power should be regarded as an expected outcome of a successful introduction of an innovation, and not as a leading motive for a firm to innovate.

Schumpeter speaks about monopolistic practices (or "restrictive practices") in the eighth chapter of his book *"Capitalism, Socialism and Democracy"* (1943). Knowing his perspective on innovative profit distribution, we can easily conclude that he emphasizes the "restrictive practices" as possible options for an innovative firm to protect its innovation and to compensate the undertaken investment. Since he holds the opinion that an innovator should earn a higher share of the innovative profits than an imitator, it is reasonable to expect that he will also advise how an innovator can achieve this task in practice. First, Schumpeter discusses patent protection as a possibility for a firm to protect its innovation and to secure a monopolistic position for a certain period of time. Patents are quite an interesting topic to be discussed, especially because of their, so to speak, dual nature. The question of whether patents are a restrictive practice which legally inhibits innovations or quite the opposite; encourages them, still remains to be answered.

Besides the fact that patents impose legal restriction on the use of specific information or practice, there is also another perception of patents, as they increase firms' incentive to create and innovate (Glezos, 2010). By offering legal protection, a patent ensures the innovative firm that for a specific period of time it will have monopolistic position in the market, which will enable the firm to repay the undertaken investment. In some cases when a patent cannot be acquired or if acquired cannot offer proper protection, then other methods should be used for a firm to justify its investment (Schumpeter, 1943, p. 88). Nowadays, some MNCs use patents as a legal measure to protect their innovations, while others decide to employ some other "restrictive practice". The question is why some of them refuse to protect their innovations through patents? One of the main reasons why firms decide to use other methods than patents, is still linked to the lack of confidence. Many of them still believe that by revealing valuable information, there always exists a certain risk for illegal disclosure of that information.

Besides the patents, Schumpeter also speaks about other ways to protect an innovation and to secure monopolistic position, which we will see that, even today, are commonly used in practice. Securing monopolistic position can be achieved through building entry barriers. As we know, even today, many MNCs use this strategy to secure their positions in the market. High capital requirement to enter a certain industry is one of the strongest barriers to prevent new firms from entering the industry. The experience that a first-mover firm enjoys is another important aspect that should be considered by new firms willing to enter the industry. A firm which operates in an industry that demands high capital to enter and which, at the same time, owns the needed experience has an opportunity to gain time and space for further technological developments (Schumpeter, 1943, p. 89). At the same time, such competition discourages new firm from entering the industry (Schumpeter, 1943, p. 89).

In the section of monopolistic practices, Schumpeter also speaks about price rigidity in the context of protecting innovations. He defines price rigidity as a phenomenon which is characterized by less price sensitivity with regard to changes in demand and supply, than it would be in perfect competition (Schumpeter, 1943, p. 92). Some innovations enable the firm to offer its final products at lower prices than before, while other innovations induce higher prices for the firm's final products. The former are innovations that cause reduction of the production

costs, thereby enabling the firm to produce its products at lower costs per unit than before. The unit cost reduction is almost always a result of some technological innovation; innovation in the technological production process of the firm. The latter are usually improvements of the firm's existing products. Each improvement involves additional costs that are reflected in the product's final price. In this context we can say that, for a firm it is of crucial importance to be able to adapt the prices in accordance with the type of the innovation introduced. Even if the firm, intentionally or unintentionally, fails to adapt the prices, according to Schumpeter, in the long run the prices will not fail to adapt themselves to the technological progress (Schumpeter, 1943, p. 93). This is very important point, because it emphasizes that even if a firm is able to impose "unfair" price for its products(to keep the price rigid) using its market power, in a long run the price will correct itself. Such price rigidity is mainly a short-term phenomenon (Schumpeter, 1943, p. 93).

What is really important to say here is that, Schumpeter does not promote rigid prices as a possible method to achieve monopolistic position, on the contrary, he understands the strategy in question as a way *"...to avoid seasonal, random and cyclical fluctuations in prices and to move only in response to the more fundamental changes in the conditions that underlie those fluctuations. Since these more fundamental changes take time in declaring themselves, this involves moving slowly by discrete steps-keeping to a price until new relatively durable contours have emerged into view."* (Schumpeter, 1943, p. 93).

I give myself the right to conclude this section with one Schumpeter's sentence which, I think, best highlights his perception of perfect competition: *"...perfect competition is not only impossible but inferior, and has no title to being set up as a model of ideal efficiency."* (Schumpeter, 1943, p. 106).

1.3. Penrose's perspective on profit and firm's growth

Edith E. T. Penrose, like Schumpeter before her, claimed that the main source of profit, which is crucial for a firm's long term corporate growth and prosperity, are innovations. In her book *"The theory of the growth of the firm"* published in 1959, Penrose argued that the innovation comes as a result of a constant learning process within the firm of how to develop new applications of an existing internal knowledge base (Cantwell, 2000/2001, p. 13). Penrose, like Schumpeter before her and other economists after her (like Nelson and Winter, 1982), perceived the firm as a constant seeker for higher profits through value-adding activities, and not as a purely profit-maximizer creating profits by using its strong market position (market power). She clearly made a difference between profits arising from market power, which are in their nature short-termed, and profits arising from innovations, which are more stable and persistent. We can see that she differentiated between firm's profitability and corporate growth as a consequence of technological progress and firm's profitability and growth resulting from monopolistic practices in the following sentence: *"Examples of growth over long periods which can be attributed exclusively to such protection [referring to market power] are rare, although elements of such protection are to be found in the position of nearly every large firm."* (Penrose, 1959, p. 113).

Technological diversification was another important aspect which Penrose addressed as essential for firm's expansion. She emphasized that such diversification is to be based on the firm's underlying technological complement and relatedness of activities (Cantwell, 2000/2001, p. 14). An important condition for a firm to be able to technologically diversify is its existing technological base. If the firm has a strong technological base, then it can more easily become more technologically diverse. Some other authors later, like Cohen and Levinthal (1989), termed this condition as an *"absorptive capacity"* of the firm. Penrose pictured the firm as a primary source of innovation, because of its continuous internal learning process and its absorptive capacity. *"I have placed the emphasis on the significance of the resources with which a firm works and on the development of the experience and knowledge of a firm's personnel because these are the factors that will to a large extent determine the response of the firm to changes in the external world and also determine what it 'sees' in the external world."* (Penrose, 1959, pp.

79-80). This statement links Penrose's perspective on what is crucial for technological progress and a firm's growth with regards to Cantwell's theory of technological accumulation, which will be discussed in greater detail in the fourth chapter of this thesis. Some empirical findings will be elaborated later in this work to show that, a firm is able to successfully innovate mainly in those sectors in which its technological strengths were historically concentrated, thereby additionally confirming the hypothesis that the technological progress results from the cumulative nature of the firm's internal process of learning in production (Cantwell and Fai, 1999, p. 331).

In the context of the firm's growth, Penrose spoke about the importance of the ability of the firm's personnel to learn and develop experience. She emphasized that the most valuable resource of a firm is the human resource and its potential to be an active part of the internal learning process in creating firm-specific advantages. The firm's personnel and its continuous learning in production help the firm to accumulate knowledge and experience and to create firm-specific technological competence. Having technological competence, the firm is able to respond in an appropriate way to the fast changing market conditions and consumers' requirements. In this sense, Penrose perceived the firm as the principle source of technological development and innovation, and not the market, as Adam Smith's famous dictum claimed (that the division of labor is determined by the extent of the market (Cantwell and Fai, 1999, p. 332)). Adam Smith in his original theory of economic growth considered only capital accumulation to be responsible for economic growth (Cantwell and Fai, 1999, pp. 335-336). Not only Adam Smith, but also other classical economists as David Ricardo and Karl Marx, believed that capital accumulation is the most important process in the economy. In their perspective, capital accumulation is the main driving force towards technology creation, and not the process of learning in production. However, this perception of economic growth can be more easily understood if we consider the fact that, in Smith's time the profits from trade were the principle foundation of capital accumulation. This accumulated capital was then used for organizing new production processes (Cantwell and Fai, 1999, p. 336). Besides the classical theory of economic growth, which is most importantly represented by Adam Smith, there are many evolutionary economists, like Penrose, who did not share the same opinion about the economic growth and progress as the classical theorists. Clark (1985), Kodama (1992), Utterback (1994), and Christensen (1997), claimed that the technological progress of a firm is an evolutionary outcome of constant activities to improve

the internal production process of the firm. The technological progress is the principle condition for a firm's growth. This evolutionary perception of the firm's technological development and progress is actually an indicator that Schumpeter's "*creative destruction*" is more applicable to products or markets than it is to technologies (Cantwell and Fai, 1999, p. 334).

In accordance with this evolutionary view, the firm is the one that organizes and initiates economic development and economic progress through its firm-specific technological competences (Cantwell and Fai, 1999, p. 333). Logically, the firm is not and cannot act as some separated part from the market in which it operates. Furthermore, it is in constant interaction with other firms, institutions and with its customers. Satisfying the customers' needs by improving the final products through improvement of the production process remains to be the principle objective of each firm. However, the main point here is that the firm should be perceived as a conceptually separate institution from the market, which has specific influence on the economic activities (Cantwell and Fai, 1999, p. 333). From the above discussed, I can draw the conclusion that Penrose's approach to analyze the firm's technological progress through innovations was implying the technological accumulation theory (like Cantwell's approach to analyze MNCs and international technological competition) and not Schumpeter's theory of "*creative destruction*", which, according to the common interpretation used by many authors, explains the technological progress as a discontinuous process, claiming that the process of creative destruction represents "*incessantly destroying the old one, incessantly creating a new one*" (Schumpeter, 1943, p. 83).

However, one important drawback of Penrose's theory is her failure to clarify the difference between the firm's national and international expansion, which for the analysis here is crucial. My focus in this work is on MNCs (as opposed to national ones) that gain advantages mainly from the narrow technological specialization of countries and firms, so the separation of national and international expansion is rather important.

2. Technological innovation

"I never think of the future. It comes soon enough."

Albert Einstein

As outlined in the introduction, change is as fundamental as existing. Innovation is a new idea (simple, or complex) that is intended to cause change in many economic areas – in organization, structure, production, technology, quantification, knowledge, ethics and culture. Its main supposition is improvement. Innovations tend to improvement (not indifference or regression), therefore we can define innovation as idea + change + improvement.

Changes through innovations are not only determinant of economic progress and prosperity, but are also considered to be the foundation of many basic sciences (or general purpose sciences, as they are termed later in this work), such as mathematics, biology, physics, and many others.

Many processes in the economy are analogous to physics. In this sense, we can compare the functioning principles of demand in the economy to the process of energy creation in physics. In accordance to Newtonian physical axioms, changes in nature are related to the following “primitives”: time, space, constants, force, energy, and inertia. Concepts (ideas) have analogical primitives to the physical. The notion (entity) of innovation is a combination of idea + change, therefore something sourcing from the subject (“individuum”) to the environment (collectivity, plurality). In Newtonian language innovation is the relation (causative) of force and acceleration, or in Leibniz-Newtonian language it is projection from differentiation to integration. Alternatively, it is the mapping of the individual will to the plural (clustered) forms. In the Escher-ian world it would be a continuum of primitive(*abstract forms*) → to harmonized(*complexity*). Finally, innovation can be an output of systematical work or serendipity.

In this work, I will stick only to innovations in the context of economy. In the economic world, the main driving force of innovations is profit. Each innovation aims to increase profit either through cost reduction or increase in demand. Achieving this purpose depends on the following

conditions (proportionalities): market power, enterprise size, technology availability (technological development), appropriability (protection, adaptability) and demand.

The types of changes that innovations induce can be defined as follows: For convenience we denote here: C as "changes" and f as 'is function of'.

- Functional changes, where

$$C = f(\text{strategy, goals, functional relations, cause – consequence})$$

- Relational changes, where

$$C = f(\text{clarity + working flow, connectivity, sequences, optimality, configurations})$$

- Combination changes, where $C = f(\text{people + resources + environment})$
 - Structural changes, where $C = f(\text{management, control, relations})$
 - Limit changes, where $C = f(\text{finances, human resources, consortia, market – position, circumstances, ethics})$
 - Performance changes, where $C = f(\text{efficiency + satisfaction})$
 - Quantitative changes, where
- $$C = f(\text{numbers, dimensions, operations, representation, sequences, proportions})$$
- Logical changes, where
- $$C = f(\text{logical relations and operations, abstractions, topological spaces/invariants})$$
- Environmental changes, where $C = f(\text{security, benefits, complexities})$
 - Ethical changes, where
- $$C = f(\text{consequences, good vs. bad, legal issues, politics, beliefs, histories and culture})$$

Innovations might reflect:

- Small vs. fundamental changes
- Continuous vs. discontinuous changes
- Input information vs. output information
- Sequence of: facts, numbers, metaphors, models, preferences, utilities
- Complexity vs. simplicity
- Linearity vs. nonlinearity
- Nearer vs. farther future

Albers and Gassmann (2005) categorize five innovation dimensions, namely: context, intensity, subjective, process and normative (Albers and Gassmann, 2005, p. 26). In accordance with their content ("*What is new?*"), we distinguish between process innovations and product innovations (Albers and Gassmann, 2005, p. 26). Process innovation could be defined as an improvement which increases the efficiency of the production process. Process innovations might reduce the unit costs, might increase the quality of outputs, might reduce the production time or might make the production process safer (Albers and Gassmann, 2005, p. 26). While process innovations are pursuing to find new combinations of existing production factors, thereby making the production process more efficient, product innovations are pursuing to exploit the market. With a product innovation, the firm aims to offer its customers fulfillment of completely new purposes or fulfillment of existing purposes in a completely new way (Albers and Gassmann, 2005, p. 26). Thus, product innovation aims to increase the effectiveness.

In accordance with the intensity of an innovation ("*How new is it?*"), we make a difference between radical and incremental innovations. Radical innovations induce fundamental changes, while incremental innovations create small changes or improvements.

We make another distinction according to the subjective dimension of innovations ("*For whom it is new?*"), between subjective and objective innovations. Subjective innovations are considered to be new only to a certain group of customers or to the firm that creates the innovation, while objective innovations are new, so to say, to the whole world.

The process dimension of innovations refers to the whole innovation process, from initiation to the utilization of an innovation.

The fifth dimension, the normative one, deals with questions concerning the success of an innovation.

My focus in this work is to find the relationship between technological innovations and MNCs. More precisely, to find out why technological innovations (rather than other types of innovation) are fundamental for a firm's growth, its long-term existence and its success.

Technological innovation covers everything within the production process itself, which over time raises the productivity of inputs (Cantwell, 1989, p. 8). According to Caves (1982), technological innovation is *"knowledge about how to produce a cheaper or better product at given input prices or how to produce a given product at lower cost than competing firms"*.

In other words, technological innovation is a process innovation, which tends to make the production process of a firm more efficient over time. By increasing the efficiency of the production process through process innovations, the firm lowers the production costs or it improves the quality of the inputs used. By lowering the unit costs, the firm will be able to induce price reduction more easily than its competitors, thereby increasing the demand for its products. By improving the quality of the inputs used, the firm will produce more value-added products, which can be marketed at higher prices than the products of its major rivals. Thereby, the firm can induce higher prices for its final products and can increase its profit margins.

Technological innovation is a process that takes a longer period of time, as we can see from the definition above. It is a process that over time raises the productivity of inputs. Thus, it can be concluded that technological innovation is a result of gradual accumulation and constant, incremental improvements of the firm's production process (Cantwell, 1989, pp. 8-9). In this sense, technological innovation is a result of continuous systematic work and not an output of serendipity.

If we look for an explanation of the strong connection between technological innovation and MNCs, there is no better way than to explain it in Cantwell's language, namely the growth of MNCs is a result of a continuous *"process of cumulative technological change within the firm, in which innovation and the growth of international production are mutually supportive"* (Cantwell, 1989, p. 7).

3. The importance of internationalization and the concept of multi-nationality for large MNCs

The internationalization of large manufacturing firms finds its beginnings in the period after WWII, when US firms started to intensively invest in Europe. During the 1970s and the 1980s, when European firms recovered from the devastated economy in which they were left after the war period, they followed the example of the US firms and began to invest in the US.

The latter emergence of Information and Communication Technology (ICT) enabled enormous number of firms to internationalize their operations. Firms began to establish internationally integrated networks and to globalize their production and R&D operations. The newly established international networks differed from the former ones in their form and purpose. The principle difference between the previously and the newly established international networks was that the new networks were more integrated and dependent on each other than the old ones were. With the expansion of ICT and the establishment of global MNC networks in the early 1990s, the era of globalization began.

In the current trend of technological globalization, the importance of the knowledge flow between firms and countries increased enormously (Cantwell and Janne, 1999, p. 121; Cantwell and Santangelo, 1998, p. 132). Both firms and countries became more dependent on the global knowledge flow for technological development and technological diversification. In order to gain advantages from the global technological knowledge and experience, many firms internationalized their research and development (R&D), thereby employing less hierarchical and less centralized form of organizations. By establishing R&D and production units in different centers of excellence worldwide and by building global organizational networks, the most successful and technologically advanced firms became MNCs. Although, MNCs were primarily motivated to internationalize their R&D by the advantages that the market proximity offered, nowadays the R&D units abroad have gained a more important role, namely to generate new technology from the specific knowledge flow of the country in which they are located (Cantwell and Mudambi, 2005, p. 1109). The MNC's subsidiaries abroad that acquired a more creative role in the process of technological development have become a strongly integrated part

of the MNC's international network, compared to the subsidiaries that stayed focused only on market exploiting activities. In accordance with the role of the subsidiaries within the integrated MNC's network, Cantwell and Mudambi (2005) distinguish between "*competence-exploiting subsidiaries*", whose principle role is product adaptation to the local needs and regulations and to the local factors of production, and "*competence-creating subsidiaries*" with a main function to create technologies. They emphasized that the competence-exploiting subsidiaries may evolve in competence-creating ones. The subsidiaries' evolution depends upon many factors, such as the location in which the subsidiary is stated, but sometimes the "*subsidiary evolution may to some extent gain a logic of its own*" (Cantwell and Mudambi, 2005, p. 1110).

Other authors have worked on the topic of MNCs' subsidiaries evolution as well, like Birkinshaw and Hood (1998) and Frost et al. (2002). Birkinshaw and Hood (1998) defined the environmental factors, the choice of the subsidiary itself and the assignment that the subsidiary receives from the firm's headquarters as the three most important factors in the process of subsidiary's evolution. Frost et al. (2002) addressed the dynamism of the environment in which the subsidiary is located, the level of the subsidiary's autonomy, the support that the subsidiary receives from the firm's headquarters and the level of integration between the subsidiary and the other parts of the MNC's structure in competence-creating activities as the most decisive factors in the determination either the subsidiary will evolve in competence-creating or not.

The intensity of R&D activities varies among the two types of subsidiaries. According to Cantwell and Mudambi (2005), subsidiaries with competence-creating role tend to have higher degree of R&D activities than the subsidiaries with simply competence-exploiting assignments. They also found out that the subsidiaries located in a center of excellence, with a higher degree of autonomy and with support of the parent company have a higher chance to become competence-creating subsidiaries than the subsidiaries that do not fulfill these requirements (Cantwell and Mudambi, 2005, p. 1112). All of the factors that influence the evolution of subsidiaries are presented in the following table, together with the intensity of R&D activities in each of the two types of subsidiaries.

Table 1. Evolution of subsidiaries and varying determinants of localized R&D

Process of subsidiary evolution				
		Stage 0	Stage 1	Stage 2
Locational, subsidiary-level and MNC group-level conditions	More favorable	Competence-exploiting mandate	Competence-creating mandate	Local R&D driven mainly by needs of technological creativity
	Less favorable	Competence-exploiting mandate	Competence-exploiting mandate	Local R&D continues to be driven mainly by needs of technological adaptation

Source: own representation based on Cantwell and Mudambi, 2005, p. 1112

As we can see from the Table 1, all MNC's subsidiaries abroad began their evolutionary journey in stage 0 as competence-exploiting subsidiaries with a purely market-orientation focus. As the MNCs' international networks were expanding and becoming more integrated, some of the competence-exploiting subsidiaries, which had a favorable combination of locational, subsidiary-level and MNC-group level conditions, evolved in competence-creating subsidiaries in Stage 1, with local R&D driven by technological creativity in Stage 2. Subsidiaries that had a less favorable combination of these three factors did not acquire a competence-creating mandate and their local R&D remained mainly driven by the needs of technological adaptation.

Another important contribution of Cantwell and Mudambi's (2005) work is the examination of the effect that an acquisition may have on the evolution of a firm's subsidiaries and their R&D intensity. This topic will be elaborated in the sixth chapter of this work, in which I am going to discuss M&As as a possible strategy for greater technological diversification.

As we saw from the evolution of the MNCs' subsidiaries, almost each MNC subsidiary abroad began to work with a competence-exploiting mandate, thereby completely focusing only on

market-oriented activities. Historically, a firm's decision to become a MNC depended mainly on the advantages that the market proximity offered. Market proximity enabled the firm to respond appropriately to the local demand by adapting its products to the local tastes and regulations. It also enabled the firm to take advantage of the locally available factors of production and to adapt its products in accordance with the availability of the local resources and production conditions (Cantwell and Mudambi, 2005, p. 1109).

The trend among MNCs towards establishing closely integrated global networks is well discussed in the literature of business strategy (Porter 1986; Hedlund, 1986; Doz, 1986; Dunning, 1988a; Bartlett and Ghoshal, 1989) according to which, it is expected that in the future the networks' integration will be even more unified (Cantwell and Sanna-Randaccio, 1993, p. 275). Doz (1986) has spoken about the advantages that a MNC can gain from such a closely integrated global network. Such advantages mainly arise from the possibility for a MNC to improve its performance. Dunning (1988a) emphasized the possibility for creating technological capabilities, as the most important advantage that a MNC can obtain within such a globally integrated network. Cantwell and Sanna-Randaccio (1993) claimed that the main benefit that a MNC can gain from such a network derives from the possibility of each MNC's affiliates abroad to specialize in the local supply and demand. By adapting to the locally available resources, such as factors of production, labor force, communication and interaction with local organizations, and to the local consumers' tastes and needs, the firm would be able to benefit from the refined locational division of labor within the MNC (Cantwell and Sanna-Randaccio, 1993, p. 275). The experience that certain affiliates abroad can gain from its local specialization can create positive spillovers in some other parts of the MNC's integrated network.

Overall, global integration stimulates knowledge and technology diffusion and vice versa.

The advantages that a MNC can obtain from its internationally integrated network are in positive correlation with the MNC's degree of multi-nationality, as measured by the value of international production for which the MNC's affiliates abroad are responsible, relative to the value of domestic production for which the parent firm is responsible in its home-country (Cantwell and Sanna-Randaccio, 1993, p. 276). Multi-nationality is defined as a geographical dispersion of

MNC's production and not necessarily of its markets (Cantwell and Sanna-Randaccio, 1993, p. 282).

Because of the numerous positive effects that a firm may obtain when becoming a MNC, the multi-nationality is perceived here as a source of competitive advantages for the firm.

To be able to claim that the multi-nationality is a source of advantage for the firm, first we should see how it affects the firm's profit and growth. The idea about the existence of a connection between the multi-nationality and the firm's growth originates from Penrose's (1959) and Downie's (1958) theory of growth of the firm. Radice (1971) and Devine (1976) have later worked the same topic, summarizing the findings of Downie and Penrose. Two functions relate the firm's growth (G_f) to its profit rate (r_f), namely the first one which is depicted by Downie (1958) and Marris (1964) and which claims that the firm's growth is constrained by the availability of financial resources (termed as institutional constraints on growth), and the second one which claims that the firm's rate of profit depends upon the growth rate, the growth in demand, the growth of its technological opportunities in the industry, the size, the technological capabilities, the market power and upon factors associated with the degree of multi-nationality of the firm (Cantwell and Sanna-Randaccio, 1993, pp. 277-278). The first function depicts the financial resources available to the firm as a main determinant of the firm's growth, such that the growth is positively influenced by the firm's profitability (Cantwell and Sanna-Randaccio, 1993, p. 277). The second, cost-of growth function, suggests that the firm's growth induces costs which vary in accordance with the firm's willing to gain market share from its competitors, whereby the firm's rate of profit is an inverse function of its growth (Cantwell and Sanna-Randaccio, 1993, p. 277).

The growth of the firm is constrained by two types of financial resources, internal and external. Internal resources are related to the firm's shareholders and their willingness to reinvest in the firm and external resources are related to the possibility for the firm to gain resources from the capital market. The ability of the firm to borrow from the capital market in order to grow depends on its profit rates. The amount of the reinvested capital of the firm's shareholders depends on the firm's profit rates as well. Namely, the shareholders require certain portion of the firm's profit to be paid in dividends. The higher the firm's profit rates, the higher is the possibility

that the shareholders will agree the excess profit to be reinvested in the firm, because only if the firm is able to pay the dividends to its shareholders, they may consider the idea of reinvesting. Overall, we can conclude that the firm's growth depends positively on the profitability.

A firm's growth can be external, internal or both at the same time. According to Ansoff's (1957) product-market strategies for future growth, the firm has four possibilities to grow externally, namely by market penetration, by market development, by product development or by diversification. When employing the market penetration strategy, the firm reduces the product price and increases the support in promoting and distributing its products. Thereby, the firm should be aware of the possibility that such an action may force the competition to react and there is a high risk for this strategy to become contra-productive (Cantwell and Sanna-Randaccio, 1993, p. 278). If the firm decides to implement the market development strategy, it tries to develop a new market with its existing products. Apropos the product development strategy, the firm extends its product range by introducing new products to the existing markets. The strategy of diversification is certainly the riskiest one, where the firm increases its market shares by introducing new products to new markets.

When discussing the internal growth of the firm, we are referring to what Penrose (1959) defined as an expansion of the firm's management team. Almost each external growth of the firm is followed by internal growth and vice versa. Expanding the firm's management team induces costs which increase proportionately to the increase in newly hired managers. As Penrose (1959) suggested, these costs can be reduced if the learning capabilities of the new managers and the experience and skills of the old ones are at the highest level. The effectiveness of the new managers depends on their learning abilities (or absorptive capacity, as termed previously). Such an effectiveness will be secured only if they are capable of acquiring knowledge and experience from their older colleagues, when working together (Cantwell and Sanna-Randaccio, 1993, p. 278). Therefore, the utility of the firm's managers can be expressed as a function of the firm's growth (the third function below). The higher the utility of the managers, the faster is the firm's growth. In sum, the firm's internal and external growth depends on its profitability. Therefore, the higher the firm's profitability, the faster is its growth.

The three functions discussed above can be formally written as follows (Cantwell and Sanna-Randaccio, 1993, pp. 277-278):

$$G_f = f_1(r_f, I), \quad dG_f / dr_f > 0$$

$$r_f = f_2(G_f, G_D, G_{TO}, S_f, TC_f, MP_f, \{M_f\}), \quad dr_f / dG_f < 0 \text{ for } G_f > G'_f$$

$$UM_f = f_3(G_f), \quad dUM_f / dG_f > 0$$

where,

I represents the institutional constraints on growth

G_D represents the growth in the firm's demand in its industry

G_{TO} represents the growth of the firm's technological opportunities in its industry

S_f represents the firm's size

TC_f represents the firm's technological capabilities

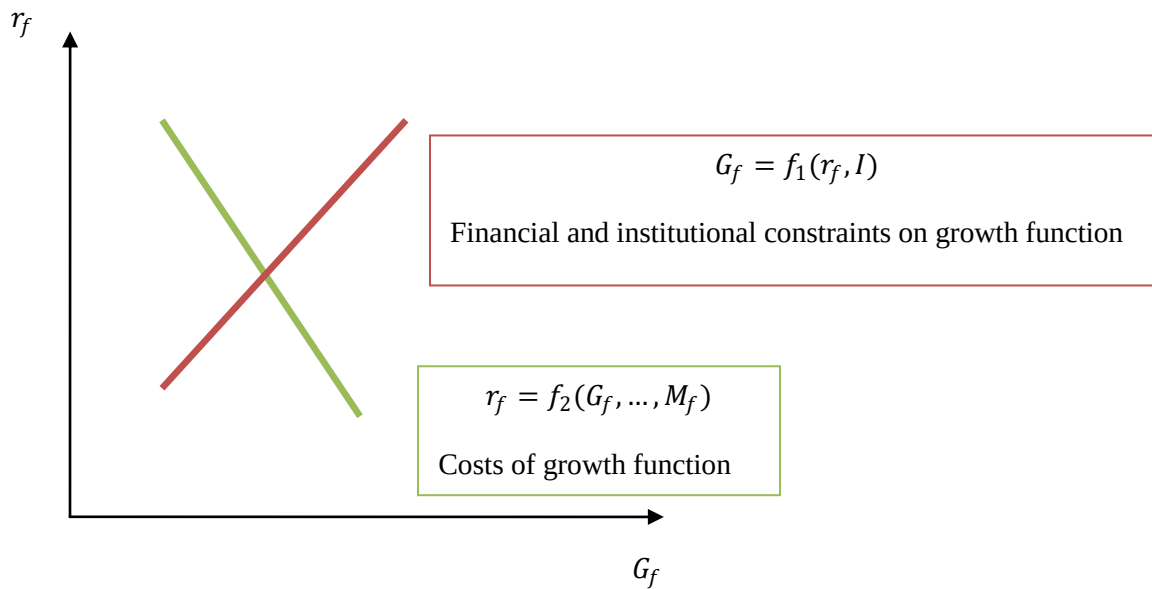
MP_f represents the firm's market power

M_f represents the factors associated with the degree of the firm's multi-nationality

UM_f represents the utility of the firm's managers

The graphical presentation of the first two functions follows in Figure 5. Firm's managers can choose to set the firm's growth rate at the point where the two functions intersect or at any other point on the costs-of-growth function above the intersection point (Cantwell and Sanna-Randaccio, 1993, p. 279).

Figure 5. The relationship between the firm's growth (G_f) and its rate of profit (r_f)



Source: own representation based on Cantwell and Sanna-Randaccio, 1993, p. 279

Cantwell and Sanna-Randaccio (1993) analytically examined the effect of multi-nationality on a large industrial firm's growth. When analyzing the effect of multi-nationality on a firm's growth, we should be aware of the effect that the firm-specific competitive advantages have on the firm's profit and growth. Important to highlight here is that, the competitive advantages of a firm are defined relative to the competitive advantages of its major competitors in the industry (Cantwell and Sanna-Randaccio, 1993, p. 281). The competitive advantages of each firm are different and firm-specific, but as Penrose (1959) said, all of them derive from the firm's internal learning process and its accumulated experience and knowledge. The most important competitive advantage of a firm, which certainly affects the firm's profit and growth, is the firm-specific technological capability. The firm's technological capabilities affect the firm's external and internal costs of growth and shape its technological competitiveness. The higher the technological capability of a firm, the lower are the production costs per unit and the higher is the demand curve of the firm (Cantwell and Sanna-Randaccio, 1993, pp. 280-281). Due to the high demand, a firm is able to realize higher profits and to grow faster externally. Therefore, the firm-specific technological capability affects the firm's profitability in a positive way.

The more technologically capable and experienced the firm is, the faster is its internal growth.

Because the growth of a firm can be described as a function of its rate of profit, as outlined before, we can conclude that the technological capability of a firm has a positive effect on the firm's profit rates and consequently, on the firm's internal and external growth.

The position that a firm has in its markets forms another type of competitive advantage which affects the external growth of the firm (Cantwell and Sanna-Randaccio, 1993, p. 281). The degree of market power that the firm enjoys shapes the flexibility of the firm to set prices and to organize product promotions. Namely, the firm can easily employ market penetration strategy if it has greater market power. By exercising market penetration strategy, the firm can acquire high profits, which will positively influence its growth rates. If the firm has strong technological capabilities and high market power compared to its competitors, it has a profit-growth frontier that lies above the average position for the industry (Cantwell and Sanna-Randaccio, 1993, p. 281).

As outlined previously in this section, the multi-nationality is perceived as a source of competitive advantage for the firm, because, as discussed by Doz (1986) and Dunning (1988), it lowers the firm's costs of growth and increases the profits. The greater the degree of international integration of the production facilities within the MNC, the lower are the firm's costs of growth (Cantwell and Sanna-Randaccio, 1993, p. 282). By being able to take advantage of the economies of location, economies of scale and scopes, the firm can lower its production costs and can easily impose price reduction. By doing so, the firm increases its international demand and grows externally by increasing its market shares internationally. While economies of location and scale economies in production affect the firm's external costs of growth, economies of scope affect both external and internal costs of growth. Economies of location lower the production costs, because the firm is able to use locally available resources and skilled labor force. The firm can also develop products in accordance with the local customers' needs and can easily support sale promotions locally. Economies of scale also lower the production costs and facilitate the firm's external growth. Economies of scope which arise from the integrated structure of an MNC, lower both external and internal costs of growth (Cantwell and Sanna-Randaccio, 1993, p. 283). What affects the external costs of growth is that each affiliate within the integrated MNC's structure located abroad is not only specialized in a specific production of a certain product, but its

acquired knowledge and experience can be also used to improve the production process of some other production affiliate within the MNC's network. Such positive spillovers lower the affiliate's production costs and improve its efficiency. The specialization process within each affiliate facilitates the learning process and the accumulation of experience not only in the specific affiliate, but at the corporate level as well. The acquired knowledge and skills in a specific affiliate can be used as a resource input in other parts of the integrated MNC' network. In this sense, the creation of specialized knowledge accelerates the internal growth of the firm.

Generally, we can conclude that the great degree of integration within the MNC's structure positively affects the firm's growth and its profitability. However, this claim does not hold for every industry. The effects that the economies of location, economies of scale and scope have on the firm depends on the industry in which the firm operates (Doz, 1986). Therefore, the impact that the multi-nationality has on a specific firm largely depends on its industry. Important to notice here is that the degree of a firm's multi-nationality is not expressed in absolute terms, but in relative, compared to the degree of multi-nationality of other firms in the same industry (Cantwell and Sanna-Randaccio, 1993, p. 284). It is the relative degree of multi-nationality that moves the firm's profit-growth frontier higher, not the absolute one (Cantwell and Sanna-Randaccio, 1993, pp. 283-284). To conclude, the creation of firm-specific advantages is determined by the firm's relative degree of multi-nationality, compared to its major competitors in the industry, and these advantages vary across different industries (Cantwell and Sanna-Randaccio, 1993, p. 285).

If we look at the multi-nationality concept historically, we can draw a conclusion that firms did not decide to become multi-national because of the possibility to create firm-specific competitive advantages, but because of market proximity. The costs were the main determinant of whether the firm would evolve into a MNC or stay within its national borders. Therefore, in sectors in which the transportation costs and import taxes were high, the firms more often evolved into MNCs (Cantwell and Sanna-Randaccio, 1993, p. 284). However, the situation changed during the late 1960s and the early 1970s, when international production emerged. Internationalization of production became firms' main tool to spread their organizational network and to become multinational. During this period firms became more focused on creating firm-specific

advantages by closely integrating production facilities from different geographical locations within the MNC's structure. The benefits of the close international integration are already discussed earlier in this section and it is emphasized that these advantages vary across different industrial sectors. The degree of multi-nationality is low in industries in which firms serve government-controlled agencies, in which firms are under strong national regulations or under strong local servicing requirements, and in which firms are offering national differentiated products (Cantwell and Sanna-Randaccio, 1993, p. 285). In industries with high trade barriers, the degree of firms' multi-nationality is high, because firms are trying to overcome any obstacle which prevents the establishment of internationally integrated networks.

From the discussion about the effect of multi-nationality on firm's growth, an overall conclusion can be drawn that the firm's high demand, the creation of firm-specific competitive advantages within the internationally integrated MNC's structure and the firm's strong position in its markets positively influence the firm's growth (Cantwell and Sanna-Randaccio, 1993, p. 292).

When discussing the multi-nationality another important question that emerges is whether multi-nationality (and globalization) destroys nationality or embraces it. Internationalization and national specialization are complementary parts of a common process, not conflicting trends (Cantwell and Santangelo, 1998, p.138). Globalization tends to increase countries' national differentiation and firms' technological specialization (Cantwell and Janne, 1999, p.121), which is the *raison d'être* of MNCs. By establishing internationally integrated networks, MNCs benefit from the technological differences arising from different countries. Tapping into the specific knowledge concentrated in a certain country or location helps the firm to improve its own technological capabilities and to increase its own technological competitiveness. For greater understanding of how the firm can gain technological competitiveness through globalization, we should look at the firm's overall research activities, as measured by its US patent activities (Cantwell and Harding, 1998, p. 100). The greater the firm's patent activities, the greater are the benefits that the firm has gained from globalization. In this sense, internationalization and globalization enable a MNC to diversify its technological base and to take advantage from complementary technologies, which are created elsewhere. Thus, by broadening the technological capabilities, a MNC extends its technological base, thereby including in its exiting technological base new related technologies which support the firm's core technologies. In

addition, population diversification stimulates product and methodology modifications, more complexities and therefore demand expansion.

Nowadays firms are more oriented towards joint technological development and inter-firm cooperation in learning (Cantwell and Santangelo, 1998, p. 135). MNCs use their international R&D networks to create firm-specific competitive advantages in specific technological areas (Cantwell and Harding, 1998, p. 100). Countries and firms narrowed their technological specialization in industrial areas in which they were historically strong, which established them as centers of excellence. When a country gains the reputation of being a center of excellence, it becomes an attractive location for foreign MNCs to site their R&D and production facilities. As we will see later in this work, that is what happened in countries like Germany for example. By narrowing the specialization in technologies in which German firms were historically strong, Germany has become a major center of excellence in Europe in many industrial areas, such as chemicals, pharmaceuticals and motor vehicles. The example of Germany and German firms is the best example which shows that the internationalization and national specialization of firms are not mutually exclusive trends.

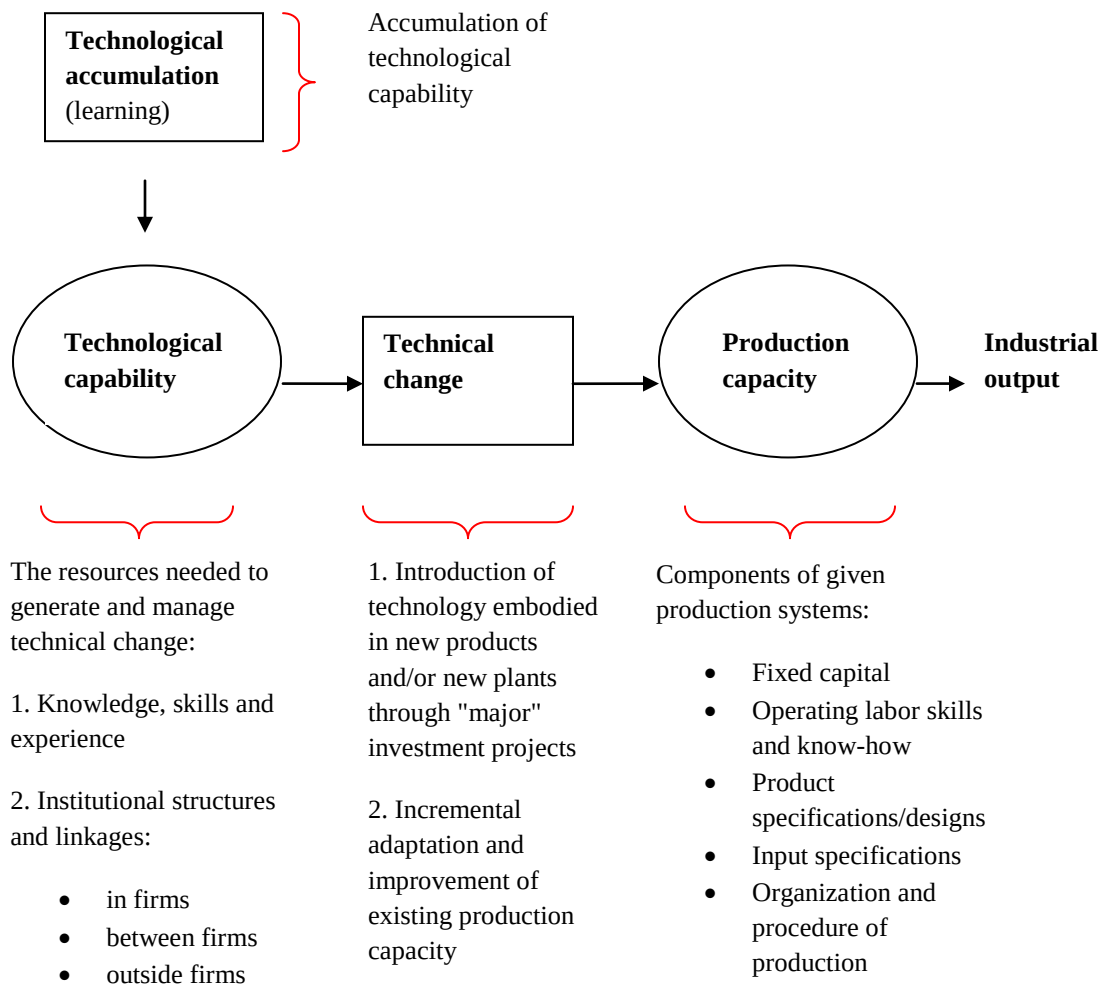
Many concerns were expressed when during the 1990s German firms intensively increased their outward foreign direct investment (FDI) and reduced their involvement in domestic R&D. At the same time, the inward investment in Germany by foreign investors decreased, which many experts and analytics understood as a signal that the attractiveness of Germany as a host-country for foreign R&D investment declined. Although the German R&D's expenditure in 1994 remained relatively high in relation to their GDP from the same year (2.34% of the GDP in year 1994), there was certain decline in the expenditure from year 1989 of some 0.56% of the GDP (Cantwell and Harding, 1998, p. 99). The fact that the German firms located their R&D abroad concerned many experts who interpreted this trend as an indicator that domestic research has weakened and German firms don't have confidence in it anymore. Even though German firms relied on domestic research during most of the post-war years, large firms from other European countries, such as the UK and France, internationalized their R&D much faster than the German firms.

Cantwell and Harding (1998), using the US patent data from the period between 1969 and 1995 for 784 world's largest firms (from which 56 were German firms and 325 had research located in Germany), statistically proved that although German firms increasingly internationalized their R&D during the 1990s, Germany still remained an attractive location for foreign R&D (especially in industries such as motor vehicles, electronics and chemicals) and that German firms stayed technologically strong in areas of their traditional technological strengths (chemicals, pharmaceuticals, motor vehicles, metals and electrical equipment) (Cantwell and Harding, 1998, p. 100). The results from the research showed that German firms increasingly internationalized their R&D in the period between 1983 and 1995, showing highest interest for the US as a foreign location (see Table 1 in the appendix) (Cantwell and Harding, 1998, p. 102). However, the largest increase in internationalization of German R&D is in the period between 1991 and 1995. German firms have internationalized their R&D in sectors in which they were technologically strongest, such as in chemicals, pharmaceuticals, motor vehicles and electrical equipment (see Table 2 in the appendix) (Cantwell and Harding, 1998, p. 104). The highest increase in internationalization of R&D in these sectors is noted in the period between 1987 and 1995. If we agree with the fact that MNCs choose foreign location to site their R&D according to the possibility of exploiting competitive advantages in the country's technologically strongest industrial areas, then it would be logical to expect that foreign-owned MNCs would be most interested in German's chemical, pharmaceutical, motor vehicle and electronic industries. The statistical findings of Cantwell and Harding (1998) showed exactly the same, that foreign firms showed highest interest for German's chemical, pharmaceutical and metal industries, industries in which Germany has traditionally been strong (see Table 3 in the appendix) (Cantwell and Harding, 1998, p. 105). However, a decline in the internationalization of R&D in motor vehicles industry is noted, especially in the period between 1991 and 1995. This decline may be explained as a result of a subsequent consolidation of R&D, sales and marketing activities in the industry, because, as Belitz (1997) explained, internationalization of R&D follows the internationalization of sales and marketing activities with a lag (Cantwell and Harding, 1998, p. 105). Thus, the increased sales and marketing activities in the industry during the 1970s resulted with an increase in internationalization of R&D activities in the period between 1983 and 1986 (from 26.50% in 1978-1982 to 31.70% in 1983-1986) (Cantwell and Harding, 1998, p. 105).

4. The theory of technological accumulation

In this chapter I focus my discussion on the theory of technological accumulation, which was first articulated by Pavitt (1987), but it was also embodied in the ideas of Rosenberg (1976 and 1982), Usher (1929), Atkinson and Stiglitz (1969), Nelson and Winter (1977), and Stiglitz (1987), and in great detail elaborated by Cantwell (1989) in his book *“Technological innovation and multinational corporations”*. The term *“technological accumulation”* was first used by Pavitt (1987) to explain the cumulative nature of technological development within a firm (Cantwell, 1989, p. 7). The theory of technological accumulation describes the success of MNCs through the process of generation of ownership advantages. These ownership advantages are generated through the accumulation of technology and innovation. Bell and Pavitt (1993) define technological accumulation as an accumulation of a firm’s technological capabilities (Bell and Pavitt, 1993, p. 159). Under firm’s technological capabilities they categorize the firm-specific skills, knowledge and experience, and the institutions that enable the firm to generate and manage technological innovations (Bell and Pavitt, 1993, p. 159 and p. 163). The basic concept of technological accumulation and the key terms are presented in Figure 6.

Figure 6. Technological accumulation: basic concepts and terms



Source: own representation based on Bell and Pavitt, 1993, p. 164

In the essence of this theory stands its perception of technological development and progress as an outcome of the firm-specific competence creation. The competence creation comes as a result of a constant and cumulative learning process in the production system of a firm. Only such technological development can guarantee further economic growth and progress. This understanding of the technological development and economic growth may be opposed to what the Schumpeterian model of innovation and technological development stands for.

The theory of technological accumulation indicates that the technological specialization of firms and countries is determined by their historical technological strengths. According to Pavitt (1987), the innovative activity in a given country or among firms originating from the same country reflects the past technological accumulation. Because of such technological accumulation, industries in which firms from a certain country were traditionally (historically) strong, have later become the core sources for technological leadership of the country. The leadership of US firms in woodworking and oil-industry, the leadership of British firms in metal working and pharmaceutical industry, and the superiority of German firms in electronics, motor vehicles, chemicals and pharmaceuticals, are results of the path-dependent course of technological accumulation (Cantwell and Fai, 1999, pp. 336-337). These countries have become very attractive locations for foreign-owned R&D, mostly because of the advantageous positions they hold in these areas. Today, they are known as world's centers of technological excellence.

A similar topic is elaborated in the paper entitled as *"The location of MNCs' technological activities in Europe: agglomerative tendencies and other territorial externalities"*, (2000), from Cantwell and Piscitello, where they statistically proved that the existing knowledge base in a certain country has a crucial role in the decision of foreign MNCs of where to locate their R&D activities (Cantwell and Piscitello, 2000, p. 1). By using patents granted in the US to the world's largest industrial firms for inventions achieved in their European-located R&D units (Cantwell and Piscitello, 2000, p. 1), the examination showed that the most attractive European countries for foreign MNCs to locate their R&D activities are: Germany (29% in 1991-1995), UK (21%) and France (16%) (Cantwell and Piscitello, 2000, p. 4). Italy is the fourth most attractive European location with only 6% during the same period (Cantwell and Piscitello, 2000, p. 4).

Among other things, the paper showed that the industries in which a country is technologically strong are less dependent on foreign R&D. The contribution of foreign R&D to European research as a whole is below average (the average is 24%) in industries such as chemicals (15.6% as against 24%), motor vehicles (12.3%), aircraft and aerospace (13%) and metals (13.3%), and only slightly above average in pharmaceutical industry (27.4%) (Cantwell and Piscitello, 2000, p. 5 and p. 24). This is due to the fact that European firms are technologically strong in these industries and less dependent on foreign R&D. Furthermore, these are the industries in which the European countries historically concentrated their technological efforts.

On the contrary, in industries in which European firms are technologically weak, the contribution of foreign R&D is high. Consequently, the contribution of foreign R&D in Europe as a whole is above average in electrical equipment (30.5%), office equipment (67.4%), professional instruments (45.6%), and coal and petroleum products (39.3%) (Cantwell and Piscitello, 2000, p. 5 and p. 24). In these industries, European firms are technologically weaker than the US and the Japanese firms (Cantwell and Piscitello, 2000, p. 5). Similar results are found across individual European countries. The foreign contribution to German R&D is low in motor vehicles, chemicals and pharmaceuticals, again in the industries in which German firms are technologically the strongest. In the UK, the foreign investment penetration is low in food industry and coal and petroleum products, in which domestic firms are strong. In Italy, the foreign contribution is very low in office equipment and oil industry, and in France, in coal and petroleum products and electrical equipment (Cantwell and Piscitello, 2000, p. 5 and p. 24). For a closer look at these numbers, please look Tables 4 and 5 in the appendix.

The attractiveness of the European countries as locations for establishing foreign R&D is also partially elaborated in the paper *"Technological globalization and innovative centers: the role of corporate technological leadership and locational hierarchy"* (1999), written by Cantwell and Janne. For each industry, a hierarchical position is determined in accordance with the level of technological competence in the industry (Cantwell and Janne, 1999, p. 124). RTA index values greater than one suggest that technological competence in a particular industry is high and thus, that industry is hierarchically higher in rank (Cantwell and Janne, 1999, p. 124). *"The RTA index is defined as a group's share of all US patenting in a technological field, relative to its share of all US patenting in all fields-all large firms patenting in the US, irrespective of their country of ownership or of where technological development is located"* (Cantwell and Janne, 1999, p. 123). Considering the chemical and pharmaceutical industry in the period from 1969 until 1995, the three countries with the highest RTA indexes are Switzerland (2.59), Belgium-Lux (2.32), and Germany (1.81). Other European countries with RTA indexes greater than one in chemical and pharmaceutical industry are Norway (1.63), Italy (1.52), UK (1.40), Denmark (1.15), France (1.08) and Ireland (1.01). Considering the metal products and mechanical engineering, the three countries with the highest RTA indexes are Sweden (4.11), Austria (3.80) and Finland (3.34). Other countries with RTA indexes greater than one in metal products and mechanical

engineering are Greece (2.65), Norway (2.52), Spain (1.95), Denmark (1.95), Germany (1.71) and Switzerland (1.57). In the industrial group of electrical equipment and computing the Netherlands (2.00) and Ireland (1.52) are the only two countries with index values greater than one (Cantwell and Janne, 1999, pp. 124-125).

The above discussed empirical findings represent further proof of the reliability and the practical implications of the theory of technological accumulation. As we can see from the results, technological development is a continuous process, which is determined by the cumulative nature of the learning process. The gradual learning process within the firm shapes the creation of technological competence and technological specialization of the firm. Firm's technological competence tends to be persistent and quite stable over long periods of time. Because of that persistence, technologies, in which a firm (or a country) had historically a strong technological position, are today the leading technologies of the firm (or of the country). The creation of technological competence and technological progress is predominantly an internal process, taking place within the firm. In this sense, the technology is not, as the neoclassical theory of economic growth states, some exogenous factor of production that could be traded on the market, but it is a result of the constant learning process within the firm (Cantwell and Fai, 1999, p. 337). Overall, we can easily conclude that the technology accumulation theory does not explain the innovation as *"an individual act of technology creation"* (Cantwell, 1989, p. 9), but as an outcome of continuous and persistent learning processes within the firm.

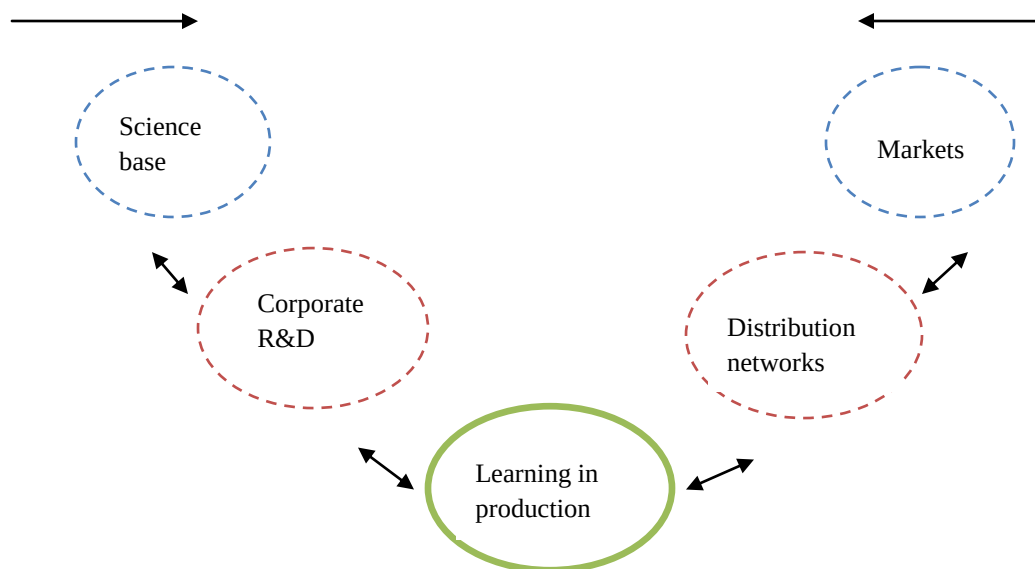
When describing technological development and progress of a firm as an outcome of an internal and continuous learning process, another question which appears to be inevitable is the question about the determinants of such technological development and progress. According to Schumpeter's theory of economic development, the changes through technological innovations are the principle determinant of technological development and progress. However, one crucial difference between the Schumpeterian model of economic development and the model of economic development based on the technological accumulation theory is the source of innovations. Cantwell and Fai (1999) proposed a new model of innovation, which differs from Schumpeter's "linear model" of innovation and from Schmookler's "demand-pull" model (Cantwell and Fai, 1999, p. 338). This new approach of understanding the source of innovations

is graphically presented in Figure 7. As we can see from the figure, the learning in production is the principle source of innovations for a firm. However, there are also other factors that have an important influence on the innovation process of the firm. The most influential among them are surely the markets, the existing science base or existing technology, and the corporate R&D. The existing science base and the markets are external factors to the firm, while the corporate R&D and the distribution networks are integrated within the firm's structure and are classified as internal factors. Each firm follows a different path-dependent course during the internal learning process, which helps it to develop specific technological competences, different from the competences of other firms in the industry.

Figure 7. Learning as the principle source of innovation

Schumpeter's "science-push" or "linear" model

Schmookler's "demand-pull" model



Source: own representation based on Cantwell and Fai, 1999, p. 338

In this new model, the corporate R&D is not the main initiator of technological innovation, but it only contributes to the innovative process of the firm by providing "public" knowledge, which can be useful for the firm's specific problem-solving activities (Cantwell and Fai, 1999, p. 339). Since the main activities of almost each corporate R&D department are primarily organized to find solutions to the existing problems in the firm's production processes, it would be incorrect to

think of corporate R&D as a principle innovation driver (even though it may have an important role in the initiation process) (Cantwell and Fai, 1999, p. 339). R&D also reflects what is technologically achieved outside the firm, in the existing science base, through the "public" knowledge and not only what is achieved within the firm due to the firm's internal learning process.

The model presented in Figure 7 gives a completely different light on the dilemma of whether the science base (or the existing technology) or the market is the principle driver of innovation. In this sense, the new model differs from the old "science-push" (or "technology-push") and "market-pull" models, where the main driver of innovation is either science or the market. When perceiving the firm as a principle driver of innovation, the focus shifts from external factors, such as public knowledge and markets, to internal factors that influence the learning process of a firm.

Cantwell and Fai (1999) in the paper entitled as *"Firms as the source of innovation and growth: the evolution of technological competence"* went one step further and not only showed that the firm's technological competence comes as a result of the cumulative nature of the firm's internal learning process, but they also statistically proved that the specific technological competence of a firm tends to persist over long periods of time (Cantwell and Fai, 1999, p. 331 and p. 341). Markets and especially products change quite dramatically especially over longer periods of time, because of the fast-changing customers' needs and requirements. Firms' technological competences are much more stable. They change very slowly to the fast-changing market conditions. The cause of such a long persistence may be the institutional continuity, which is characteristic of many large firms (Cantwell and Fai, 1999, p. 361). Even though the persistence of the firm's technological competence is strong and stable, the firm tends to engage constantly in technological diversification in order to take advantage of new knowledge and new technologies. The firm could also engage in technological diversification in order to be able to appropriately answer new customers' needs and requirements, thereby taking advantage of new markets. The most attractive technological areas for a firm to diversify its technological base are the ones of great present (and possibly of great future) importance.

5. The evolutionary development of technological competition since the 1950s

Analyzing the evolution of international technological competition after WWII to the present days would be incomplete without considering the process of internationalization of large manufacturing firms that took place after the war period.

The story of internationalization begins in the 1950s, after WWII, with the intensive investments of US firms in Europe. The increased direct investment in Europe stimulated the technological competition between American and European firms. US firms intensified their investments in Europe with the formation of the EEC in 1958. In the following almost twenty years, until the end of the 1970s, the investment was generally one-sided. Large and technologically advanced US firms were investing in Europe, thereby ensuring themselves a position as innovative leaders in Europe. Many European analytics (like Servan-Schreiber, 1967) were concerned about the developing situation of unbalanced positions between the US and the European firms in terms of technological competence. Because of the existing "technological gap", the analytics feared from the possibility that the most important European industries would be overtaken by US firms (Cantwell, 1989, p. 1). These concerns were in a way understandable, if we agree that by overtaking the most important European industries, competition would be destroyed, which could further damage the already devastated European economy in that period.

However, in the 1970s, when European firms recovered and started to expand in the US, the concerns of the US analytics were the same. During 1970s the European economy completely recovered from the war period and European firms got the strength to respond appropriately to the so called "*American challenge*", thereby building their own international networks and expanding production internationally. In 1970s and 1980s intra-industry production (for exact definition of intra-industry production see p. 56) between US and European firms started to grow rapidly.

As we will see in the following sections, the international competition from the 1950s, 1960s and the first half of the 1970s was quite different from the competition that took place since the mid-1970s. While the first wave of technological activities of the large European firms was more in a direction of improving the European export rates, the second wave of activities went in a

direction of establishing international production networks. By establishing international production networks, the most successful and technologically advanced firms expanded their organizational structures internationally and evolved into MNCs. The period of expansion of MNCs is a result of a long process of technological development through technological learning in production within the firms, where innovation and expansion of international production are mutually supportive factors (Cantwell, 1989, p. 7). Technological innovations lay the foundation of international production and trade.

When in the 1980s, Japanese firms established themselves as an important player in international technological competition, US and the European firms shifted the attention towards the activities of their new competitors. Today, we are witnessing the same situation with Chinese firms.

With the emergence of Information and Communication Technology (ICT) in the 1990s, the international competition changed dramatically. Building international networks became much easier. Among other things, the transfer of knowledge, which is a very important condition for a successful innovation process, has become much easier as well. Before the expansion of ICT, the knowledge transfer had been a big issue for MNCs with R&D locations in different parts of the world.

During the evolutionary development of international technological competition, the most successful firms became MNCs (Cantwell, 1989, p. 3). As we will see later in this work, firms originating from countries with advantageous technological capabilities and long-lasting innovative traditions were able to adapt more easily to the new market conditions and to survive. Furthermore, the ability of European firms to respond to the "*American challenge*" depended upon their previous technological achievements. European firms have shown greatest results in catching up with the US firms in industrial sectors in which they were historically technologically very strong.

In the 1970s and especially in the 1980s intra-industry production between US and European firms increased faster in those industrial areas in which firms from both countries involved had mutual technological strengths. Close linkages between firms were established in an attempt to encourage innovation. By organizing international networks, the leading MNCs tended to locate their production facilities and R&D units in countries that were centers of excellence. As we will

see later in this chapter, US firms showed the highest interest in Germany (West Germany at that time) as the most attractive industrial location to site their production and R&D, compared to other European locations. (West) German MNCs showed the highest interest in US as a location where they can establish their production and R&D units than in the rest of the world. These facts further prove that technological development is a cumulative process, such that technological strengths of countries tend to be persistent over long periods of time (Cantwell, 1989, p. 50). Therefore, countries that had long innovative traditions and technological strengths in certain industrial areas were able to retain the position of technological leaders to the present days. The same holds for firms, namely technologically advanced firms transformed themselves into successful MNCs which currently hold the positions as the world's technological leaders in their industries.

5.1. Analyzing the evolution of international technological competition with Vernon's Product Cycle Model

In this section I will try to explain why neither the Schumpeterian model of innovation nor Vernon's PCM I and II are adequate models to analyze the international technological competition that took place since the early 1970s. Based on the Schumpeterian approach of economic development and growth, in 1966 Vernon developed the Product Cycle Model (PCM). The model offered a useful explanation of the US direct investment in Europe during the 1950s and the 1960s (Cantwell, 1989, p. 54), when only firms from one country, namely from the US, were involved in competing innovations. Later on, when firms from more than one country engaged in competing innovations, the PCM failed to offer satisfactory explanations (Cantwell, 1989, pp. 51-52). As internationalization of manufacturing firms started to grow, Vernon developed the second version of the PCM in 1974, which was extended to incorporate oligopolistic considerations as well (Cantwell, 1989, p. 54). Accordingly, the economic critique distinguishes now between PCM Mark I (1966) and PCM Mark II (1974).

When analyzing international technological competition, the most commonly used model is the Schumpeterian model of innovation and economic growth, which emphasizes discontinuity and

"creative destruction" in the process of technological development. Vernon's PCM practically applies the Schumpeterian model of economic development and growth in the area of international trade and investment (Cantwell, 1989, p. 51).

The PCM embodies the classical theory of trade, according to which innovations are the underlying basis of international trade and investment. In its dynamic framework, the model perceives the growth of production as a result of innovation, which consequently increases the rate of international trade. Innovations (in form of introduction of new products), production and international trade are viewed as factors which are positively dependent from each other. An increase in the production as a result of an increased number of innovations, will eventually result in an increase in international trade rates. In this sense, international production is viewed as a tool to encourage rapid rates of domestic economic growth (Cantwell, 1989, p. 52). However, some elements of the neo-classical theory of international trade and investment can be found in the PCM as well. The comparative cost factor, as the main determinant for production location, and the understanding of technological innovation as an exogenous and not as an endogenous and firm-specific, are sufficient indicators that the PCM incorporates elements of the neo-classical trade theory too.

Similar to the Schumpeterian model, the PCM focuses on the discontinuities that become apparent after the introduction of entirely new products and analyzes the effects that such an introduction has on international trade (Cantwell, 1989, p. 51). In an attempt to minimize the costs of production, the PCM focuses on finding the optimal location for a firm to establish its production facilities, namely the location that secures the optimal production costs for the firm. The principle focus of the model is on the product itself. The maturation of the product is the main determinant of the firm's international strategy.

The question, whether the classical Schumpeterian model is still an adequate tool to analyze the evolution of technological competition since the 1950s or not, seems to be an inevitable one. The Schumpeterian model was a reliable model to examine the technological development of industries in the nineteenth century (Cantwell, 1989, p. 60), when entrepreneurs introduced radical innovations, thereby creating both new firms and industries. The success of those initial innovators, known as "first-movers", was secured as long as they were capable of retaining their ownership advantages. Therefore, the Schumpeterian model suggests that follower-firms from

any industry would be able to successfully catch-up with the initial innovators as long as the technological dominance of the first movers is not so strong. This is very much the same in the PCM I, in which firms were capable of surviving only if they retained their ownership advantages (Cantwell, 1989, p. 60). In PCM II the focus shifted from retaining the ownership advantages towards building entry barriers that would prevent new firms from entering the industry. Furthermore, the Schumpeterian model suggests that technological competition is a random process (Cantwell, 1989, p. 49) and as we will see in the following sections, this may be quite the opposite. According to the theory of technological accumulation, the course of technological competition may be highly predictable.

The following two critiques are addressed to the Schumpeterian model of innovation and subsequently to the PCM I and PCM II, both of which are based on the Schumpeterian model. The critique also compares Schumpeter's theory of innovation and Cantwell's theory of technological accumulation and emphasizes why Cantwell's theory seems to have much more practical application.

- The Schumpeterian model of economic development and growth through innovations is discontinuous, which is well explained by his term of *"creative destruction"*, which involves *"...incessantly destroying the old one, incessantly creating a new one"* (Schumpeter, 1943, p. 83), referring to the process of *"industrial mutation"* of the steel industry that *"incessantly revolutionizes the economic structure from within"* (Schumpeter, 1943, p. 83). When comparing Cantwell's understanding of innovation and Schumpeter's model of innovation we can notice one big difference. According to Cantwell's understanding, innovation is an outcome of a cumulative (Cantwell, 1989, p. 50) and continuous learning process, which I personally find to be true. However, Cantwell in one of his later works entitled as *"Innovation, profits and growth: Schumpeter and Penrose"* published in 2000/2001, when speaking about the Schumpeterian theory of profit, gives a completely new perspective on Schumpeter's process of *"creative destruction"* by saying that the creative destruction *"is often misunderstood, as the disruption referred to relates to the circular flow (of money) and established market structures, but the creative process itself is likely to be cumulative and incremental"* (Cantwell, 2000/2001, p. 6). Discontinuities are common if we consider the

overall rate of innovation, as measured by the total number of patents granted. Overall innovation rates may vary dramatically throughout the years. Consequently, in the 1950s and 1960s we had major waves of innovations. In the 1970s and 1980s the innovation rates had fallen, but the sectoral pattern of innovations tended to stay much more persistent across the firms from most of the countries (Cantwell, 1989, p. 50). Therefore, we should make a clear difference between discontinuities in the overall rate of innovation, which are logical and usual, and discontinuities in the sectoral pattern of innovation, which practically never occur (Cantwell, 1989, p. 50). To be able to analyze the effect that the major wave of innovations from the 1950s and 1960s had on the subsequent path of technological competition across sectors (Cantwell, 1989, pp. 50-51), we need a new model which applies the accumulation theory and which perceives the innovation process as a cumulative one.

- According to Cantwell's view of innovation as a continuous and cumulative process, and according to his perspective on continuity in the industrial pattern of innovation (Cantwell, 1989, p. 16), it seems that the technological competition that took place since the 1950s is not a random process (as neo-Schumpeterian economists may suggest), but a predictable one. Because of the continuity in the innovation process, whether the firms from the so called "follower nations" will be able to catch up with the "first-movers" or not, depends upon their potential for innovation, and not upon the scope for imitation as Schumpeter suggests (Cantwell, 1989, p. 50).

Following the general critique of the Schumpeterian model of innovation, I would like to emphasize some points that refer particularly to Vernon's PCM Mark I (1966) and PCM Mark II (1974). The following points are specifically a critique on both versions of the PCM:

- As mentioned before, one of the essential drawbacks of the PCMs is their understanding of innovation as a discontinuous process. The creation of new products is a continuous process and not a result of a series of discrete actions (Cantwell, 1989, p. 53).
- Another limitation of the models is their absolute focus on the product (and accordingly, on product innovation) (Cantwell, 1989, p. 53). Therefore, the PCMs face major

limitations, which make them unreliable models to analyze the current situation in which firms from different countries interact with each other and influence one another (Cantwell, 1989, p. 56). However, PCM I offered quite valuable explanations about international trade and investment in the 1950s and 1960s, when only firms from the US held the position of technological leaders. In the mid-1970s, when European and Japanese firms also established themselves as technological leaders in many industrial areas and the international technological competition became more balanced, the model failed to offer exact clarification of the situation.

In the PCMs the firm is not regarded as the main source of innovation, but as a passive agent which only reacts to the changing market conditions. The product development through the three evolutionary stages (named as new product, mature product and standardized product) is the principle determinant of the international strategy of a firm.

- According to the employed innovation theory in the PCMs, the innovation process is viewed simply as a market-determined process, that relies entirely upon demand and relative cost factors (Cantwell, 1989, p. 53). According to the PCM I, innovations are determined only by consumer demand. In this sense, the main driver of innovation is the existing unsatisfied consumers' needs. The model dynamic is secured simply by the evolution of the demand (Cantwell, 1989, p. 55). Furthermore, the decision for relocating production depends mainly on the cost factor. If the marginal costs of production + transport costs < cost of production in the importing country, then the firm decides to stay at home and to avoid investment and vice versa (Vernon, 1966, p. 197). Communicational issues and external economies are other powerful factors which determine the production location (Vernon, 1966, p. 194). According to Vernon (1966), the major reason for a firm to relocate its production is any threat to the established position of the firm (Vernon, 1966, p. 200), which is again a market-determined driver.
- The firm is perceived simply as a reactive agent to the changing market conditions and not as an active agent influencing the market (Cantwell, 1989, p. 54). Cantwell and Fai (1999) in their paper entitled as *"Firms as the source of innovation and growth: the evolution of technological competence"* described the firm as a principle source of

innovation and growth. In this sense, the innovation is firm-specific and depends upon the continuous, incremental changes (innovations) in the production process of the firm. Neither the market nor the science base are the main drivers for innovation. They are important factors for innovation, but not decisive ones, as the PCMs suggest.

- During the 1950s and 1960s, when US firms introduced mainly radical innovations, PCM I was quite an appropriate model to explain the situation on the market. In the 1970s, when major economic changes took place at the level of international trade between manufacturing firms and the focus shifted from radical to incremental innovations, the model lost its explanatory capacity. Such incremental innovations were not a result from a series of separate actions, but furthermore were an outcome of a continuous process of technological development within the firm. Vernon's models failed to perceive the firm as the principle source of innovation. They stayed focused primarily on the market. Perceiving the technology as an exogenous factor and not as an endogenous factor and firm specific, was another major drawback of the PCMs.
- Even though Vernon became aware of the fact that the PCM I was losing its explanatory capacity, in the second version of the model, released in 1974, he was not able to abolish the major deficiencies of the first version (Cantwell, 1989, pp. 58-59). The crucial difference between the PCM I and PCM II was that the PCM II was extended to consider the newly created industries with oligopolistic structures, which resulted from the growing number of MNCs on a global level (Tolentino, 1993). However, the old way of understanding the technological innovation didn't change in the PCM II. The main focus stayed on the product and its maturation as a shaper of the international strategy of a firm.

5.2. Analyzing the evolution of international technological competition with Cantwell's model based on the theory of technological accumulation

As we saw from the previous section, the PCM I and PCM II are relatively unreliable models for analyzing the evolutionary development of international technological competition between

MNCs. Therefore, I will try to achieve this purpose by using Cantwell's model, which is based on the above discussed theory of technological accumulation, and is presented in his book *"Technological innovation and multinational corporations"*, published in 1989.

In the fourth chapter of this work I already discussed some of the main principles of the theory of technological accumulation. Now, the discussion will be more precise in explaining the three main propositions of the theory in order to make an appropriate link between this theory and Cantwell's model, which relies on it.

According to Cantwell (1989, pp. 16-18), the accumulation theory consists of the following principle propositions:

- the first one is that technological change is cumulative, such that the created technological competence due to technological change tends to be persistent over periods of 10 to 20 years (Cantwell, 1989, p. 16). Because of the cumulative nature of technological development, the improvements in the production process of a firm are the results of incremental, rather than radical innovations. Even the radical innovations, which create radically new technologies or production processes, are developed on the basis of previous technological achievements
- the second proposition claims that the technological change develops incrementally, such that the firm may slowly shift its point of interest towards some related industrial sectors. This proposition states that the industrial composition of innovation may change over long periods of time (Cantwell, 1989, p. 17).
- the third proposition of the theory points out that each firm follows different path-dependent course of technological development, thereby creating firm-specific technological competence (Cantwell, 1989, p. 18). The same statement holds for states or locations.

Using the first proposition, which claims that technological change is cumulative, we can explain the recovery of European firms after the American "economic invasion" of Europe in the 1950s and 1960s, and their ability to respond appropriately to the so called *"American challenge"*. Their recovery depended very much on their traditional technological strengths in certain technological areas. More precisely, European firms were able to catch up with the US firms in those industries

in which the technological efforts of the European firms were historically concentrated (Cantwell, 1989, p. 62). The firms' competitive technological strengths shaped their future international strategies (Cantwell, 1989, p. 62).

Table 2 lists the countries in which firms have obtained the highest number of patents in the periods of 1890-1892, 1910-1912, and 1963-1983. We can clearly see from the table that the European countries in which firms received the highest number of patents in the period from 1890 to 1892 (UK and West Germany) have also retained in the following two periods the highest number of patents granted. Countries like France, Switzerland, Sweden, Italy and the Netherlands had high increases in the number of patents granted in the third period (1963-1983), compared with the two previous periods. Japan is the only exception here. The Japanese example contradicts the theory of technological accumulation, since the number of patents granted to Japanese firms was extremely low in the first two periods and drastically increased in the period from 1963 to 1983. The case of the Japanese economy and how Japanese firms responded to the American and European "challenge" will be briefly discussed in the section 5.2.3 from chapter 5. These statistical numbers are further proof of the cumulative nature of technological change, where technological innovation is perceived as a further development of already existing technological achievements.

Table 2. The total number of US patents granted to residents of the major countries of origin

Country of origin	1890-1892	%	1910-1912	%	1963-1983	%
USA	66 766	91.6	95 022	88.6	929 133	69.1
Non-USA, total	6 084	8.4	12 285	11.4	416 113	30.9
UK	2 145	2.9	2 970	2.8	55 028	4.1
West Germany	1 378	1.9	3 961	3.7	101 864	7.6
Canada	975	1.3	1 673	1.6	22 160	1.6
France	548	0.8	1 031	1.0	38 956	2.9

Austria (-Hungary)	198	0.3	439	0.4	4 560	0.3
Australia	147	0.2	284	0.3	4 072	0.3
Switzerland	139	0.2	310	0.3	23 733	1.8
Sweden	101	0.1	318	0.3	14 621	1.1
Belgium- Luxembourg	54	0.1	149	0.1	5 125	0.4
Ireland	44	0.1	37	0.0	309	0.0
Italy	31	0.0	175	0.2	13 299	1.0
Denmark	22	0.0	94	0.1	2 760	0.2
Netherlands	19	0.0	56	0.1	12 317	0.9
Spain	17	0.0	35	0.0	1 316	0.1
Japan	6	0.0	34	0.0	94 046	7.0

Source: Cantwell, 1989, p. 23

(Original source: US Index of Patents, various sources; OTAF, unpublished data)

Estimating the regression of the distribution of revealed technological advantage (RTA index) in 1977-1983 on the distribution in 1963-1969 for 27 industries (see in the appendix the list of the 27 industries included in the examination), Cantwell (1989) showed that those countries in which firms were able to rapidly restructure their industries since the 1960s and in which technological development relied upon innovations have retained leading technological positions over a long period of time (Cantwell, 1989, p. 37 and p. 42). To get a more detailed look into the data description used in the estimation and the employed statistical methodology, you can see Chapter 2: *Historical trends in international patterns of technological innovation* in Cantwell's book *"Technological innovation and multinational corporations"* (1989). For my work only the interpretation of the results is relevant and therefore I am not focusing on explaining the employed methodology. The results of the regression have shown that since the 1960s German firms have retained the leading positions in chemicals, motor vehicles, textiles and rubber products. Since then they were able to improve their positions in industries such as mechanical

engineering and construction and mining equipment. In radio and TV receivers and in professional and scientific instruments they were not able to retain positions of technological leadership (Cantwell, 1989, p. 42).

Since the 1960s UK firms have improved their technological strengths in chemicals, pharmaceuticals, food products, agricultural machinery and non-metallic mineral products. Industrial sectors in which UK firms have fallen behind their European competitors are mechanical engineering, motor vehicles, radio and TV receivers, non-ferrous metals and coal and petroleum products (Cantwell, 1989, p. 42).

Japanese firms are the only exception here; since the 1960s they have maintained advanced technological positions in electrical equipment in general, rubber products, non-ferrous metals and professional and scientific instruments. Certain improvements of their technological positions are found in motor vehicles and industrial engines, while they lost their positions in chemicals and shipbuilding, the industries in which they were historically strong (Cantwell, 1989, p. 42).

The results of the estimation are further evidence of the reliability of the theory of technological accumulation, which explains the persistence and the stability of firms' technological competences since the 1960s. Overall, we can conclude that the future technological development of firms and countries is highly dependent on the past technological achievements. If we follow the continuous course of the technological development of firms, we can see that those firms that had innovative tradition and advanced technological positions, have become the most successful MNCs today.

5.2.1. Cantwell's model: Conceptual framework

After a detailed discussion of the main characteristics of the theory of technological accumulation, I can now focus on trying to explain why the alternative model proposed by Cantwell (1989), which is based on this theory, is well founded to examine the technological competition between modern industrialized firms and countries.

When examining the technological competition between MNCs from the major industrialized countries from 1950s up to the present day, it would be useful to divide this long period of time into two shorter periods; the first one, which took place after WWII up to the 1970s, and the second one, which started since the mid-1970s. This separation is necessary, if we consider the fact that during the 1950s and the 1960s European firms were catching up with their US competitors only in terms of exports, and since the mid-1970s they started to internationalize their production and the "catch up" was more in a direction of international production of manufactured goods.

In accordance with these two evolutionarily different phases of international competition, Cantwell (1989) splits the examination of international technological competition into two separate stages: 1. Technological Competition between US and European firms from 1955 to 1975, and 2. Technological Competition between US, European and Japanese firms since the mid-1970s until the late 1980s.

During the 1990s the situation in the marketplace at the international level changed quite a lot in terms of technological competition between large MNCs, partially because of the successful recovery of the Chinese economy. After successful implementation of the economic reform from 1979, the Chinese economy has become one of the most progressive economies worldwide. Today, China is one of the major economic powers in the world. Since the second half of the 1990s many American and European MNCs have shown interest in China not only in respect of exploiting the enormous Chinese market potential, but also to take advantage of the technological excellence existing in China. Many technologically-oriented MNCs chose China as a location for their R&D activities. This trend shows that, aside from the purely market-driven reasons to choose China as a foreign country to invest in, MNCs decided to locate their R&D laboratories in China in order to take advantage of the local technological development and knowledge flow. According to OECD report from 2003, China has achieved remarkable results in advancing its science base and improving its technological development since the 1990s. It has become the third most R&D-intensive country in the world, at least in purchasing power parity (PPP) (OECD, 2003; von Zedtwitz, 2004, p. 439). In 2001, the statistical data demonstrated that China's total R&D spending was estimated at about 60 billion USD, which puts China in third place after USA and Japan, whose R&D expenditures for the same year were

282 billion USD and 104 billion USD respectively (OECD, 2003; von Zedtwitz, 2004, p. 439). According to the number of researchers in the same year, China took second place in the world with 743, 000 researchers, after USA with 1.3 million researchers (OECD, 2003; von Zedtwitz, 2004, p. 439). After China comes Japan with 648, 000 researchers and Russia with 505, 000 researchers (OECD, 2003; von Zedtwitz, 2004, p. 439). The number of foreign-owned R&D laboratories in China have increased dramatically since 2000. In 2000 the number of R&D laboratories established in China by foreign MNCs was 34, in 2001 this number increased to 82 laboratories and in 2002 this number reached the level of 92 laboratories (von Zedtwitz, 2004, p. 440). A more recent study from Boutellier, Gassmann and von Zedtwitz (2008) showed that the number of foreign R&D units in China continued to increase further in 2003 and 2004, reaching the level of 750 units in 2005. According to the number of foreign R&D units in 2005, China reached second place in the world after USA (Boutellier, Gassmann and von Zedtwitz, 2008, p. 62). This trend is expected to continue in the future, taking into consideration that China continually improves its economic, education and innovation systems (Boutellier, Gassmann and von Zedtwitz, 2008, p. 62). The following table shows the number of foreign R&D centers in China.

Table 3. Number of foreign R&D centers in China

Number	Focus	Year	Source
18	Beijing	2000	China Economic Weekly (2000)
40	Shanghai	December 2001	Xinhua News Agency (2001)
80	Shanghai	February 2003	Xinhua News Agency (2003)
34	China	Early 2000	Xue& Wang (2001)
82	China	August 2002	China's Statistical Office (STS, 2003)
100	China	2002	Greatwall (2002)
120	China	June 2002	People's Daily (2002)
148	China	2002	Asia Pulse (2002)
223	ICT companies in China	2002	Walsh (2003)
400	China	October 2002	People's Daily (2002)

Source: von Zedtwitz, 2004, p. 440

Many successful European, American and Japanese MNCs have established R&D centers in China. Among the European MNCs with R&D units in China are Nokia, Ericsson, Bayer, Hoffmann-La Roche, Volkswagen, Schindler, Unilever, Tetrapak, Electrolux, Nestle, Siemens, Philips, Alcatel and Novo Nordisk (Boutellier, Gassmann and von Zedtwitz, 2008, p. 65). American MNCs such as Microsoft, Motorola, Lucent, DuPont, Proctor & Gamble, IBM, Intel, Sun, Hewlett-Packard, GM, Kodak and GE have R&D units in China as well (Boutellier, Gassmann and von Zedtwitz, 2008, p. 65). Although Japanese MNCs generally tend to keep their R&D units at home, as we will see later in this chapter, the fact that many of them have R&D centers located in China, shows that the Japanese managers are well aware of the importance to take advantage of the international knowledge flow and the international technological experience. Japanese MNCs like Hitachi, Toshiba, Yamaha, Ajinomoto, Canon, Toyota, Sharp, Sony, Matsushita Electric, Fujitsu and Honda have established R&D units in China (Boutellier, Gassmann and von Zedtwitz, 2008, p. 65). Not only MNCs from the most developed countries in the world, but also MNCs from other less developed countries have R&D centers in China, such as Acer, Infosys, BenQ, Tata, Nortel, Merry Electronics, LG and Samsung (Boutellier, Gassmann and von Zedtwitz, 2008, p. 65).

Since I do not consider the impact of China and Chinese MNCs on international technological competition in this work, it might be interesting for future research to broaden the examination and include Chinese MNCs in the analysis as well. Some might disagree with this suggestion, since many experts consider China only as a location where MNCs establish R&D units purely driven by market-development, and not as a center of excellence. It is quite true that during the 1980s and the first half of the 1990s the main decision criteria for MNCs to invest in China were the low labor costs. However, recent statistical data shows that since the second half of the 1990s the situation has changed quite a lot. More and more MNCs decide to locate their R&D in China in order to take advantage of the Chinese experience in some industrial sectors, such as electronics for example. Although China is mainly a location where MNCs decide to site their development centers, many MNCs consider Beijing lately as an attractive location for their research activities. Beijing has more than 100 universities, the Chinese academy of science is located there, and the Zhongguancun district (high-tech zone with many R&D laboratories) is in Beijing as well (Boutellier, Gassmann and von Zedtwitz, 2008, p. 68). All this increases the attractiveness of Beijing as a location for research-intensive activities.

In order to analyze the first stage of technological competition between the US and European firms, Cantwell (1989) focused on two regions, USA and Western Europe, as the most important industrialized regions where the main economic activities were concentrated. For the purposes of the analysis, he examined three possible groups of industries: 1. industries in which the leading US firms are strong while the European firms are weak and more narrowly specialized, 2. industries in which US firms are weak and European firms are strong, and 3. industries in which both, US and European firms are strong and in competition (Cantwell, 1989, p. 62). By dividing the industries in three separate groups, three possible outcomes can be identified (Cantwell, 1989, pp. 63-64): 1. in the first group of industries, the US firms have retained their strong technological position on the European market, 2. in the second group, the strong European firms were able to retain their advantageous positions in Europe, and 3. in the third group, strong European firms were able to catch up with their American competitors. Establishment of international networks and production is the most common practice among the industries from the third group. (Cantwell, 1989, pp. 63-64).

He identified seven stages of development that characterize each of the above described industries. These stages are the following (Cantwell, 1989, pp. 65-67):

1. stage: *"the Schumpeterian technological leadership phase"*
2. stage: *"US export growth phase"*
3. stage: *"US firms' international production growth phase"*
4. stage: *"the early European recovery stage"*
5. stage: *"the European firms' international production growth phase"*
6. stage: *"intra-industry production phase"*
7. stage: *"the balanced innovation phase"*

Underlying assumption

The growth of each industry is equal for every country included in the examination. Therefore, we are facing constant market shares of indigenous firms and imports. (Cantwell, 1989, p. 65).

Notation

$i = 1,2,3$ are the three possible groups of industries

U is the US market

U_i for $i = 1,2,3$ is the total US market for industry i

$U_{i,j}$ for $i = 1,2,3$ is the part of the US market served by domestic firms

$U_{i,m}$ for $i = 1,2,3$ is the part of the US market served by imports

E is the European market

E_i for $i = 1,2,3$ is the total European market for industry i

$E_{i,j}$ for $i = 1,2,3$ is the part of the European market served by domestic firms

$E_{i,m}$ for $i = 1,2,3$ is the part of the European market served by imports

(Cantwell, 1989, p. 64).

Relations that hold

$$U_i = U_{i,j} + U_{i,m} \text{ for } i = 1,2,3$$

$$E_i = E_{i,j} + E_{i,m} \text{ for } i = 1,2,3$$

$$\dot{U}_i = \dot{U}_{i,j} = \dot{U}_{i,m} = \dot{E}_i = \dot{E}_{i,j} = \dot{E}_{i,m}$$

(Cantwell, 1989, pp. 64-65).

These relations hold because of the underlying assumption that the market shares of domestic and foreign firms are equal, and the proportion of production and the proportion of innovation in firms of each state are positively related and equal. The dots represent the proportional rates of growth:

$$\dot{U}_i = \left(\frac{1}{U_i}\right) \left(\frac{d U_i}{d t}\right)$$

(Cantwell, 1989, p. 65).

Under the described conditions, it is further assumed that the innovative activity of each firm depends upon its ownership advantages. The lower the firm's total costs per unit compared to its competitors, the higher are the ownership advantages of the firm. By increasing the firm's ownership advantages, the market share of the firm increases as well.

Results

(Cantwell, 1989, pp. 65-67):

1. Stage: "*The Schumpeterian technological leadership stage*"

(Cantwell, 1989, p. 65):

In the first stage of development, in $i = 1$, US firms had stronger ownership advantages than European firms. Therefore, they had RTA values higher than one.

In $i = 2$, US firms had lower ownership advantages than the European firms, thus their RTA values were smaller than one.

In $i = 3$, the ownership advantages of the US and European firms were pretty much the same, so the RTA values of firms from the both countries were around one.

The first stage is called the "*Schumpeterian technological leadership stage*", because during this stage, US firms enjoyed the so called first-mover advantages. Because of the increased number of innovative activities in the US, US firms were able to retain their strong ownership advantages and high market shares in the US, thereby making the American market not dependent on imports. Therefore, the part of the US market served by domestic firms ($\dot{U}_{i,j}$) was larger than the total US market for industry i ($\dot{U}_i$). The total US market for industry i ($\dot{U}_i$) was also larger than the total European market for industry i ($\dot{E}_i$).

2. Stage: "*US exports growth phase*"

(Cantwell, 1989, p. 65):

Because of the strong ownership advantages and technological strength, in the second stage, US firms began to expand in Europe through exports. Therefore, this stage is named as "*US exports growth phase*". During this phase of development, the section of the European market served by imports ($\dot{E}i, m$) was larger than the European total sales in industry i ($\dot{E}i$). The number of local sales of European firms in industry i ($\dot{E}i, j$) was lower than the sales due to imports in the same industry ($\dot{E}i, m$).

3. Stage: "*US firms international production growth phase*"

(Cantwell, 1989, p. 66):

As the name suggests, in this stage, the US firms started to expand in Europe not only through exports, but also through establishing networks of international production. US firms established subsidiaries in Europe. Sales are denoted as Ei, s . The whole European market (Ei) in this stage was served by European firms (Ei, j), imports (Ei, m) and by the US firms' subsidiaries in Europe (Ei, s). The European total market for industry i ($\dot{E}i$) was larger than the US total market for industry i ($\dot{U}i$). The sales of the US firms' subsidiaries in Europe ($\dot{E}i, s$) were higher than the total sales in the European market ($\dot{E}i$).

4. Stage: "*The early European recovery stage*"

(Cantwell, 1989, p. 66):

Although the first signs of recovery of European firms were apparent in the third stage, it was in the fourth stage when European firms were able to engage in real competition with the US firms in $i = 1$. They began to gain advantages from licensing technology from the US firms. In this stage, many European firms in $i = 1$ were eliminated from the competition by technologically stronger US firms or bought by them.

Local sales of European firms due to licensing American technology are denoted as Ei, l , while sale of US firms in the US market due to licensing European technology are denoted as Ui, l .

In this stage the total European market (Ei) was served by domestic firms (Ei,j), imports (Ei,m), US firms' subsidiaries in Europe (Ei,s) and by European firms licensing technology from US firms (Ei,l).

In $i = 1$, the number of US firms' subsidiaries in Europe continued to grow. In $i = 3$ and especially in $i = 2$, US firms that were technologically weaker than their European competitors started to license technology from them. In this stage, the highest growth of imports in the US was recorded in industry 2, which made the US market in this industry more dependent on imports. In the same group of industries ($i = 2$) in Europe, the number of European exports to the US started to increase.

In $i = 3$ technologically strong European firms started to export in the US, while strong US firms increased the number of subsidiaries in Europe.

5. Stage: *"The European firms' international production growth phase"*
(Cantwell, 1989, pp. 66-67):

In this stage industry 1 started to stabilize, because weak European firms were driven out from the industry and only strong European firms stayed in competition with strong US firms. During this stage, firms grew at the same proportional rates and market shares became stable again (Cantwell, 1989, pp. 66-67). Such stabilization was achieved, because the sum of the European sales ascribable to imports and the sales ascribable to the US firms' European subsidiaries in industry 1 ($E_{1,m} + E_{1,s}$) rose considerably relative to the sales from indigenous firms in the same industry ($E_{1,j}$).

The situation in $i = 2$ was quite different, namely the sales of foreign-owned subsidiaries in $i = 2$ were zero ($E_{2,s} = 0$), because US firms' European subsidiaries in this industry were overtaken by strong European firms. Therefore, the proportion of the European market served by domestic firms ($E_{2,j}$) was larger than the proportion served by imports ($E_{2,m}$) and larger than the proportion served by firms which licensed technology from US firms ($E_{2,l}$). Furthermore, the proportion of the European market served by imports ($E_{2,m}$) was larger than the proportion served by those European firms which licensed US technology ($E_{2,l}$). In industry 2, the number

of established European subsidiaries in the US ($\dot{U}_{2,s}$) was bigger than the total US market for this industry ($\dot{U}_2$).

In $i = 3$, technologically advanced European firms established their own subsidiaries in the US ($\dot{U}_{3,s} > \dot{U}_3$) and the licensing agreements between European and US firms were greater than zero in Europe, as well as in the US ($\dot{U}_{3,l} > 0$ and $\dot{E}_{3,l} > 0$).

6. Stage: *"Intra-industry production phase"*

(Cantwell, 1989, p. 67):

In industry 3, weaker European or American firms were overtaken by more technologically advanced European or American subsidiaries in each country. This was the developmental phase when in $i = 3$ intra-industry production started to grow and the strongest European and American firms started to establish international networks ($\dot{E}_{3,s} > E_3$ and $\dot{U}_{3,s} > U_3$).

In industry 2, technologically stronger European firms' subsidiaries in the US acquired technologically weaker US firms, while the comparatively weaker European firms started to license technology to those US firms that were not overtaken by the strong European subsidiaries in the US. However, in $i = 2$ the proportion of the US market served by those American firms that licensed technology from the European firms ($\dot{U}_{2,l}$) was greater than the proportion of the market served by domestic firms ($\dot{U}_{2,j}$).

7. Stage: *"The balanced innovation phase"*

(Cantwell, 1989, p. 67):

In this stage, all three groups of industries ($i = 1,2,3$) became stable again. Firms were growing at the same proportional rate, while market shares were constant again.

In industry 1 and 2, the strongest European and American firms had established international networks, so their world market shares increased.

In industry 3, inter-industry production between European and American firms continued to grow.

The situation in the final stage was the following:

The total US market (U_i), for all three industries, was served by domestic firms ($U_{i,j}$), imports ($U_{i,m}$), European subsidiaries established in the US ($U_{i,s}$) and by US firms which licensed technology from technologically stronger European firms ($U_{i,l}$), while the sales of the European subsidiaries ($U_{1,s}$) and the sales of those firms that licensed European technology ($U_{1,l}$) in industry 1 were zero (Cantwell, 1989, p. 67):

$$U_i = U_{i,j} + U_{i,m} + U_{i,s} + U_{i,l} \quad U_{1,s} = U_{1,l} = 0$$

In the European market the situation was the same; the total European market (E_i), for all three industries, was served by domestic firms ($E_{i,j}$), imports ($E_{i,m}$), US firms' subsidiaries in Europe ($E_{i,s}$) and by domestic firms licensing US technology ($E_{i,l}$), while the sales of the subsidiaries ($E_{2,s}$) and the sales of the domestic firms licensing foreign technology ($E_{2,l}$) in industry 2 were zero (Cantwell, 1989, p. 67):

$$E_i = E_{i,j} + E_{i,m} + E_{i,s} + E_{i,l} \quad E_{2,s} = E_{2,l} = 0$$

Cantwell's model vs. PCM

PCM best outlines the situation in the second ($i = 2$) of the three previously described industries (Cantwell, 1989, p. 67). However, there are two main points that should be précised. Firstly, the PCM considers only breakthrough innovations, which are radical and discontinuous, and does not pay attention to incremental innovations which are continuous and adaptive. Thus, PCM begins and ends in a static rather than a dynamic equilibrium (Cantwell, 1989, pp. 67-68). Under such constellation, PCM loses its dynamism and it is often defined as a special case of the static theory of international trade and investment (special case of the neoclassical approach), in which technology is perceived as a production factor, same as capital or labor (Cantwell, 1989, p. 53). Secondly, PCM may describe the success of the European firms in the 1960s and 1970s as a consequence of an imitation and not as a result of their high potential for innovation. European firms were able to increase their export rates and international production because of their accumulated technological capabilities in industrial areas of their historical technological

strengths and not because they imitated their US rivals. Furthermore, in the PCM the industry is expected to shift from Europe and USA to same new developing countries and not to settle down (Cantwell, 1989, p. 68). In the last evolutionary stage, namely "*the balanced innovation phase*", the industry settled down and didn't shift to industrializing countries. Important to note here is that, when I speak about shifting the industry to developing countries I don't refer to shift assembly type of activities, but to shift research activities. In this sense, the research activities stayed within the developed countries, while assembly activities shifted to developing countries mainly because of the cost factor.

Finally, only the first three stages of the evolutionary development of international technological competition can be described with the PCM. Starting from the fourth stage, when innovation becomes an ongoing phenomenon, the PCM loses its explanatory capacity.

The model proposed by Cantwell (1989) has been inspired by the continuous trend towards internationalization and globalization. MNCs tend to internationalize their production and to establish global integrated networks, thereby gaining technological competitive advantages from the international knowledge flow. By establishing production and research in foreign centers of excellence, a MNC aims to improve its technological development by tapping into the specific knowledge and the specific technological experience of the foreign country. This trend towards internationalization and globalization of a firm's operations has become a way of strengthening technological accumulation and competitiveness at the firm level (Cantwell, 1989, p. 69). However, gaining technological competitiveness through internationalization and globalization varies across industrial sectors.

5.2.2. The first evolutionary phase of international technological competition

The first four developmental stages of Cantwell's model describe part of the evolution of international technological competition that took place in the time period from 1955 up to 1975. During the first evolutionary stage, the main competitive activities were only between European

and American firms. The principle focus in this phase of international competition is on the European recovery in terms of exports.

Although many economists were concerned about the technological progress and economic growth of European firms after the expansion of US firms in Europe, some other authors, like Dunning (1971, 1970a and 1970b) for example, perceived the growth of American firms in Europe as a stimulus for the European firms to start to act, rather than as being disadvantageous for European competition. In this sense, one of the reasons for improving the European export rates in that period was the competitive pressure that US firms created, after they started to expand their affiliates in Europe. The US investment in Europe helped European countries in improving their position not only as a location where American firms can sell their exports, but also as a region where they can site the production of research intensive goods (Cantwell, 1989, p. 73).

Not only Dunning, but also other authors came to the conclusion that the expansion of US firms in Europe and the sharp competition they created afterwards have improved the innovation and export rates of the European firms. Lake, in his papers, *"Transnational activity and market entry in the semiconductor industry"* (1976) and *"Foreign competition and the UK pharmaceutical industry"* (1976), found out that the rapid growth of American firms in the semiconductor and pharmaceutical industry in the UK helped domestic firms to improve their own technological capabilities in both industries. Stimulated by the US expansion in the UK, domestic firms began to open their own R&D laboratories, which helped improve their innovation rates and create competitive advantages. Only by improving the innovation rates, could UK firms stay competitive and survive.

From the period of 1955 up to 1975, the export rates of Europe as a whole had increased. During this period, European firms focused on catching-up with the US firms in terms of exports, rather than in terms of international production. This was the primary response of the European firms to the *"American challenge"*. According to the statistical data from Table 4, we can see that in all European countries considered in the examination, the number of exports has increased. The export rates have especially increased across the six countries from the EEC. All European

countries, with exception of the UK, performed better than the US for both periods (1955-1965 and 1965-1975).

Table 4. The growth in exports of European countries and the USA, 1955-1975

Country	1955-1965	1965-1975	1955-1975
USA	177.1	407.7	722.0
EEC six:	284.5	510.1	1451.2
West Germany	315.9	514.5	1625.3
France	228.8	522.2	1194.8
Italy	359.9	490.5	1765.3
Netherlands	276.4	538.7	1489.0
Belgium and Luxembourg	248.5	472.1	1173.2
UK	171.4	329.6	564.9
Denmark	328.8	389.4	1280.3
Other Europe	208.7	447.4	933.7
Europe	251.2	488.3	1226.6
Total	228.1	468.2	1068.0

Source: Cantwell, 1989, p. 77

(Original source: United Nations, *Commodity Trade Statistics*, 1955, 1965 and 1975)

After the second developmental stage named as "*US export growth phase*", the recovery of the European firms began and in the following period Europe was able to improve its export rates (as we saw from the statistical data in Table 4). As a response to the European recovery in terms of exports, US firms began to establish subsidiaries in Europe, making Europe an attractive location not only for exports, but also for establishing production. The output of the US firms' subsidiaries located in Europe became an important factor in the third developmental stage of the international competition, namely in the "*US firms' international production growth phase*". In the third phase, international production of the US firms started to replace the exports from the

US (Cantwell, 1989, p. 78). Because of the increased interest of US firms for Europe as an attractive production location, the output of the US subsidiaries in Europe was continually rising, compared with the number of US exports in Europe. Consequently, the $Ei,s/Ei,m$ (Sales of the US subsidiaries located in Europe/Sales of imports in Europe) ratio was continually rising (Cantwell, 1989, pp. 77-78). However, it would be incorrect to think that starting from the third developmental stage, the output of the US subsidiaries in Europe completely replaced the exports from the US. Although the sales/export ratio increased, the US exports and the sales of their subsidiaries in Europe became complementary with each other, rather than substitutes to one another (Cantwell, 1989, pp. 78-79). In this section, we will see how the international production of the US firms affected the European recovery.

From Table 5 we can see that Italy, Belgium, Netherlands and Luxembourg have the highest increase in the sales/export ratio. UK has the lowest increase. The $Ei,s/Ei,m$ ratio increased in almost all industrial sectors, with the exception of the electrical equipment sector. In the electrical equipment sector, we can see that the ratio has slightly fallen. This is because European firms are technologically weaker than the US firms in this particular sector. Sales/export ratio increased above-average in chemicals and allied as well as in rubber products, sectors in which Europe was historically very strong (Cantwell, 1989, p. 78). Above-average increase of the ratio are demonstrated in the paper and allied as well as in primary and fabricated metals sectors. Overall, we can conclude that the expansion of innovative American firms in Europe, first in terms of exports and later in terms of international production, helped the European firms to restructure and to improve the industrial sectors in which they were historically strong. European firms were, in a way, forced to rebuild the sectors of their traditional technological strengths in order to stay in competition, which after the entry of the US firms in Europe became very aggressive. In this sense, the entry and the expansion of the US firms in Europe was highly beneficial for the production and the exports of European firms (Cantwell, 1989, p. 91) and for the European economy as a whole.

Table 5. The sales of US manufacturing affiliates in Europe and exports from the USA to Europe, 1957-1975 (\$m)

		Europe			EEC six			West Germany		
		1957	1966	1975	1957	1966	1975	1957	1966	1975
Chemicals and allied	A).	822	3,417	19,798	275	1,733	12,478	46	464	3,063
	B).	353	927	2,666	223	596	1,816	43	121	352
	C).	2.33	3.69	7.43	1.23	2.91	6.87	1.07	3.83	8.70
Primary and fabricated metals	A).	435	1,619	7,985	145	648	4,458	45	207	2,057
	B).	462	497	1,220	214	296	633	70	87	189
	C).	0.94	3.26	6.55	0.68	2.19	7.04	0.64	2.38	10.88
Mechanical engineering	A).	1,009	4,099	21,235	502	2,431	13,007	228	903	4,571
	B).	567	1,571	5,451	306	822	2,923	59	238	825
	C).	1.78	2.61	3.90	1.64	2.96	4.45	3.86	3.79	5.54
Electrical equipment	A).	678	2,170	11,891	299	1,214	8,463	73	n. a	3,133
	B).	114	644	2,179	55	338	1,202	8	100	421
	C).	5.95	3.37	5.46	5.44	3.59	7.04	9.13	n. a	7.44
Transportation equipment	A).	1,700	5,012	16,339	764	2,747	9,822+	n. a	n. a	5,917
	B).	244	647	2,493	130	350	1,152+	14	138	419
	C).	6.97	7.75	6.55	5.88	7.85	8.53+	n. a	n. a	14.12
Rubber products	A).	262	662	2,190	77	276	1,321	n. a	n. a	204
	B).	97	128	178	60	86	118	19	29	25
	C).	2.70	5.17	12.30	1.28	3.21	11.19	n. a	n. a	8.16
Paper and allied	A).	34	384	3,221	13	241	1,671#	6	61	420
	B).	91	257	916	44	157	482#	15	55	195
	C).	0.37	1.49	3.52	0.30	1.54	3.74#	0.40	1.11	2.15
All products	A).	4,940	17,363	82,650	2,074	9,290	52,221	890	3,920	19,365
	B).	1,928	4,671	15,103	1,032	2,645	8,326	228	768	2,426
	C).	2.56	3.72	5.47	2.01	3.51	6.27	3.90	5.10	7.98

A). Sales of affiliates

B). US exports

C). *Sales/export ratio ($E_{i,s}/E_{i,m}$)*

n. a not available

+ Excluding Netherlands transportation equipment

Excluding Netherlands paper and allied

* Excluding paper and allied

^ Excluding rubber products and transportation equipment

Source: Cantwell, 1989, pp. 80-81

(Original source: United Nations, *Commodity Trade Statistics*, 1975, 1966 and 1975;

US Department of Commerce, *Survey of Current Business*, 1960 (supplement), August 1974 and February 1977)

Table 5. (continued)

France			Benelux			Italy			UK		
1957	1966	1975	1957	1966	1975	1957	1966	1975	1957	1966	1975
114	475	2,907	60	478	4,771	55	316	1,736	517	1,365	4,738
48	98	278	86	306	953	46	71	233	44	171	374
2.38	4.85	10.46	0.70	1.56	5.01	1.20	4.45	7.45	11.75	7.98	12.67
60	154	680	19	116	1,135	21	172	584	230	781	2,630
53	74	125	45	56	215	46	79	103	128	119	352
1.13	2.08	5.44	0.42	2.07	5.28	0.46	2.18	5.67	1.80	6.56	7.47
192	810	3,686	36	386	3,090	46	333	1,660	480	1,479	6,623
113	248	813	72	210	883	62	125	401	92	316	1,106
1.70	3.27	4.53	0.50	1.84	3.50	0.74	2.66	4.14	5.22	4.68	5.99
79	n. a	2,194	67	n. a	1,978	80	303	1,159	270	n. a	1,737
13	113	279	16	68	285	18	58	217	9	129	428
6.08	n. a	7.86	4.19	n. a	8.94	4.44	5.22	5.34	30.00	n. a	4.06
174	n. a	2,528	138	n. a	732+	n. a	63	645	789	n. a	4,970
39	63	245	67	130	307+	10	20	179	19	58	352

4.46	n. a	10.32	21.06	n. a	2.38+	n. a	3.15	3.60	41.53	n. a	14.12
n. a	104	426	28	n. a	596	n. a	29	95	139	268	574
19	23	31	12	23	51	10	11	11	19	12	26
n. a	4.52	13.74	2.33	n. a	11.69	n. a	2.64	8.64	7.32	22.33	22.08
n. a	60	475	4	67	446#	n. a	54	330	21	89	449
12	31	112	11	31	61#	6	39	115	41	65	193
n. a	1.94	4.24	0.36	2.16	7.31#	n. a	1.38	2.87	0.51	1.37	2.33
619	2,497	12,895	353	1,603	13.752	202*^	1,269	6,209	2,446	6,511	21,721
266	650	1,883	309	824	3,118	172*^	403	1,259	352	870	2,831
2.33	3.84	6.85	1.14	1.95	4.41	1.17*^	3.15	4.93	6.95	7.48	7.67

5.2.3. The second evolutionary phase of international technological competition

The second phase of the evolution of international competition started in the mid-1970s. Since 1975, European firms entered in a stage of international expansion of their production. Their focus shifted from exports (manufactured in their home countries) to internationalization of their production processes and establishing global organizational networks. The phase of expansion of international production began in the fifth developmental stage of Cantwell's model, when not only American, but also European firms internationalized their production.

The sixth developmental stage was a result of the growth of international production. Because each country and each firm were narrowly specialized in different technological areas, intra-industry production began to grow among industrial sectors in which the firms of both countries involved had certain technological strengths (Cantwell, 1989, p. 137). *"Intra-industry production occurs where firms from two different countries but from the same industry each establish production facilities in the other county"* (Cantwell, 1989, p. 138). The reason for the increasing interest of firms to establish production facilities in foreign countries which are centers of innovation, is because it enables the firm to take advantage of the technological development there, which is different but mostly complementary to their own technology base developed at

home (Cantwell, 1989, pp. 137-138). Intra-industry production is expected to increase further between countries whose firms are technologically advanced in the industry in question (Cantwell, 1989, p. 68). The increasing intra-industry production is actually a consequence of what the third proposition of the theory of technological accumulation claims, namely that each firm follows different path-dependent courses of technological development, thereby creating firm-specific technological competence.

This proposition can be supported by statistically proving that, in the era of expansion of intra-industry production, West German MNCs were especially attracted to the US as an industrial location for siting their production and that the US MNCs were mostly favoring West Germany as an attractive location for their production. USA and West Germany were and still are, the major technological leaders in the world and the most important centers of excellence. Table 6 shows that MNCs from West Germany were especially attracted to the US in food products, other transport equipment, rubber products and coal and petroleum products, while US MNCs were attracted to West Germany mostly in motor vehicles, other transport equipment, textiles and rubber products (Cantwell, 1989, pp. 155-156). GIPUS (German International Production in the US) is the index that shows the share of German MNCs in international production located particularly in the US, relative to the share of total international production of non-US firms in the world. USIPG (US International Production in West Germany) shows the share of the US affiliates located in West Germany, relative to the US share of total international production of non-West German firms in the world (Cantwell, 1989, pp. 155-156). GIPUS and USIPG are calculated for 1982. You can find the exact calculation of the indices and detailed description of the data in the seventh chapter of Cantwell's book *"Technological innovation and multinational corporations"* (1989). For the purpose of my work, only the interpretation of the results presented in Table 6 is important and not the underlying calculations. Therefore, I decided not to go further into details with the calculations. My main aim is to show that the theory of technological accumulation, on which I have based my work, is statistically proven and can be used to analyze the evolution of international technological competition between MNCs.

Table 6. The index of the relative attractiveness of the USA for the international production of West German firms, and of West Germany for the international production of US firms

	GIPUS	USIPG
Food products	2.349	0.238
Chemicals	0.921	0.668
Metals	0.755	0.526
Mechanical engineering	0.551	0.785
Electrical equipment	0.416	0.814
Motor vehicles	0.883	1.674
Other transportation equipment	1.805	1.231
Textiles	0.466	1.828
Rubber products	2.121	1.200
Non-metallic mineral products	0.536	0.632
Coal and petroleum products	13.734	0.486
Other manufacturing	0.353	0.631

Source: Cantwell, 1989, p. 155

During the period of expansion of intra-industry production, the collaboration and co-operation between foreign and domestic firms took a quite different path and intensity than before. Co-operations between foreign and local firms emerged, mainly because it enabled foreign firms to adapt more easily and quickly to the local conditions and regulations. In the 1970s, when the focus shifted from geographical dispersion of intra-firm networks to inter-firm linkages, M&As started to appear. M&As were one of the possible forms to establish these linkages. M&A as a corporate technological strategy to transform portfolios of technological competences (Cantwell, 2005, p. 178) and to reshape corporate technological boundaries (Cantwell, 2005, p. 174) will be discussed in the following chapter of this work.

In the final developmental stage of Cantwell's model, "*the balanced innovation phase*", as its name suggests, no technological leadership exists anymore and all three industries ($i = 1, 2, 3$)

start to follow a course of equal growth rates across groups of firms and stable market shares (Cantwell, 1989, p. 67). In the seventh stage, the firms from all countries involved in international technological competition have pretty much an equal level of technological development and their market shares are quite the same.

Internationalization of production became a trend not only among firms originating from the most industrialized countries in the world, like the USA, Germany, the UK, Italy, France, but also among Japanese firms (Cantwell, 1989, p. 96). Since the 1970s, Japanese firms started to become heavily involved in international competition as well. During the 1970s and 1980s they moved from domestic exports to international production. Consequently, US firms started to lose world market shares dramatically. However, they continued to expand internationally and once firms from other countries internationalized their production, they led them towards a closer integration of the firms' networks.

The “catching-up” of Japanese firms is an interesting topic to look at closer. After they succeeded to catch up with their European and US competitors during the 1970s and the 1980s and after establishing themselves as technological leaders in many industrial areas, in the 1990s, the Japanese economy started to face numerous difficulties and major drawbacks. The reasons for such an abrupt turn in the Japanese economy will be analyzed later in this section, in accordance with the paper from Cantwell and Zhang (2006) entitled as *“Why is R&D Internationalization in Japanese Firms so Low? A Path-Dependent Explanation”*.

The degree of internationalization of production and its relative importance varied among firms from different countries. Some countries were more dependent on exports, while others relied more on international production. If we compare the results from Tables 7 and 8, we can see that the USA and the UK are more dependent on international production than the other countries listed. As we can see from Table 7, the USA accounts for 42.43% and the UK for 18.32% of international production in the world, while the shares of the other countries are much lower, West Germany 10.64%, Italy 1.56%, France 5.38% and Japan 4.87%. West Germany, Italy, France and Japan are more dependent on exports than they are on international production. From Table 8 we can see that West Germany accounts for 12.20% of international production plus

exports, Italy accounts for 4.15%, France for 6.45% and Japan for 9.36%. To see the exact calculations behind the numbers presented in Tables 7-14, and to see how the data for the calculations is collected, you can read Chapter 5 from Cantwell's book *"Technological innovation and multinational corporations"* (1989), Dunning and Cantwell (1987) *"The IRM directory of statistics of international investment and production"*, Dunning and Pearce (1985) *"The world's largest industrial enterprises, 1962-1983"*, Cantwell (1984) *"The revaluation of the UK's outward foreign direct investment stock"* and Cantwell (1986) *"Recent trends in foreign direct investment in Africa"*.

If we look at Tables 7-10, we can see which industries are more dependent on international production and which on exports. According to the data shown in these tables, we can conclude that the industries of food products (15.72% compared to 14.89%), chemicals (14.17% compared to 11.61%), electrical equipment (11.56% compared to 10.73%), motor vehicles (10.17% compared to 9.76%), rubber products (2.49% compared to 2.03%), non-metallic mineral products (2.73% compared to 2.06%) and coal and petroleum products (22.31% compared to 11.97%) are more dependent on international production, while the industries such as metals (9.33% compared to 6.78%), mechanical engineering (10.60% compared to 7.07%), other transport equipment (2.96% compared to 1.07%), textiles (5.71% compared to 1.74%) and other manufacturing (8.37% compared to 4.20%) are more dependent on exports (Cantwell, 1989, pp. 101-103).

Tables 7-10 give a clear picture of how important the international production and exports are for the firms from different countries in the world.

Table 7. The geographical distribution of international production in manufacturing by source country, 1982

Source country	Value of production (\$m)	Share of production (%)
USA	357,244	42.43
West Germany	89,586	10.64
UK	154,230	18.32
Italy	13,141	1.56

France	45,333	5.38
Japan	41,047	4.87
World total	842,027	100.00

Source: Cantwell, 1989, p. 98

Table 8. The geographical distribution of international production and indigenous firm exports in manufacturing combined, by source country, 1982

Source country	Value of production plus exports (\$m)	Share of production plus exports (%)
USA	521,269	27.60
West Germany	230,466	12.20
UK	212,816	11.23
Italy	78,434	4.15
France	121,709	6.45
Japan	176,687	9.36
World total	1,888,357	100.00

Source: Cantwell, 1989, p. 100

Table 9. The industrial distribution of international production in manufacturing, 1982

Industry	Value of production (\$m)	Share of production (%)
Food products	132,373	15.72
Chemicals	119,281	14.17
Metals	57,056	6.78
Mechanical engineering	59,532	7.07
Electrical equipment	97,299	11.56
Motor vehicles	85,665	10.17

Other transport equipment	9,039	1.07
Textiles	14,625	1.74
Rubber products	20,958	2.49
Non-metallic mineral products	22,958	2.73
Coal and petroleum products	187,889	22.31
Other manufacturing	35,352	4.20
Total world manufacturing	842,027	100.00

Source: Cantwell, 1989, p. 102

Table 10. The industrial distribution of international production and indigenous firm exports in manufacturing combined, 1982

Industry	Value of production plus exports (\$m)	Share of production plus exports (%)
Food products	281,149	14.89
Chemicals	219,271	11.61
Metals	176,148	9.33
Mechanical engineering	200,197	10.60
Electrical equipment	202,591	10.73
Motor vehicles	184,296	9.76
Other transport equipment	55,820	2.96
Textiles	107,817	5.71
Rubber products	38,244	2.03
Non-metallic mineral products	38,839	2.06
Coal and petroleum products	225,971	11.97
Other manufacturing	158,025	8.37
Total world manufacturing	1,888,357	100.00

Source: Cantwell, 1989, p. 103

As mentioned before, after the European recovery first in terms of exports and later in terms of international production in the mid-1970s, US firms began to dramatically lose their shares not only in total international production in manufacturing, but also in total international economic activity (international production plus exports) (Cantwell, 1989, pp. 102-105). Tables 11-14 show national firms' shares of international production by manufacturing sector in 1974 and in 1982 and national firms' shares of total international economic activity of manufactured goods in 1974 and in 1982. If we compare the data from Table 11 and 12, we can see that the US firms' shares of total international production in manufacturing have fallen from 55.3% in 1974 to 42.4% in 1982. At the same time, the firms' shares of total international production in the rest of the countries (West Germany, the UK, Italy, France and Japan) have increased. West German firms have increased their shares of total international production from 6.8% in 1974 to 10.6% in 1982. UK firms have increased their shares from 12.4% in 1974 to 18.3% in 1982. Italian firms have increased the shares from 1.1% in 1974 to 1.6% in 1982. French firms have increased their shares as well, from 3.9% in 1974 to 5.4% in 1982. Japanese firms had also an increase in their shares, from 2.1% in 1974 to 4.9% in 1982.

If we look at the firms' shares of international production by manufacturing sector in both periods, 1974 and 1982, we can see that US firms lost their shares most heavily in chemicals (from 52.8% in 1974 to 37.2% in 1982), electrical equipment (from 65.6% in 1974 to 49.3% in 1982), motor vehicles (from 66.7% in 1974 to 40.5% in 1982), in non-metallic mineral products (from 47.6% in 1974 to 28.6% in 1982) and in coal and petroleum products (from 66.2% in 1974 to 53.0% in 1982) (Cantwell, 1989, pp. 103-105). The US MNCs lost their shares of international production in chemicals mostly to German and British MNCs. In the sector of chemicals, as we already know, British and especially German firms were historically very strong. In the sector of electrical equipment, the US MNCs lost their shares of international production to Japanese firms. In motor vehicles, they lost their shares to the European and the Japanese MNCs. In coal and petroleum products they lost their shares to British MNCs. The only two sectors in which the American MNCs increased their shares of international production were other transport equipment (from 14.4% in 1974 to 25.6% in 1982) and in other manufacturing (from 63.0% in 1974 to 70.7% in 1982).

The data of the national firms' shares of international production plus domestic exports of manufactured goods for 1974 and 1982 are presented in Tables 13 and 14. US firms' shares of total international production and exports have fallen from 35.1% in 1974 to 27.6% in 1982. The firms' shares of all other countries have increased during this period. West German MNCs increased their shares of total international economic activity from 10.4% in 1974 to 12.2% in 1982. British firms increased their shares as well, from 8.7% in 1974 to 11.3% in 1982. Italian MNCs had an increase of 1.1%, namely from 3.1% in 1974 to 4.2% in 1982. France MNCs also increased their shares from 5.6% in 1974 to 6.4% in 1982. Japanese MNCs had an increase of 2.6%, from 6.8% in 1974 to 9.4% in 1982.

Table 11. National firms' shares of international production by manufacturing sector, 1974 (%)

	USA	West Germany	UK	Italy	France	Japan
Food products	32.8	1.1	21.8	0.5	1.2	1.2
Chemicals	52.8	22.1	9.2	3.3	7.8	3.8
Metals	40.4	8.7	23.2	0.2	5.4	1.0
Mechanical engineering	51.1	8.6	10.9	0.3	2.5	1.2
Electrical equipment	65.6	13.2	10.8	1.0	3.8	4.6
Motor vehicles	66.7	11.7	9.3	2.5	6.3	2.6
Other transport equipment	14.4	23.8	36.5	0.3	3.3	0.3
Textiles	40.5	10.3	40.1	0.4	2.4	5.3
Rubber products	55.9	5.6	9.8	12.3	11.3	4.2
Non-metallic mineral	47.6	5.3	19.9	0.1	11.1	4.2

products						
Coal and petroleum products	66.2	0.3	5.9	0.2	2.9	0.1
Other manufacturing	63.0	7.3	4.7	0.1	0.5	7.3
Total	55.3	6.8	12.4	1.1	3.9	2.1

Source: Cantwell, 1989, p. 104

Table 12. National firms' shares of international production by manufacturing sector, 1982 (%)

	USA	West Germany	UK	Italy	France	Japan
Food products	31.0	2.5	34.7	0.3	1.8	2.4
Chemicals	37.2	27.4	13.4	2.4	4.6	5.8
Metals	34.5	10.3	15.8	0.5	5.5	3.3
Mechanical engineering	38.1	13.9	12.5	0.5	2.4	2.9
Electrical equipment	49.3	13.1	12.5	1.3	6.8	11.0
Motor vehicles	40.5	18.1	8.3	4.7	9.4	8.1
Other transport equipment	25.6	11.1	13.3	0.4	3.5	0.8
Textiles	29.8	15.0	42.7	0.7	4.0	8.0
Rubber products	43.5	7.8	21.9	10.5	9.7	5.9
Non-metallic	28.6	9.7	22.3	0.1	21.3	6.2

mineral products						
Coal and petroleum products	53.0	0.5	19.6	0.9	5.4	0.3
Other manufacturing	70.7	8.8	7.3	0.1	1.0	14.9
Total	42.4	10.6	18.3	1.6	5.4	4.9

Source: Cantwell, 1989, p. 105

Table 13. National firms' shares of international production plus domestic exports of manufactured goods, 1974 (%)

	USA	West Germany	UK	Italy	France	Japan
Food products	24.4	1.8	10.7	1.6	4.7	1.1
Chemicals	30.0	21.0	9.0	4.6	7.6	5.9
Metals	17.6	13.5	8.7	2.9	7.2	13.2
Mechanical engineering	39.1	15.3	8.1	2.9	3.9	6.1
Electrical equipment	41.3	14.9	7.2	2.6	5.4	9.9
Motor vehicles	48.2	16.8	7.7	4.5	8.0	11.3
Other transport equipment	27.2	9.2	9.9	1.5	5.3	23.5
Textiles	1.24	11.7	13.9	8.8	7.1	8.9
Rubber	39.2	10.6	7.0	9.7	8.3	6.8

products						
Non-metallic mineral products	33.6	11.0	15.8	5.6	10.4	6.4
Coal and petroleum products	63.2	1.2	6.0	1.1	3.5	0.2
Other manufacturing	28.8	12.0	7.4	2.1	3.1	8.6
Total	35.1	10.4	8.7	3.1	5.6	6.8

Source: Cantwell, 1989, p. 106

Table 14. National firms' shares of international production plus domestic exports of manufactured goods, 1982 (%)

	USA	West Germany	UK	Italy	France	Japan
Food products	24.0	3.6	18.3	1.9	5.3	1.6
Chemicals	27.0	23.2	11.9	3.5	7.0	5.6
Metals	15.3	12.7	8.5	4.5	7.4	13.0
Mechanical engineering	28.1	17.2	8.4	5.4	5.1	10.0
Electrical equipment	35.5	12.5	8.7	2.9	6.7	19.4
Motor vehicles	25.8	21.3	5.5	4.0	8.4	20.2
Other transport equipment	28.8	13.7	8.7	2.3	8.2	13.7

Textiles	8.7	10.6	9.4	11.8	5.4	7.1
Rubber products	29.5	11.4	15.0	9.3	7.6	9.0
Non-metallic mineral products	20.3	11.5	15.6	6.5	16.3	8.3
Coal and petroleum products	46.5	1.1	17.2	2.3	6.0	0.4
Other manufacturing	27.0	11.0	6.4	5.3	3.8	11.1
Total	27.6	12.2	11.3	4.2	6.4	9.4

Source: Cantwell, 1989, p. 107

From the statistical data presented in the tables above we can summarize that, in general European firms were able to better respond to the *"American challenge"* in those industrial sectors in which they were historically technologically very strong. This is one further proof of the reliability of the technological accumulation theory and its cumulative and continuous nature. The expansion and the growth of American MNCs in Europe was an incentive for the European firms to restructure their old and less effective organizational systems and to improve their production processes. By improving the inner organizations and especially the production processes, they improved their outputs eventually. The innovative capacity of a firm, as an essential factor in the overall improvement process, depends upon the accumulated technological strengths of the firms and on the learning capacity of its personnel. As Penrose claimed, the human resource is the most valuable resource of a firm and it is the initiator of the innovative process. The strong competition that was primarily initiated by the American MNCs, was at the end beneficial for every agent in the economic system and for the economy as a whole. In this sense, a conclusion can be drawn that, the Schumpeterian understanding of economic development and growth through technological innovation in imperfectly competitive economic environment accurately reflects what actually happened in the world economy since the 1950s.

Primarily because of the technological superiority, US firms were able to successfully expand their business operations in Europe. Improving the technological competences in order to gain technological advantages is what helped the European firms to recover after WWII and to stay in competition with the US firms. Japanese firms were able to catch up with the American and European firms only because of their strong innovative capacity.

As I mentioned at the beginning of this chapter, the example of the Japanese economic recovery is quite an interesting case to be discussed. After the fast-technological progress and the successful catch-up with firms from the Western countries during the 1970s and 1980s, Japan became one of the major technological leaders in the world in many industrial areas such as motor vehicles, instruments, office equipment and electrical equipment (Cantwell and Zhang, 2006, p. 250). In the 1970s the Japanese GNP per capita has greater than that of the UK and in the 1980s it exceeded that of the US (Minami, 1994). In the 1990s the economic situation in Japan suddenly changed. Japan's growth rate fell down to only 1%, from 9.3% in 1956-1973 and 4.1% in 1975-1991 (Katz, 1998). Many authors (such as Dore, 1998; Katz, 1998; Vogel, 2001; Schaefer and Grimes, 2003) tried to find the reasons for such drawback of the Japanese economy and many of them came to the same conclusion, that the Japanese *keiretsu* networks that worked very well in the 1970s and 1980s, restrained the Japanese firms from internationalizing their R&D in the 1990s. They were practically stuck in these close networks and unable to take advantage of the technological development in other centers of excellence worldwide.

The paper entitled as *"Why is R&D internationalization in Japanese firms so low? A path-dependent explanation"* from Cantwell and Zhang (2006) deals, among other things, also with the question, why Japanese firms decided to keep their R&D at home and not to internationalize it, following the example of the firms from other industrialized countries. The authors worked with data from the US patent database to show the technological activity of Japanese firms in time period from 1969 to 1995. To see the exact description of the data used in the analysis and the methodology employed, you can see pp. 252-254 in the paper *"Why is R&D internationalization in Japanese firms so low? A path-dependent explanation"* from Cantwell and Zhang (2006). I will not focus on the data and methodology description, but on the final results of the research, which I believe to be most relevant for the discussion in my work.

Table 15 shows that in time period from 1991 to 1995 Japan had the lowest share of R&D located in foreign countries (only 1.08%), compared with the shares of other industrialized countries like the USA (8.63%), Germany (20.72%), the UK (43.01%) and France (33.18%). Even though it was common practice for firms from the major industrialized countries, like the USA and Germany, to keep their R&D at home mainly because of the very strong technological base in their home countries, Japanese R&D internationalization is the lowest, even compared with these countries (Cantwell and Zhang, 2006, p. 254). As we can see from the data in Table 15, Japan had higher shares of abroad located R&D in 1969-1972 (2.63%), 1973-1977 (1.88%), 1978-1982 (1.22%), 1983-1986 (1.26%) than it had in 1987-1990 (0.93%) and 1991-1995 (1.08%). This decrease in the percentage of the total shares of US patents attributable to R&D conducted abroad (outside Japan) was due to the very strong technological base existing in Japan (Cantwell and Zhang, 2006, p. 255). Japanese firms had a strong technological base in their home country which was needed for their technological development, so they had no need to relocate their R&D abroad in order to tap into a foreign knowledge base. If we compare the last two rows of Table 15, we can see that the numbers of Japanese patents from foreign locations are much lower, compared with the total number of patents granted to Japanese firms (patents from home plus foreign locations).

Table 15. Shares of the US patents of the world's largest firms attributable to research in foreign locations, organized by nationality of patent firm, 1969-1995 (%)

Country	1969- 1972	1973- 1977	1978- 1982	1983- 1986	1987- 1990	1991- 1995
USA	4.91	5.88	6.41	7.54	7.91	8.63
Germany	12.77	11.05	12.07	14.47	17.05	20.72
UK	32.27	33.41	32.95	37.76	39.95	43.01
Italy	13.39	16.03	13.85	12.59	11.14	16.47
France	8.16	7.74	7.17	9.19	18.17	33.18
Japan	2.63	1.88	1.22	1.26	0.93	1.08
Netherlands	63.07	57.32	55.60	61.78	59.52	62.79

Belgium	50.00	54.32	56.27	71.21	59.04	67.25
Switzerland	44.36	43.63	43.78	41.59	42.99	52.47
Sweden	17.82	19.90	26.20	28.94	30.60	42.42
Canada	41.19	39.30	39.49	35.82	40.12	43.96
Total	10.03	10.67	10.55	11.02	11.24	11.24
Japan (patents from foreign locations)	210	343	284	392	442	771
Japan (total patents from both home and foreign locations)	7998	18278	23249	31169	47793	71212

Source: Cantwell and Zhang, 2006, p. 255

(Original source: US patent database developed by John Cantwell, with cooperation of the US Patent and Trademark Office)

As mentioned before, the main reason why Japanese firms had such low internationalization rates were the close domestic inter-firm networks, known as keiretsu systems. Although they were very effective systems for the Japanese economy after WWII, in the 1990s when the trend of internationalization of technological activities and the era of globalization began, they constrained the Japanese firms from following these trends. After WWII the Japanese economy was devastated and Japanese firms were obliged to find an effective solution to recover their destroyed economy. The organizational structure known as keiretsu system enabled the Japanese firms to not depend on foreign firms and even countries, but solely on domestic suppliers and financiers. Firms that are classified as keiretsu-firms can be part either of horizontal-type of keiretsu integration, known as H-type, or of vertical keiretsu, known as V-type. The most successful Japanese firms are parts either of H-type or of V-type of close integration. Mitsubishi, Mitsui, Sumitomo, Fuyo, Sanwa and DKB are parts of horizontally integrated network, while Toyota, Nissan, Matsushita, Hitachi, Toshiba and Sony are parts of vertical keiretsu (Cantwell and Zhang, 2006, p. 256).

Table16 shows that the Japanese firms that are part of a certain keiretsu network, internationalize their R&D less often than Japanese firms that are not part of such a network.

If we compare the total shares of US patents attributable to research outside Japan for keiretsu and non-keiretsu firms, we can see that the keiretsu firms have much lower percentage of only 1.14, while non-keiretsu firms have higher percentage of 2.81. If we look at each of the four sectors separately, we can see that the keiretsu-firms have a lower degree of R&D internationalization in all four sectors. The different levels of R&D internationalization between keiretsu and non-keiretsu firms is most notable in chemicals and motor vehicles. This difference is not so big in electrical and office equipment and in professional and scientific instruments.

Table 16. Share of US patents of the largest Japanese-owned firms attributable to research outside Japan, *keiretsu* vs. non-*keiretsu* firms, 1969-1995 (%)

Sector	<i>Keiretsu</i> firms	Non- <i>keiretsu</i> firms
Chemicals	1.62	14.69
Electrical and office equipment	1.53	1.55
Motor vehicles	0.76	5.17
Professional and scientific instruments	1.06	1.24
Total	1.14	2.81

Source: Cantwell and Zhang, 2006, p. 256

(Original source: US patent database developed by John Cantwell, with cooperation of the US Patent and Trademark Office, and Industrial Groupings in Japan, 1994/1995, Dodwell Marketing Consultants, Tokyo (for the keiretsu classification of firms))

Another very interesting fact that can be observed from Table16 is that in sectors, such as electrical and office equipment and motor vehicles, in which Japanese firms are technologically quite strong, the degree of R&D internationalization is pretty low. For other industrialized countries, such as Germany, Switzerland and the Netherlands, the situation is completely the opposite. Firms originating from these countries have a higher degree of internationalization of their R&D in sectors in which they are technologically strong. Namely, except in Japan, in almost all other industrialized countries, the degree of R&D internationalization is high in

industrial sectors in which domestic firms are technologically strong (Cantwell and Zhang, 2006, p. 259).

If we classify the Japanese firms by technological activity rather than industry, we can see that they are more focused on sourcing technology abroad in industrial fields in which they are technologically weaker than the firms from other countries (Cantwell and Zhang, 2006, p. 259). Therefore, Japanese firms source technology internationally in areas such as pharmaceuticals (where the share of the US patents of the largest Japanese-owned firms attributable to research outside Japan was 2.48% in 1991-1995), mining equipment (was 14.29% in 1991-1995), bleaching and dyeing processes (11.63% in 1991-1995), image and sound equipment (2.18% in 1991-1995) and aircraft (7.69% in 1991-1995) (Cantwell and Zhang, 2006, pp. 258-259). For a more detailed look into these numbers, please see Table 6 in the appendix.

Important to notice here is that, the keiretsu systems consisting of close inter-firm networks were in the past a source of strength for Japanese firms and for the Japanese economy as a whole (Cantwell and Zhang, 2006, pp. 262-265). These networks helped Japanese firms to successfully recover from the after-war period and to catch-up with firms from Western countries in the 1960s and 1970s.

During the 1980s the global technological competition had changed and science-based knowledge became a predominant source of competitive advantage for MNCs. Therefore, MNCs began to source technology internationally, in other technologically advanced locations abroad. They started to build internationally integrated networks for technological development, which with the emergence of information and communication technology (ICT) became much easier to establish and manage. When ICT came into sight, the complete picture of international technological competition changed quite a lot. Because the international organizational networks became easier to maintain, MNCs organized their international organizations in a more decentralized way than before. They shifted the focus from centralized home-country based research to decentralized international research. Being able to tap into international knowledge bases and to transfer knowledge from some location abroad to the home-based research department, helped MNCs to improve their technological strengths at home.

Because of the close keiretsu networks, Japanese firms were unable to take advantage of the international knowledge flow during the 1980s, because they didn't internationalized their R&D.

Their decision to further maintain centralized and home-based research caused many difficulties for the Japanese economy later on. Even though Japanese managers realized the importance of international R&D, it was not easy for them to leave the keiretsu system. According to the evolutionary perspective of observing the international technological competition and according to the path-dependent approach of technological development, during the process of technological development a firm interacts with the institutional environment in which it is located and it would be extremely difficult for such a firm to abandon the established interaction and cooperation networks if some new situation emerges (Cantwell and Zhang, 2006, p. 262). This explanation can be used to describe why Japanese firms decided to stay within their established keiretsu networks and not to internationalize their R&D.

Excursion: I permit myself to finish this chapter with an excursion which, I think, shows the analogy between the theory of technological accumulation and the human biology in order to show that the process of technological accumulation is a natural process which enables natural evolution of firms (from national to multi-national), same as human evolution.

The cumulative processes are like father and son. The father has accumulated knowledge and experience with sophisticated performances. The son has "primitive" performances because of the still low accumulation of knowledge and experience. In the future, the father achieves the maximum accumulation of knowledge and his performances are becoming circular. As the son grows, he learns new things and he has the opportunity to achieve the same or even better performances than his father. If we view the father as a first-mover firm and the son as a firm-follower, we can say that the son (the firm follower) can achieve the same or better performance than his father (the first-mover firm) only through the continuous learning process (through innovations). Both the father and the son can achieve the best performances if they co-operate and share their knowledge and experience, as is the case with some large corporations collaborating together.

With this analogy, we can explain in a very simple way what happened historically between US and European firms; innovative US firms had the role of father in the international technological competition and the European firms had the role of the son.

6. M&As as technological strategy for greater technological diversification

Since the 1970s, when intra-industry production started to expand rapidly, M&As as a possible form of inter-firm co-operation emerged. Since 1995, M&As have become widely adopted across many industrial sectors (Cantwell and Santangelo, 2005, p. 175).

In the current much more complex technological environment and fast changing and highly demanding markets, the technological interrelatedness between firms from different technological sectors and the communication between them appear to be of great importance. Given the complex and highly demanding techno-socio-economic conditions (Cantwell and Santangelo, 2005), firms are becoming unable to develop by themselves all the competences required to stay in competition. This is the main reason why firms are becoming increasingly dependent on their closely integrated global networks for diversifying their existing technological base. Thus, technological diversification becomes an important strategic tool for technological development.

The new techno-socio-economic environment necessitated new corporate strategies (Cantwell and Santangelo, 2005, p. 176). Under such new conditions, technological development changed its trajectory from an individual firm-specific development towards a more integrated technological development. This is what Andersen (1998) described as a shift from intragroup technological diversification towards intergroup diversification. In this new model of technological development, general purpose technologies gained great importance (Cantwell and Santangelo, 2005, p. 176). These technologies (such as the ICT) have gained so much importance in MNCs because of the actual possibility to find applications in a wider range of applied technologies. This type of technologies aims to facilitate the innovation potential of firms through easing the process of finding new combinations within the firm's existing resource base. More precisely, they serve as a facilitator of new technological combinations of interrelated technological activities. Under such a constellation, basic research has become crucial for MNCs' long-term success and existence.

In this work, I decided to put the focus on M&As as a possible corporate strategy for restructuring the corporate technological portfolio, because M&As seem to be the most effective strategic form for achieving rapid transformation in the scale and composition of a firm's capabilities (Cantwell and Santangelo, 2005, p. 178). In order to restructure their corporate technological portfolio, firms should focus on more interrelated technologies, either by narrowing or by broadening their technological capabilities (Cantwell and Santangelo, 2000).

Cantwell and Santangelo (2005) discussed M&As as a strategic tool for technological diversification in their paper entitled as: "*The boundaries of firms in the new economy: M&As as a strategic tool toward corporate technological diversification*". Opposite to the actual transaction cost perspective of M&As existing in the literature, they proposed a completely new explanation of it, namely they perceive M&As as a strategic tool for technological development whereby technological diversification is the most important condition for strengthening technological capabilities and increasing competitiveness. M&As could be also perceived as a strategy for a firm to extend its technological boundaries and to move towards more decentralized organizational forms. Because of the increased importance of basic research and its high uncertainty and great costs, MNCs decide to employ strategies for technological development which extend the boundaries of the individual firm. Moving beyond their individual boundaries, firms extend the range of their technological capabilities by expanding their knowledge base in a more efficient, faster and costs-saving way. In this sense, we can conclude that MNCs decide to engage in M&As not purely because of marker-related motives, such as increasing market power and corporate size, but more because of capability-related issues. Thus, I underline the innovations-related motives for M&As. If we try to apply Penrose's (1959) perspective of firm's growth in this M&As context, we can say that by implementing a M&A strategy the firm can grow through finding new combinations within its existing resource base or finding new applications for its existing resources.

Under such highly demanding environmental conditions and increasing co-operation between firms, MNCs are progressively moving towards what is known as *multi-technology corporation*. A multi-technology corporation is defined as a corporation whose technological base diversifies into several areas of technical competence (Granstrand et al., 1997; Patel and Pavitt, 1997; Cantwell and Santangelo, 2005).

Using US patent data for the world's largest firms, Cantwell and Santangelo (2005) investigated the corporate dynamism of post-M&A technological specialization (Cantwell and Santangelo, 2005, p. 195). Implementing econometric and statistical analysis they succeeded to prove that M&As may improve the innovative capacity of a firm by creating a possibility for the firm to take advantage of the opportunity to form new combinations of previously disparate technological capabilities (Cantwell and Santangelo, 2005, p. 179). They also proved that post-M&A technological restructuring leads to a cumulative and incremental re-composition of the firm's corporate technological capabilities and its corporate technological portfolio (Cantwell and Santangelo, 2005, p. 179). In the phase of post-M&A technological restructuring firms tend to technologically diversify into more general purpose technologies, especially into ICTs (Cantwell and Santangelo, 2005, p. 180). This explains the increased interest of MNCs for basic research and basic sciences. Finally, in the science-based industries, they identified two different industrial models of corporate technological development in the post-M&A phase (Cantwell and Santangelo, 2005, p. 180). The first model is identified in science-based industries in which general purpose technologies are developed, while all other science-based industries can be classified into the second industrial model of technological development (Cantwell and Santangelo, 2005, p. 195). Whether the direction of technological development in science-based industries in the phase of post-M&A technological restructuring will follow the first or the second industrial model depends on the relationship between ICT and the core fields of development in each of these industries (Cantwell and Santangelo, 2005, p. 180).

Cantwell and Mudambi (2005) examined the effect that an acquisition might have on the evolution of MNC's foreign-located subsidiaries and on the R&D intensity within these subsidiaries. They researched the impact that the acquisition strategy may have on each of the two types of subsidiaries, previously discussed in chapter 3 (competence-creating and competence-exploiting subsidiaries). This is an important research question since a large quantity of survey evidence suggests that MNCs' R&D that are located abroad result from acquisitions (Hakanson, 1981, 1995; Cantwell and Mudambi, 2005, p. 1111 and p. 1114).

They classified the post-acquisition effect on subsidiaries' evolution as a MNC group-level determinant (Cantwell and Mudambi, 2005, p. 1114). The process of post-acquisition restructuring and integration decides the very existence of foreign-located subsidiaries, their

evolution and the R&D-intensity in them. The post-acquisition effect is generally different in competence-creating and competence-exploiting subsidiaries. The underlying motives for acquisition are the main determinant of the future of subsidiaries (Cantwell and Mudambi, 2005, p. 1114). If the motives are mainly financial, the competence-exploiting subsidiaries of the acquired group are in a much worse position than the competence-exploiting subsidiaries of the acquiring group. In case of duplication of the newly acquired competence-exploiting subsidiaries' activities with the activities of the competence-exploiting subsidiaries of the acquiring group, there is a high possibility that such a duplication will be eliminated to the detriment of the subsidiaries of the acquired group. In this case, the acquired competence-exploiting subsidiaries will suffer from massive budget-cuts. Thus, their R&D-intensity will decrease massively. Considering the fact that the number of competence-exploiting subsidiaries is significantly higher than the number of competence-creating ones, the finding of Hitt et al. (1991) that, during a post-acquisition restructuring the R&D intensity within the firm generally decreases, seems to be quite true. The budget-cuts and the elimination of duplications to the detriment of the acquired group's competence exploiting subsidiaries might be due to the lack of influence of their managers in the new head office of the acquiring group (Cantwell and Mudambi, 2005, p. 1123). This is similar to what Sambharya (1996) found about the managers of the acquired group, namely that the acquired group's managers are often taken less seriously. If the motives for the acquisition are not purely financial (for example asset-seeking objectives and synergy of complementary productive resources (Cantwell and Mudambi, 2005, p. 1115 and p. 1123)), then the competence-creating subsidiaries of the acquired group are in a better position. When the acquiring firm has asset-acquiring objectives (Cantwell and Mudambi, 2005, p. 1115), the contribution of the acquired group's competence-creating subsidiaries in R&D terms is important to the acquiring group. In this case, these subsidiaries will retain the resources needed for R&D. Therefore, their R&D intensity may increase or remain at the same level, depending on the importance of their contribution from the standpoint of the acquiring firm. By using statistical data and implementing econometric estimations, Cantwell and Mudambi (2005) succeeded to prove their hypothesis that, in the post-acquisition integration process the R&D intensity in competence-creating subsidiaries of the acquired group tends to increase, while the R&D intensity in competence-exploiting subsidiaries tends to decrease (Cantwell and

Mudambi, 2005, p. 1115). This is an important finding in the field of M&As in general and in the effect of M&As on the internationalization of R&D in particular.

7. Conclusions and critical overview of the Cantwell's model (1989) and the technological accumulation theory

The theory of technological accumulation is an example of an evolutionary theory (or a dynamic theory), which examines the international technological competition between MNCs over time. The theory of technological accumulation understands the technological development and progress of the firm as a constant and cumulative process which takes place over a longer period of time. In Cantwell's model (1989) for analyzing the international technological competition between MNCs which was presented in this work, the accumulation theory is extended to examine international production of MNCs as well.

Other theories of international trade and investment are more interested in questions concerning the very existence of MNCs, not with their evolutionary progress. The accumulation theory treats questions such as what is the reason that some MNCs grow faster than others and why in some locations the conditions are more favorable to MNCs' growth than in others (Cantwell, 1989, p. 187).

The model introduced previously in this work analyzes the international production at a mesoeconomic level. Precisely, the international production between MNCs is examined at an industry level.

Besides the mesoeconomic level, the international production could be analyzed at macroeconomic and microeconomic level. In accordance with the level at which the international production is analyzed, the literature distinguishes between four main theories of international production.

The first theory for analyzing international production is based on the firm's market power. It explains the internationalization of production as a tool for the firm to lower international competition, to increase its market power and to create conditions where the establishment of collusive networks among firms will be easier. Important representatives of the market power approach are Baran and Sweezy (1966), Newfarmer (1985) and Cowling and Sugden (1987). The basic theoretical framework of this approach is presented by Hymer (1976) and it is

grounded on his understanding of the firm mainly as an agent for market power and collusion (Cantwell, 1989, p. 189).

The second theory for analyzing international production is based on Coase's theory of the firm. According to this approach, a firm decides to internationalize its production only to improve efficiency by entering new markets with favorable conditions for the firm to fulfill the desired task. Representatives of this theory are Rugman (1980), Buckley and Casson (1976 and 1985), Casson (1987) Williamson (1975), Teece (1977) and Caves (1982) (Cantwell, 1989, p. 189).

The third group of theories includes macroeconomic approaches, thereby examining important national and international trends and their influences on the firm. The earlier version of the PCM (Mark I), introduced by Vernon (1966) and previously discussed in this work, is a typical macroeconomic approach. Not only Vernon (1966) in his Mark II, but also Hirsch (1967), Kojima (1978), Ozawa (1982), Dunning (1982), Cantwell and Tolentino (1987), Aliber (1970), Rugman (1979) and Casson (1982) incorporated macroeconomic approaches in their works to investigate international trade and investment (Cantwell, 1989, p. 189).

The fourth group of theories analyzes the international production in terms of competition in international industries. The so called "*competitive international industry approaches*" (Cantwell, 1989) compose this group of theoretical frameworks. The theory of technological accumulation belongs to this group of theories. The latest version of the PCM (Mark II) is classified in this group as well. Besides the technological accumulation theory (Cantwell, 1989) and Vernon's (1974) latest version of the PCM (Mark II), under this group we can classify the work of Graham (1975), Flowers (1976), Knickerbocker (1973), Jenkins (1987), Warren (1980) (Cantwell, 1989, p. 189).

An alternative analytical framework for examining international production known as "*eclectic paradigm*" and developed by Dunning (1977, 1981 and 1988b) exists in the literature as well. It incorporates elements of all previously outlined groups of approaches, thereby is classified in a separate, fifth group of theoretical frameworks.

The main difference between all five groups of approaches lies mainly in their understanding of the driving force for internationalization of production (Cantwell, 1989, p. 206). As defined above, the first group of theories based on the market power approach perceives the internationalization of production only as a tool for a firm to increase its market power and its market shares. The internationalization approach understands the internationalization of production simply as a process to increase firm's efficiency. According to this approach, the principle motivator either to expand or to tighten international production are the costs. If the costs of operating in particular market are higher than the costs of coordinating the transactions from abroad, then the firm will decide to tighten its international production. If it is the other way around, the firm will decide to expand its international production. The main driving force for internationalization of production according to the macroeconomic approach is the developmental position of countries and their firms (Cantwell, 1989, p. 206). If the developmental position of a particular country is favorable to the firm, thereby offering the firm a possibility for further technological development and/or technological diversification, the firm will decide to expand its production in that country and vice versa. According to the technological accumulation approach, the principle driving force for internationalization of production is the potential of a particular country or location for technological development and/or technological diversification.

Competitive international industry approaches

One of the crucial differences of the competitive international industry approaches compared to the other approaches is their understanding of the influence of international production on international competition and firm's growth. The theory of technological accumulation belongs to this group of approaches. According to the accumulation theory, the prior technological achievements and the accumulated technological experience of a firm determine the process of internationalization of production in such a way, that the higher the degree of technological experience of a firm, the faster is the process of internationalization. In this sense, the internationalization in production, similarly to technological development, is a cumulative process. Furthermore, the internationalization of production influences the international technological competition. The competitive international industry approaches hold the belief that

the growth of international production positively influences the international competition between firms.

The degree of technological development of a firm and the degree of its accumulated technological experience define the so called "*ownership advantages*" (Cantwell, 1989) of the firm. The stronger the ownership advantages of a firm, the lower are the production costs per unit and the higher is the firm's profitability (Cantwell, 1989, p. 207). Thus, the ownership advantages affect the firm's unit costs, its profit margins and its market shares. The lower the unit costs of a firm, the faster is its domestic and international growth. Overall, the ownership advantages improve the position of the firm in the industry, relative to the position of other firms in the same industry.

One of the two main characteristics of the accumulation theory, which distinguish it from the other theories, is its consideration of the importance of the firm's ownership advantages in the process of internationalization of production and their influence on international competition. The ownership advantages are firm-specific, because each firm follows a different path of technological development. They are essential for the firm's long-term existence and success, thereby affecting many aspects of the firm. Most importantly, the ownership advantages affect the process of internationalization of production and the international growth of the firm. The stronger these advantages, the faster is the process of internationalization and the faster is the international growth of the firm.

The firm's ownership advantages positively affect not only the international production of a firm, but also the expansion of domestic production. However, for a firm with weak or without ownership advantages, it is easier to survive in domestic market than in international, because of the possibility to enjoy for example the support of domestic government and the support of its loyal domestic customers (Cantwell, 1989, p. 208). A firm with weak or without ownership advantages is unable to survive in the international market in the long-run. Thus, the need of these types of advantages applies for both national and international firms, but it is essential for MNCs.

The firm's ownership advantages affect the competitiveness of a firm positively. There is a high risk for a firm with weak ownership advantages to be driven out of domestic and international competition in a very short time or to be overtaken by some other firm with strong ownership advantages and a strong position in both markets. Another very important aspect of the ownership advantages is that they affect the firm's innovation potential and the possibility for technology creation within the firm. The stronger the ownership advantages, the higher is the firm's innovation potential, the higher is the possibility for technology creation.

Once a MNC with strong ownership advantages has established its internationally integrated networks, it can gain some additional advantages from the location in which it has sited the production facilities, the research and development units. Usually, MNCs locate their R&D units in international centers of excellence, which not only helps the MNC to gain additional advantages from the local knowledge flow, but the MNC's research units located there help the location to improve its technological experience and its international reputation. Besides the consideration of the ownership advantages as an important factor for the firm's growth, another characteristic of the theory of technological accumulation is its allowance for interaction between the firm's ownership advantages and the location advantages (Cantwell, 1989, p. 212). When locating R&D units in international centers of excellence, the MNC improves its own competitiveness by gaining additional advantages from the local knowledge flow and technological development, however, it also helps the location with its firm-specific technological experience by increasing the competitiveness and attractiveness. Thus, these two types of advantages are highly dependent on each other and can't be analyzed separately.

Major contribution of Cantwell's model (1989)

As already discussed, Cantwell's model for analyzing the evolution of international technological competition between the major American, European and latter Japanese MNCs is based on the technological accumulation theory. The first major contribution of this model is its finding that the success of the response of European firms to the so called "*American challenge*" was largely dependent on their underlying technological capabilities. Only those European firms with strong technological capabilities were able to expand internationally and create multinational networks.

The European firms with weak technological capabilities were driven out of international markets or overtaken by other, technologically stronger European or American firms.

As we saw from the previous chapters in this work, the expansion of American MNCs in Europe in the 1950s and the 1960s helped European firms to recover from the after-war period, by motivating them to restructure their organizations and to start to innovate in those industrial sectors in which they were traditionally technologically strong. By analyzing the international technological competition between the world's largest MNCs from the 1950s up to the late 1980s, Cantwell has practically shown what the accumulation theory theoretically states, namely that the technological development of firms is a continuous and cumulative process which takes place over a longer period of time.

The second very important contribution of Cantwell's model is that it shows that intra-industry production tends to increase between countries in which firms are technologically advanced in certain industrial sectors. Therefore, the results from the analysis have shown that intra-industry production has grown, for example, between countries such as Germany and the USA and between the USA and the UK in those industrial sectors in which firms from both countries in question were technologically strong.

Major limitations of Cantwell's model (1989) and of the theory of technological accumulation

Cantwell's model (1989) suffers from several major limitations. First, it is assumed that all industries are following the trend towards internationalization and globalization, which simply does not hold for all industries. This is too simplified of an assumption. When extending the model to examine other industries than the industries considered in this analysis, it should be taken into consideration that many of them are not following this trend and are still successful and capable of surviving.

Grocery retailing is a typical example of a business for which the rules of globalization do not apply. This type of business is mostly dominated by local players (Corstjens and Lal, 2012). Statistically, when expanding globally, grocery retailing businesses have failed as often as they have succeeded (Corstjens and Lal, 2012). This is a business which mainly relies on local

customers' loyalty and local tastes for food. International R&D and global knowledge flow are irrelevant in this case. Therefore, the underlying reasons for internationalizing a grocery retailing business are more of a financial nature. There are other businesses as well for which the technology creation and innovation are irrelevant and therefore, the accumulation theory cannot be used to analyze them. In this sense, I allow myself to conclude that the theory of technological accumulation, in general, and Cantwell's model, in particular, are applicable only to large manufacturing firms.

Second, when extending the model to analyze international trade and production between MNCs from other European countries as well, it must be emphasized that the industry classification ($i = 1,2,3$) differs among different European countries. This classification depends upon the technological strengths and ownership advantages of firms from a particular country and these two parameters vary among firms from different European countries, as well as between firms from Europe and the US. The same holds if we try to extend the analysis and include some developing country in the examination as well. The process of technological accumulation differs between developed and developing countries. Many developing countries do not improve their performance and innovation rates through technological accumulation, but through imitation or adaptation of the technologies created in the developed countries. Therefore, Bell and Pavitt (1993) claim that activities such as technology creation and initial commercialization of technological innovations are concentrated mainly in developed countries, while developing countries are only involved in the process of international diffusion of technological innovations (Bell and Pavitt, 1993, p. 160). Namely, firms from developing countries simply acquire and adapt the technology created in developed countries (Bell and Pavitt, 1993, p. 160). However, during the process of technology adaptation the firms are usually required to conduct some changes and/or improvements of the acquired technology in order to use it appropriately and effectively. These small changes conducted by individual firms can be classified as incremental innovations which are usually subjective, namely are useful only for the specific-firm or for a small group of firms using the same technology. Nevertheless, even those small changes accelerate the process of technological development and are important for the technological progress in the industry. In this sense, we can conclude that the so called "adopters" can have a creative role in the overall process of technological change as well.

With respect to this critique, am I allowed to say that the theory of technological accumulation is accurate only for developed countries?

The process of technological accumulation differs not only between countries, but also between firms and industries. Bell and Pavitt (1993) identified five categories of firms, which follow different paths of technological accumulation and technical change, in order to show that the paths and patterns of technological accumulation differ between firms and industries. They found the following five different firms: supplier-dominated firms, scale-intensive firms, information-intensive firms, science-based firms and specialized supplier firms (Bell and Pavitt, 1993, pp. 178-182). Each of the five categories of firms follows a different path of technological accumulation (Bell and Pavitt, 1993, p. 178).

The supplier-dominated firms are usually active in agriculture, housing, private services and traditional manufacturing. Regarding the size, they are generally small firms and their customers are price-sensitive. Their technological activities are primarily focused in reducing production costs. In these firms the technological accumulation is mainly generated through improvements and modifications in production methods and production factors, and sometimes the improvements and the modifications might be related to product design (Bell and Pavitt, 1993, p. 178 and p. 180). The principal strategy of the supplier-dominated firms is to use the technologies which are created elsewhere in order to reinforce their own competitive advantages (Bell and Pavitt, 1993, p. 181).

The scale-intensive firms are mainly active in the production of bulk materials (steel, glass) and consumer durables, in automotive industry and in civil engineering. Their size is large and their customer base is mixed (price-sensitive and price-insensitive customers). These firms generate technological accumulation by designing, building and operating complex production systems and/or complex products (Bell and Pavitt, 1993, p. 178 and p. 180). Their strategies are focused on incremental integration of new technologies in complex systems, improvements and diffusion of best practices and exploitation of process technology advantages (Bell and Pavitt, 1993, p. 181).

Information-intensive firms are operating in the sectors of finance, retailing, travel and publishing. Their size is large and their customer base is mixed. The information-intensive firms have gained special importance after the emergence of ICT and the possibility to store, process and transfer enormous number of information digitally. Technological accumulation in these firms is generated by designing, building, operating and improving complex systems for storage, processing and transferring information (Bell and Pavitt, 1993, p. 179 and p. 180). These firms' strategies are directed to develop related products and to design and operate complex information-processing systems (Bell and Pavitt, 1993, p. 181).

Science-based firms are mainly active in electrical-electronics and chemicals. They are large firms with mixed customer base. In these firms, corporate R&D has a crucial role in the process of technological accumulation. Therefore, they are heavily dependent on academic or basic research. Science-based firms usually introduce radical and objective innovations, and open new markets through widening the spectrum of potential applications for their innovations (Bell and Pavitt, 1993, p. 179 and p. 180). Their strategies are mainly aimed at developing related products, exploiting basic science, obtaining complementary assets as well as reconfiguring divisional responsibilities (Bell and Pavitt, 1993, p. 181).

Specialized supplier firms are operating in the fields of capital goods, instruments and software. They are usually small firms with performance-sensitive customers. They focus their technological activities mainly on improving product performances in order to satisfy their advanced customers. Technological accumulation in these firms takes place through design, building and operational use of complex systems of production in the form of machinery, components, software and instruments (Bell and Pavitt, 1993, p. 179 and p. 180). The main strategic tasks of the specialized supplier firms are to observe and respond to the needs of their advanced and demanding customers and to integrate new technologies in their products in order to improve the products' performances (Bell and Pavitt, 1993, p. 181).

Third, it is too simplified to assume that in the first industry ($i = 1$), where US firms are technologically stronger than the European firms) European MNCs never establish production facilities in the US. It is also quite incorrect to conclude that in the second industry ($i = 2$),

where European firms are technologically stronger than the US firms), the international production of the US firms completely disappear.

This critique is not directly related to the accumulation theory, but it is moreover about the negative consequences that the global integration might have on certain countries. Because of the different level of technological development between developed and developing countries, MNCs will always choose the developed countries as locations where they can settle their R&D operations. Therefore, the developing countries will always be in an unfavorable position compared to the developed countries, because of their weak education systems, poor infrastructures, unstable political situations, etc. As a result of the asymmetric investments, firms from the developing countries might never get the chance to improve their positions and to become technological leaders. Furthermore, there is a high possibility that they can never create the advanced knowledge to initiate technological change and will always stay in a position in which innovation creation will be inferior.

This further critique on the global integration is related to the enormous power (political, social, financial) that big MNCs are enjoying nowadays. With such a power and such close integration, they are becoming very hard to control. Moreover, they are able to dictate the political situation in many countries in accordance with their needs. However, the governments are the ones who are responsible to find a balance between the interests of the individuals and the interests of the corporations. They are obligated to prioritize the individuals and their rights over the needs of the corporations. Among other things, they are also responsible to protect the environment from pollution and with legal policies to support the firms in innovations that will make the production processes more environmentally friendly. If we consider the government as a corrector of a possible market failure, then its policy intervention can be justified and to some extent indispensable. Government policies should control the direction of technological change in a way that would be beneficial for all participants in the market.

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Appendix

Table 1. The share of US patents of the world's largest firms attributable to research in foreign locations (outside the home country of the parent company), organized by the nationality of parent firms, 1969-1995 (%)

	1969-1972	1973-1977	1978-1982	1983-1986	1987-1990	1991-1995
USA	4.96	5.89	6.40	7.53	7.91	8.62
Germany	12.77	11.05	12.07	14.47	17.05	20.72
UK	43.08	41.24	40.47	47.09	50.42	55.79
Italy	13.39	16.03	13.85	12.59	11.14	16.47
France	8.16	7.74	7.17	9.19	18.17	33.17
Japan	2.63	1.88	1.22	1.26	0.92	1.08
Netherlands	50.40	47.37	47.65	53.99	53.96	55.69
Belgium	50.00	54.24	56.27	71.21	56.04	67.25
Switzerland	44.36	43.63	43.78	41.59	42.99	52.47
Sweden	17.82	19.90	26.20	28.94	30.60	42.42
Canada	41.19	39.30	39.49	35.82	40.12	43.96
Total	10.04	10.53	10.50	10.95	11.28	11.27
Total (excl. Japan)	10.51	11.74	12.31	13.97	15.71	16.48

Source: Cantwell and Harding, 1998, p. 101

*Note: The reason for the moderate increase in the overall internationalization of technological activity during the period from 1969 to 1995 is due to *"compositional shifts in the make-up of total patenting across firms and the rising share in total corporate patenting of Japanese and Korean firms, which as yet are on average little internationalized in their technological development, and their greater contribution to the total has therefore acted to pull down the global average foreign share"* (Cantwell and Harding, 1998, p. 102).

Table 2. The share of US patents of the largest German firms attributable to research outside Germany, organized by the industrial group of parent firms, 1969-1995 (%)

	1969-1972	1973-1977	1978-1982	1983-1986	1987-1990	1991-1995
Chemicals	19.71	18.22	18.31	18.96	22.05	24.95
Pharmaceuticals	10.45	9.71	14.71	17.81	19.32	27.76
Metals	12.26	5.49	6.48	7.28	7.70	9.17
Electrical equipment	3.51	4.47	7.34	15.74	18.74	28.02
Motor vehicles	3.91	3.73	3.39	12.26	16.53	8.03
Total	12.77	11.05	12.07	14.47	17.05	20.72

Source: Cantwell and Harding, 1998, p. 102

Table 3. US patents of the largest non-German firms attributable to research in Germany, as a proportion of non-German firms patenting due to research in all foreign locations, organized by the industrial group of parent firms, 1969-1995 (%)

	1969-1972	1973-1977	1978-1982	1983-1986	1987-1990	1991-1995
Chemicals	9.29	13.77	16.57	18.97	15.55	14.48
Pharmaceuticals	5.11	9.86	9.31	9.09	7.91	7.09
Metals	15.95	22.48	25.00	27.57	29.69	24.13
Electrical equipment	22.97	25.13	29.21	33.41	28.94	22.15
Motor vehicles	25.26	29.12	26.50	31.70	30.99	23.38
Total	13.63	16.50	18.30	21.11	19.30	15.39

Source: Cantwell and Harding, 1998, p. 105

Table 4. Patenting activity attributable to European-located foreign-owned research, across host countries, 1969-1995 (%)

	Total patents from foreign-owned facilities					
European host country	1969-1972	1973-1977	1978-1982	1983-1986	1987-1990	1991-1995
Germany	27.03	30.23	31.81	35.63	33.47	28.87
UK	29.34	26.78	25.03	22.63	21.00	21.15
Italy	4.34	4.94	4.37	4.50	5.97	6.46

France	13.21	14.95	14.52	14.21	14.92	15.60
Rest of Europe	26.08	23.10	24.27	23.03	24.64	27.92
Total Europe	100.00	100.00	100.00	100.00	100.00	100.00

Source: Cantwell and Piscitello, 2000, p. 23

(Original source: US patent database developed by John Cantwell at the University of Reading, with the assistance of the US Patent and Trademark Office)

Table 5. US patents from corporate research located in each host country due to foreign-owned firms, by the industrial group of the parent company, 1969-1995 (%)

Sector	Germany	UK	Italy	France	Europe	World
Food, Drink and Tobacco	99.64	15.45	100.00	55.25	44.55	22.24
Chemicals	6.49	29.55	31.97	33.31	15.57	14.21
Pharmaceuticals	13.91	50.34	100.00	19.34	27.37	16.16
Metals	9.87	29.62	63.87	11.20	13.25	10.32
Mechanical engineering	25.84	47.16	100.00	52.00	26.93	12.47
Electrical equipment	30.01	43.48	91.32	27.85	30.48	9.74
Office equipment	86.34	76.71	21.87	56.76	67.36	10.34

Motor vehicles	8.35	13.18	7.67	21.83	12.28	5.68
Aircraft and Aerospace	15.18	10.54	100.00	2.85	13.00	2.39
Coal and Petroleum products	80.47	19.43	12.07	10.31	39.25	15.08
Professional instruments	29.90	97.79	100.00	100.00	45.62	3.37
Other manufacturing	56.64	26.71	26.13	30.66	35.16	10.39
Total	16.87	33.73	36.60	25.86	23.97	10.81

Source: Cantwell and Piscitello, 2000, p. 23

(Original source: US patent database developed by John Cantwell at the University of Reading, with the assistance of the US Patent and Trademark Office)

Table 6. Share of US patents of the largest Japanese-owned firms attributable to research outside Japan, classified by technological activity, 1969-1995 (%)

Sector	1969- 1972	1973- 1977	1978- 1982	1983- 1986	1987- 1990	1991- 1995
Chemicals	1.67	1.29	1.74	1.87	0.84	1.02
Inorganic chemicals	5.45	0.57	0.00	1.33	0.00	0.00
Agricultural chemicals	0.00	0.00	0.00	2.82	1.04	1.10

Chemical processes	2.53	2.24	1.71	1.50	0.95	0.75
Bleaching and dyeing processes	0.00	0.00	0.00	0.00	0.00	11.63
Other organic chemicals	0.83	0.63	2.01	1.14	0.74	1.36
Pharmaceuticals	0.47	0.47	0.52	1.29	1.23	2.48
Mechanical engineering	4.24	1.71	1.00	0.95	0.83	0.82
Chemical and allied equipment	10.19	3.23	1.34	1.13	0.64	0.94
Metal working equipment	3.95	1.17	0.25	0.60	1.03	1.22
Assembly equipment	4.98	1.68	2.30	1.12	1.57	0.47
Mining equipment	0.00	10.00	14.29	0.00	0.00	14.29
Specialized industrial equipment	0.83	1.74	1.20	1.44	1.02	1.67
General industrial equipment	1.56	0.50	0.20	0.71	0.48	0.32
Electrical equipment	1.65	2.04	1.28	1.21	0.76	1.14
Telecommunications	1.43	2.37	1.80	1.72	0.65	1.45
Image and sound equipment	1.71	4.42	1.93	2.15	1.59	2.18
Electrical systems	2.01	1.04	0.87	0.89	0.57	0.77
General electrical equipment	1.80	1.95	1.13	0.40	0.33	0.58
Semiconductors	0.44	0.86	0.65	1.58	0.55	0.62
Office equipment	2.34	5.16	1.66	1.74	1.76	1.52

Motor vehicles	0.73	0.70	0.68	1.21	0.50	1.01
Aircraft	0.00	0.00	0.00	0.00	0.00	7.69
Professional and scientific instruments	2.07	1.60	1.17	1.31	0.81	0.58
Photographic instruments	0.81	2.15	0.75	1.36	0.31	0.06
Other instruments	2.74	1.30	1.41	1.30	1.01	0.81
Total	2.62	1.87	1.22	1.26	0.92	1.08

Source: Cantwell and Zhang, 2006, p. 258

(Original source: US patent database developed by John Cantwell, with cooperation of the US patent and Trademark Office)

List of the 27 industries included in the examination (according to Cantwell, 1989, p. 26)

1. Food products
2. Chemicals
3. Synthetic resins
4. Agricultural chemicals
5. Cleaning agents
6. Paints
7. Pharmaceuticals
8. Ferrous metals
9. Non-ferrous metals
10. Fabricated metal products
11. Mechanical engineering
12. Agricultural machinery
13. Construction equipment
14. Industrial engines

15. Electrical equipment
16. Transmission equipment
17. Lighting and wiring
18. Radio and TV receivers
19. Motor vehicles
20. Shipbuilding
21. Transportation equipment
22. Textiles and clothing
23. Rubber products
24. Non-metallic mineral products
25. Coal and petroleum products
26. Professional instruments
27. Other manufacturing

Source: Cantwell, 1989, p. 26

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