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Kenan Rahimic

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Abstract

One of the fundamental questions in strategic management is how firms achieve and maintain competitive advantage. In today's dynamic and turbulent business environment it is important to understand why some companies are having better results and some not, even though they are in the same industry and market. In this paper processes for achieving and keeping a long-term market and competitive position will be represented relying on existing researches and (chosen) management theories such as the industrial organization theory, resource based view, evolutionary theory and dynamic capability theory that will be used in analyzing the specificity of the Red Queen effect and ways of its development. Innovation and imitation will be further considered as the main principle of the Red Queen effect and we will cover their advantage and disadvantage in today's dynamic business environments (first mover or follower), which triggers organizational learning. The empirical research will analyze the effects of company's strategic orientation for innovation or imitation in the Smartphone industry, their market position and success of (popular) companies. Therefore, we will try to identify the Red Queen effect in the Smartphone industry, which is considered as a relatively young and fast growing industry. In the end different limitations of this subject area will be examined and identified, which should help researchers and students in their decision where to steer future research regarding the Red Queen effect. The future research should focus especially on the dynamic smartphone industry, where even today many scientific papers cover this topic and more are expected to do so in the future.

Key words: smartphone industry, smartphones, co-evolution, Red Queen, innovation and imitation

Abstrakt

Eine der grundlegenden Fragen des strategischen Managements ist es, wie Unternehmen ihre Wettbewerbsvorteile erreichen und halten. Im heutigen dynamischen und turbulenten Geschäftsumfeld ist es wichtig zu verstehen warum einige Unternehmen bessere Ergebnisse erhalten und andere nicht, auch wenn sie in der gleichen Branche und Markt tätig sind. In dieser Arbeit werden Prozesse zum Erreichen und Halten einer Wettbewerbsposition präsentiert, die am bestehenden Forschungen und (ausgewählten) Theorien anknüpfen wie der Industriellen Organisationstheorie, Ressourcen-basierte Theorie, Evolutionäre Theorie und die Theorie der dynamischen Fähigkeit. Sie werden benutzt um die Spezifitäten des Red Queen Effekts und Arten seiner Entwicklung zu analysieren. Innovation und Imitation werden als Hauptprinzipien des Red Queen Effekts in Betracht gezogen und wir werden ihre Vor- und Nachteile in heutigen dynamischen Geschäftsumgebungen abdecken (Firstmover oder Follower), welches organisatorisches Lernen auslösen. Die empirische Forschung wird die Auswirkungen der strategischen Orientierung des Unternehmens für Innovation oder Imitation in der Smartphone Industrie, ihre Marktposition und Erfolg (von populären) Unternehmen analysieren. Daher werden wir versuchen den Red Queen Effekt in der Smartphone-Industrie zu identifizieren, die eine relativ junge und schnell wachsende Industrie ist. Am Ende werden unterschiedliche Einschränkungen dieses Themenbereichs untersucht und identifiziert, die Forschern und Studierenden helfen sollen um zukünftige Forschung in Bezug auf den Red Queen Effekt zu lenken. Insbesondere sollte sich zukünftige Forschung auf die dynamische Smartphone Industrie konzentrieren, in der bereits heute viele wissenschaftliche Arbeiten abgelegt wurden und in der Zukunft noch viele weitere erwartet werden.

Schlüsselwörter: Smartphone-Industrie, Smartphones, Koevolution, Red Queen, Innovation und Imitation

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1. Introduction

One of the greatest industries that most companies are fighting for is the smartphone industry. It is one of the fastest changing industries where due to new technologies and rapid innovative processes the whole structure is able to change in a very short period. Other industries that potentially could offer substitutes are strongly affecting the life cycle of that particular product and the whole creation process can become obsolete quickly. According to mentioned information it is concluded that the smartphone industry is very risky and has a volatile environment, which can be seen as running against time. In the several years that this industry exists, only strongest companies survived and still they have fierce competition. As the time is very precious in such environment, followers have the major goal to imitate as fast they can whereas innovators are using different methods to protect their products.

Due to the dynamic environment and fast reaction of managers, in this thesis processes, methods of survival and its effects will be covered together with the question whether the Red Queen effect is experienced in young and fast growing. In this case the smartphone industry was taken as the fastest growing and most competitive IT segment, where as well the mutual awareness of companies in that industry will be observed through co-evolutionary processes. This observation will be made using the data from official sources regarding performance evolution of particular characteristics in the smartphone that will be covered in the empirical research part. Many researchers and economists always made the question, why some companies perform better than others having identical conditions. This segment will be answered by observing the most popular theories starting from the evolutionary theory suggesting that companies should constantly develop and adapt to changes, which is most optimally done with innovation. However, as companies do not want to be left behind they will do anything to survive and the best way is through imitation, where saved resources from research and development can be used in other segments in order to gain advantage. Both cases have their advantages and disadvantages that will be covered firstly in the theoretical part and later in the empirical research, where it will be considered whether it is better to be the first mover or late mover in the smartphone industry.

In economics, competitive structure in an industry is the basics for deciding what strategic decision to make. Due to ever growing turbulences and volatilities in the environment, many managers are starting to distrust created tools and instruments from reputable economists that have been actually created for these purposes in the first place. However, theories are still there to help managers and they should be used, but it is important to know weaknesses and risks each theory carries. As these tools and instruments are still applied, they help us to analyze the smartphone industry in the most optimal way and what effects can possibly arise, i.e. the Red Queen effect.

It is specified that the Red Queen effect is a situation where companies have to run much faster just to hold their existing market position and run even faster if they want to improve it. This running is understood as increasing efficiency and achieving economy of scale that in turn will lower their costs, allowing companies to reduce prices of their products. However, this can lead to so called price wars and unnecessary elimination of *cream skimming* that might be only optimal in the short-run, whereas differentiation or innovative activities have better effects in the long-run. Therefore, companies in Red Queen competition mainly engage in innovative processes that can on the other side pressure its competitors to perform even better and punish the focal company for engaging into certain improvements leading to the *creative destruction* effect, meaning that such strategy can backfire to the focal firm. Hence,

as it is in the nature with the predator and prey, the Red Queen effects indicates that performance of animals, companies or products will increase in absolute terms but will stay equal in relative terms. Having so many problems and different options available for managers makes this topic attractive in today's dynamic and turbulent environment, with fierce competition and challenging customers that demand for high quality and low priced products.

1.1. Problem and the subject of research

The subject of this research is way of doing business and strategic market positioning of companies producing and placing smartphones. Goal of each company is and should be development and long term establishment of competitive advantages. In the literature we find four generic strategies (efficiency, quality, innovativeness, customer responsiveness) that help companies to achieve competitive advantages. Taking into consideration the specificity of this branch, special focus of this thesis will be the analysis of innovativeness and customer responsiveness. The fact is that in this industry there are many companies that are proactive and try to continuously innovate their products, services and business processes together with their strategic orientation.

1.2. Goals and hypothesis of research

The main goal of this research is to show theoretically and practically show the importance of evolutionary effects in industries, specifically the Smartphone industry. Such evolutionary effects depend on the availability of resources whose scarcity varies between different company life cycles. In the beginning companies have vast amount of resources while in the maturity period they become scarce and companies start to engage in company wars. These wars are made in order to create competitive advantages where companies start to realize that price war (produce cheaper) is not enough. Therefore, companies start to innovate or imitate depending on each benefits that will be covered in the paper as well, and the question is it better to be the first mover (innovate) or follower (imitate) will be answered. Through different theories the importance of resources will be explained and the Red Queen effect will be observed in the Smartphone industry.

Therefore, following goals of this thesis are shown:

- Show the process of creating sustainable long-term competitive advantages relying on current and chosen management theories
- Analyze the Red Queen effect (RQE) and methods of its achievement from the angle of chosen theories: evolutionary theory, industrial organization theory, resource based view and dynamic capability theory
- Show the importance of organizational learning for holding and improving company market position
- Show the importance of innovation for company success in today's dynamic and uncertain environment, explaining benefits and restrictions of innovation / imitation (first mover / follower)
- Analyze the effects of company strategic orientation for innovation or imitation in the smartphone industry and the success of popular companies
- Try to identify co-evolutionary processes and the Red Queen effect in the smartphone industry as a fast growing and young industry.

Given the existing frameworks within which main contribution comes from disciplines such as international management, human resource management, macroeconomics and psychology, in this thesis for the necessity of empirical research one primary and five supporting hypotheses were created based on the above defined problem and subject of the research.

The primary hypothesis is:

Strategic orientation of the company for innovation or imitation directly affects their product performance improvement.

The hypothesis is tested based on acquired secondary online data of globally known smartphone companies and brands regarding specifications and performances of models they offer.

From the primary hypothesis other supporting hypothesis can be derived:

- Action / reaction speed considered through number of innovation positively affects company success
- First movers actions will affect other companies to follow (observed through product performances)
- Ignoring movements of competitors (especially first movers) leads to stagnation and drop in company product performance
- Continuous increase (quality, performance, design, etc.) enables companies to hold their relative position in the market
- Taste of customers rather than technological improvement affects the creation of the product dominant design

1.3. Research methodology

During the analysis and interpretation of theoretical segments of this thesis, an analysis of existing scientific research on similar and other internationally connected topics will be done. Also, different sources of domestic and foreign literature were used - books, articles, journals, internet and other sources together with other relevant literature as well.

Besides the above, following methods are used as well:

- Method of analysis - used to analyze terms and different theories about the research subject.
- Method of comparison - used during comparison of chosen globally known smartphone manufacturers.
- Method of description - describing facts related to the research subject.
- Method of induction - for forming a conclusion and opinion related to the research subject.
- Method of deduction - helps to find conclusions based on consideration of relevant and available data.
- Method of confirmation - used during the main hypothesis confirmation especially during the empirical part of this thesis, where based on detailed analysis the necessity for confirmation of the main and supporting hypotheses will be observed.
- Statistical method - used in the empirical part. Major goal is through analysis and graphical presentations to check the accuracy and truth of observed results. Programs used for such analysis were Microsoft Excel and SPSS.

- Secondary data usage - means gathering, aggregating and data processing from secondary sources available on the internet, journals and publications.
- Theoretical work on the literature - using different papers from the research area.

1.4. Structure and composition

The thesis consists of six segments: 1) introduction, 2) theoretical frameworks for strategic market positioning, 3) the Red Queen effect, 4) innovation and imitation, 5) research results and 6) conclusion.

In the **first chapter**, introduction, problems and the subject of research will be defined, defined, together with the research purpose and objectives, setting the main and supportive hypothesis, and indicate the most important scientific and research methods that will be used to display the thesis structure of this thesis. In the next section the topic of different theoretical frameworks for strategic market positioning, their evolution, as well as advantages and disadvantages will be covered.

In the **second chapter**, theoretical framework for strategic market positioning will be covered regarding all methods for companies to achieve sustainable competitive advantage. Further, evolutionary theory covered is used to explain all economic processes that at the same time are connected to Darwinian connotations. Goal of this theory is that nothing in the nature works by design and it is also the case in economics, where companies should not wait and expect a problem to be solved alone or that something happens by itself. However, it suggests that it has to be gradually worked on the environment, industry and its institutions characterized with evolutionary and not radical changes. Next is the international organization theory that is in more detail explained with Porter's five forces (industry attractiveness) model and his generic strategies by which the importance of differentiation will be covered. In this theory researchers suggest that companies should find attractive industries that should provide high profits. However, extension of this theory is the resource based view that is focused mainly on internal company resources and their importance, but not exogenous factors that affect a company. These resources alone are not enough, which leads to development of the dynamic capability theory that suggests creation of core competences through applying resources and company capabilities in the right way. With this theory, historical development of understanding why companies create profits in certain situations and the possibility of achieving competitive advantage that should help a company surpass or just survive competition is represented. Through this, the importance and impact of Red Queen processes in a market are explained.

In the **third chapter**, the Red Queen effect will be covered starting from the term up to its development and discovery in different scientific areas. Further, its discovery in business processes will be covered in detail, where for companies it takes all the running they can do just to remain at the same place. Such running is considered as working harder whereas the most optimal solution would be to innovate. Engaging in innovative processes, the Red Queen competition can create creative destruction, which means that competitors react to actions of the focal company much stronger and they want to punish that company for creating the "first wave". Therefore, companies become mutually aware of each other and co-evolutionary processes are activated, which is easily explained using the case from the animal kingdom i.e. fox and rabbit. Similar situation is in business where there are predatory companies that want to eliminate the pray but the result is that the pray will become better and stronger, creating a

spiral effect. In the end the case is that in absolute values companies have increased performances while in relative terms everything remained constant.

In the **fourth chapter**, innovation and imitation as important factors of the Red Queen will be covered with all its importance and constraints. Companies use innovation as a strategy where by providing new technologies, services or products they differentiate from competitors, which may increase their customer base. However, companies should offer customers everything they seek, wish and need for. On the other side, companies in order to survive next to innovative ones are using another strategy known as imitation. It gained popularity in recent periods as it has been seen that it provides a variety of benefits and as well improves firstly innovated products. Still in minds of customers, imitators provide goods of lower quality and they are not good as the original products, which is not necessarily the case in most of situations.

Further in the **fifth chapter**, the smartphone industry, development of smartphones and empirical results will be discussed in detail. Firstly, explanation of how data was retrieved for research purposes and what difficulties were faced in this process. In the end through discussion we will make conclusions that arise from taken data and create a broader picture of the theoretical part in order to understand what is happening in this young and dynamic industry. Also instruments and sample characteristics used in research will be analyzed, after which results will be shown.

Finally, in the **conclusion**, research results will be systematically and concisely presented. Also, possible implications and research limitations will be mentioned, as well as recommendations for future research in this particular field.

2. Theoretical frameworks for strategic market positioning

We are witnessing major changes in the business environment which creates a necessity for continuous managerial reaction. Starting from the fact that industries today are characterized as dynamic, fast and with continuously changing technology, economists have focused their research to find common rules of behavior in specific situations, as well as preparation processes and methods to achieve competitive advantage that in the long-run should be sustainable. Also, the goal of increasing market share and attracting customers, which can be achieved through productivity, quality and fast reaction, had led different managerial tools and techniques to existence. These tools and techniques are constantly evolving and nowadays is a trend of combining academic discipline and management experience to get best possible theories.

In the following chapter evolutionary development will be explained starting from older times until the moment where modern evolutionary theories were created. This interesting process of theory creation will be explained further with the original evolutionary theory and then traditional economics that is in the end changed toward dynamic capability theory. It is also interesting to observe how as time passes, different characteristics of the business environment change and some theories are forgotten. This was the case with sudden appearance of the industrial organization model that specifies only the importance to find an attractive industry and integrate to given borders. As time changed and different needs appeared, researchers introduced the resource based view that is considered as the transitioning period to the latest dynamic capability theory.

2.1. Evolutionary theory

Continuous endogenous change in an open system is called evolution and its roots come from Darwin, in his book *The Origin of Species* published in 1859. As part of this thesis name, evolutionary economics is one of the most hopeful and important developments in modern economics. As it is Darwin for biology so are Adam Smith, Karl Marx, Carl Menger, Alfred Marshall, Thorstein Veblen, Joseph Schumpeter and Friedrich Hayek for economy. The term evolutionary economics as it could be realized from above is adopted out of Darwinian ideas coming from biology. Above mentioned economists have one in common and it is that their research is focused on economic change and transformation. They do not consider technology, institutions or organizational knowledge to be given, but it has to be gradually worked on them so they emerge and develop over time. In other words, just like in the nature where nothing exists and works by design, these complex phenomena are a result of competitive selection and self-organization also known as survival of the fittest.¹

Thorstein Veblen was the first that used the term evolutionary economics which was not taken seriously in that period and is not universally adopted since.² The problem further he was encountering was that even as one of the founders of the original institutional economics, his work became extremely unpopular and the word evolution in this context had no connection to Darwinian connotations.³ Evolution as a word later got its importance with help of Joseph

¹Hodgson, G. M. (2012) *Evolutionary Economics*. University of Hertfordshire Business School: 2 (<http://www.eolss.net/sample-chapters/c04/e6-28-31.pdf>) (access: 15. 01. 2016.)

²Thorstein, B. V. (1898) Why Is Economics Not an Evolutionary Science? *Quarterly Journal of Economics* 12(3): 373-397.

³Hodgson, G. M. (2004) *The Evolution of Institutional Economics: Agency, Structure and Darwinism in American Institutionalism*. London and New York: Routledge; Rutherford, M. H. (2011) *The Institutional*

Schumpeter who understood the significance of this term.⁴ However, evolution did not appear as a Darwinian term during his time, and his work was mostly focused on entrepreneurship, innovation and technological changes as the key factor of successfully doing business. Significant influence on evolutionary economics comes from the Austrian school of economics with above mentioned well known economists such as Menger, von Mises and Hayek. Theory of Menger, the *emergence of money* theory is suggested to be evolutionary because in that manner he tried to understand the development and emergence of institutions.⁵ However, Hayek made an even stronger influence on evolutionary economics where he gives credit to Darwinism as a stage of evolutionary thinking and not as intellectual revolution.⁶ Thus, in his work parallels are drawn between evolution in the society and nature.⁷

Evolutionary economics is not just something that is connected to the Darwinian gloss in the competitive sense as survival of the fittest. It is a misconception that Darwin was the first who used evolution as term and it was not observed the first time in the Galapagos Islands, but it finds its beginning in the Scottish and European 18th century society by Voltaire, Vico, Montesquieu, Smith and Hume.⁸ The observation was in the economic segment through work processes but later in the 19th and 20th century, Darwin and his followers observed these phenomena in the nature. Today it experiences rapid growth in its application starting from psychology, politics, and physics, up to computation.⁹ Besides the traditional mainstream economic theories, others have evolved to evolutionary economics and institutional economics. General difference is that traditional economics focuses on potential decision making within structures that are given. This means that limitations and borders of structure are shaped, indicating that also production methods and institutional configuration are given, as it is the case with the industrial organization theory. On the other side, evolutionary economics covers dynamic and long-term changing processes of the economic structure which is observed through development of different technologies and organization, such as in the dynamic capability theory. Austrian school and especially Schumpeter represent a great connection to today's modern economic theories having differentiation, complexity and uncertainty as key issues. Schumpeter stressed the importance of entrepreneurs and their general influence on the economic structure through innovative activities and further calling them the real innovators.

Hayek suggested that governments cannot or should not even try to make order in the evolutionary market. Therefore, the evolutionary market will have different outcomes emerging from decentralized decision making, where the market behaves organic and creates

Movement in American Economics, 1918-1947: Science and Social Control. Cambridge University Press, Cambridge and New York

⁴Schumpeter, J. A. (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, translated by Redvers Opie from the second German edition of 1926, first edition 1911 (Cambridge, MA: Harvard University Press). 57-58., from Koruna, S. (1999)

⁵Menger, C. (1871). *Grundsätze der Volkswirtschaftslehre*, 1st edition, English publication (1981) as *Principles of Economics* (New York: New York University Press)

⁶Hodgson, G. M. (1993) *Economics and Evolution: Bringing Life Back into Economics*. Cambridge, UK and Ann Arbor, MI: Polity Press and University of Michigan Press: 1-15.

⁷Hayek, F. A. (1967) *Notes on the Evolution of Systems of Rules of Conduct*. from Hayek, F. A. (1967) *Studies in Philosophy, Politics and Economics*. London: Routledge and Kegan Paul: 66-81. (<http://www.eolss.net/sample-chapters/c04/e6-28-31.pdf>)

⁸Potts J. (2003) *Evolutionary Economics - An Introduction to the Foundation of Liberal Economic Philosophy*. School of Economics, University of Queensland, Australia: 2.

⁹For example, Barkow J., Cosmides L. and Tooby, J. (1992) *The Adapted Mind*. New York, Oxford University Press; Rubin P. (2002) *Darwinian Politics: The Evolutionary Origin of Freedom*. New Brunswick, Rutgers University Press; Mitchell M. (1995) *An Introduction to Genetic Algorithms*. Cambridge, MA, MIT Press

internal harmony by itself, which will be unpredictable and unintended.¹⁰ Today's business environments are getting more dynamic and turbulent, which is the reason of greater variety of economic activities and institutional structures. All of this leads to even more complexity by new technologies, new locations, new institutions, new organizations and innovative activities that change the environment.¹¹ All of them can be affected by the environment according to the evolutionary theory but in a very hard to predict way. Evolutionary economics can be also considered as a competitive race in order to achieve certain profit opportunities that can be achieved by innovation and fast reaction speed, keeping them in front of rivals.¹² This idea led to the introduction of Red Queen hypothesis and competition characterized by innovation and speed, creating an arms race among competitors in that industry that will be in more detail explained in chapter three.

2.2. Industrial organization theory

Industries mainly differentiate in profit potential for companies that also vary in different time periods. Therefore, it is important to analyze the industry by forecasting industrial average profitability and competitor future movements. Just as in most life situations, the industry profitability is affected by factors coming from inside (endogenous) such as product price elasticity and technology used in production processes, as well as factors coming from outside (exogenous) such as the industry structure, concentration ratio and different company strategies.

As the global business environment became more competitive, researchers started to consider market structure and the way it behaves, which should affect company strategy and decision.¹³ The idea of the company positioning between competition and their interaction was the first idea of the industrial organization theory suggested by Alfred Marshall in the 18th century.¹⁴ Further, in the 30s a hypothesis, developed and analyzed by Edward H. Chamberlin in his book called *The Theory of Monopolistic Competition*, says that unique industry structure shapes and influences company performance. This hypothesis coming from Harvard University was taken, further developed and generalized in the 50s by Joe S. Bain Jr. who focused mainly on market entry barriers and potential threat of competitors, creating his well-known Structure, Conduct and Performance (SCP) paradigm.¹⁵

Bains paradigm describes long-term strategically generated profits (performances) on the one side over industry structure where the company is doing business, and its strategic behavior on the other side. Such specific and strategic behavior in an industry helps companies to achieve sustainable competitive advantages by positioning themselves adequately in attractive market niches.¹⁶ Great contribution has been made by all above mentioned researcher, but the

¹⁰Wegner, G. (1997) Economic Policy from an Evolutionary Perspective: A New Approach. *Journal of Institutional and Theoretical Economics* 153: 163-509.

¹¹Lambooy, J. G. and Boschma, R. A. (1998) Evolutionary Economics and Regional Policy. *38th Congress of the European Regional Science Association*, Vienna: 17.

¹²Nelson, R. R. and Winter, S. G. (1982) *An evolutionary theory of economic change*. Belknap Press.

¹³Ramsey, J. (2001) The Resource Based Perspective, Rents, and Purchasing's Contribution to Sustainable Competitive Advantage. *Journal of Supply Chain Management* 37(3): 38-47.

¹⁴Corley, T. A. B. (1990) Emergence of the theory of industrial organization, 1890-1990. *Business & Economic History* 19: 83-92.

¹⁵Barthawal, R. R. (2010) *Industrial Economics: An introductory textbook*3. New Delhi: New Age International Publishers: 6.

¹⁶Mintzberg, H., Ahlstrand, B. and Lampel, J. (1999) *Strategy Safari: Eine Reise durch die Wildnis des strategischen Managements*. Wirtschaftsverlag, Ueberreuter, Wien/Frankfurt

greatest comes from Michael E. Porter whose managerial tools will be in detail explained in the next section.

2.2.1. Porter's industry attractiveness model

Most important theoretician and representative of this school is Harvard professor and prominent economist Michael E. Porter, who developed the industry attractiveness and company positioning model. In order to achieve competitive advantage the company has to take an attractive position in the industry where it is doing business. Therefore, analysis of industry attractiveness and company behavior is done with the so called five forces model by separating the industry into its components and he suggests that having long-term industry profitability is achieved by having these five components in the most optimal way.

The five forces contain the following:

- threat of new entrants - situation where potential new market entrants threaten existing companies. These new companies are willing to take over that industry by introducing new technologies, resources and fresh capacities. However, as the market share and profitability of existing companies might be affected as well, prices and quality of their products will possibly experience certain change. Thus, companies doing business in industries with high entry barriers have the chance to increase profits without any disturbance, and entry barriers are created mainly by the following: economy of scale, required capital, access to distribution channels, governmental influence, product differentiation and high sunk costs¹⁷
- industry rivalry (consolidated vs. fragmented industries) - market players are dependent on each other and in the end scarce resources force them to battle. The worst situation is when companies start to have price wars, where they cut product prices to that point where they start to hurt themselves, and automatically reduce revenues. However, in order to prevent such situation it requires effort to hold the industry structure as it is, than to pursue small personal interest that in the end reduces industry profitability.
- bargaining power of buyers - obviously buyers are competitors in the industry as well. They compete by pushing product prices down and demanding greater quality that increases the war and gap between suppliers. In order to reduce their bargaining power, the best way for companies is to start producing differentiated products with greater value and scarcity.¹⁸
- bargaining power of suppliers - on the other side if suppliers have greater bargaining power it forces products to be more expensive. Also, when suppliers have power they can provide products with worse quality in order to reduce their own production costs. Therefore, the best solution to lower their bargaining power is to find other new sources or take-over the production process.¹⁹
- threats of substitutes - industries with many substitutes have reduced profitability and attractiveness. Thus, it can be concluded that before substitutes have been introduced by new entrants, the industry had most likely been very attractive. Therefore, the solution against substitutes is to create brand value and establish networking effects that in the end should build-up switching costs.

¹⁷Porter, M. E. (1980) *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press, New York: 7.

¹⁸Hollensen, S. (2011) *Global Marketing: A decision-oriented approach*. Financial Times Prentice Hall: 111.

¹⁹Porter, M. E. (1980) *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press, New York: 27.

Each of these five factors of competition puts pressure on prices and costs that in turn affect end profits and competitive strength of the company.²⁰ Companies doing business in industries with large entry barriers, small number of companies and high product differentiation are considered to have greater returns than companies in industries with opposite characteristics.²¹ Therefore, doing business in industries with high competition intensity, high bargaining power of buyers and suppliers, high threat of new entrants in the market and high substitute level is putting pressure on the company to reduce prices and develop new products or product attributes by additionally investing into technology improvement just to remain competitive. Therefore, if all five competitive forces have low effects, companies have the power to increase prices and earn greater profits without being forced to additionally invest into technology.

2.2.2. Porter's generic strategies

Moving the point of view from many companies to a single one, the question is made how competitive advantages can be achieved. This model enables companies to shape industry structure and influence industry attractiveness through its strategy. In order to achieve better results and develop competitive advantage, the company should be able to change its position in an industry, analyze its competitors and market structure where once more Porter developed a framework of generic competitive strategies. While the five forces model tries to explain competition differences between industries, the competitive strength inside an industry depends from its chosen strategy.²²

Figure 1. Porter's generic strategies

		COMPETITIVE ADVANTAGE	
		Cost	Differentiation
COMPETITIVE SCOPE	Broad Target	1. Cost Leadership	2. Differentiation
	Narrow Target	3. A. Cost Focus	3. B. Differentiation Focus

Source: Porter (1985)²³

The identified three generic competitive strategies can be concisely explained in the following way:

- Cost leadership is a strategy where the company tries to achieve competitive advantage by becoming the low-cost producer. Following this strategy the company can take a large market share and produce efficiently by lowering unit average costs and offering these products for lower prices. In such industries, price wars may easily

²⁰Porter, M. (1999) Wettbewerbsvorteile - Spitzenleistungen erreichen und behaupten. Frankfurt/New York: 25-36.

²¹Barney, J. B. (1986) Organizational culture: can it be a source of sustained competitive advantage? *Academy of Management Review*: 656-665.

²²Porter, M. (1999) Wettbewerbsvorteile - Spitzenleistungen erreichen und behaupten. Campus Verlag, Frankfurt/New York: 95-222.

²³Porter, M. (1985) *Competitive Advantage: creating and sustaining superior performance*. Free Press, New York: 12.

occur and the company with cost advantage will be able to survive, bringing its competitors in a bad position that could lead to their elimination.

- Differentiation is a strategy in which the company by providing additional value and uniqueness for its customer tries to be more attractive. To differentiate goods and services the company can offer better performance, quality, design or other attributes. Such uniqueness of goods and services forces the company to charge higher prices and margins due to greater cost pressure. However, additional costs and higher (premium) prices are not proportionally increased, which leads to above average profits. Also, companies after providing goods and services with additional value such as reliability, high quality and uniqueness in turn get loyal customers which have positive implications.
- Focus is a strategy where the company specializes in cost leadership or differentiation in a small market niche within the industry. The company selects a customer segment and focuses to serve better than other companies. Therefore, competitive advantage is achieved in a relatively small part of the industry and benefits are enjoyed on a relatively small scale.

These strategies show the process how companies are gaining competitive advantage in their market. It is important for them to choose one, either cost leadership or differentiation, because there is a situation called *stuck in the middle* where companies are trying to be best in both strategies, unable to specialize and eventually fail. However, today there are companies (mostly IT) that are able to achieve both strategies without getting into this trap.

Mentioned Porter's models require a thorough structural evaluation in order to find a satisfying understanding of industrial profitability, sources affecting competitive forces and ways that could change industry profitability in the long-run. Also, many researchers criticized Porter's models as they are predominantly focused on external factors, which forced him to upgrade these generic strategies and create the value chain model. The value chain model is the key element of Porter's theories for competitive advantage achievement as it is a methodological framework that groups all company activities into primary or supportive activities and combines them, but it will not be covered in this paper. Gaining knowledge of industry structure and having internal company analysis helps managers to understand their strengths and weaknesses, whereas they recognize areas where strategic changes have higher influence, emphasizing opportunities and threats. Goal of such industry analysis is directly connected to efficient strategy shaping that influences price policy, research, innovation, investments, etc. through history. Therefore, goal of managers using industry analysis is to position their company the most optimal way that will protect it from all mentioned forces and companies can make influence by shaping these forces in the most optimal way securing long-term benefits.

2.2.3. Criticism on the industrial organization theory

The major problem of Porter's model is the period it was developed. In the 80s there has been mainly cyclical economic movements and growth where managers had only to optimize their strategy accordingly. Due to different dynamics, stability and predictability of that period compared to today, it is logical to have certain flaws. It can be concluded that the issue comes from only focusing to the already existing industry situation and it is not suited for dynamic markets existing today. The industrial organization theory is oversimplifying very complicated processes happening between companies in the market and as well in the company itself. Further critique is that it signals companies to find markets that have

imperfect competitive situations, as they try with the help of entry barriers to limit and eliminate potential competitors, which automatically reduces the need for invention and innovation.

The most common critic of this theory is the integration in a specific market or industry that increases company profitability. However, new research suggests that only 10 - 20 percent of the profitability source falls to the industry or market, and the rest is on the internal factors of the company. Further limitations of Porter's framework is that it focuses mainly on the whole industry level, which means that large organizations that are in several markets or small organizations focusing on a certain market niche need to have in mind these limitations. As it can be seen from above, Porter's model is very static as it is only focused on certain movements that are easily forecasted in the short-run. This is not helpful in the dynamic world that we have now, meaning that it is not well suited for strategic decision making that requires long-term planning and the possibility of adaptation. Also, a lot of subjective thinking is involved in the process of creating this model for the company where individuals tend to find a specific and more attractive industry. Therefore, it requires brainstorming to eliminate possible subjectivity and it does not consider potential customers and creation of new industries i.e. blue ocean.

Also, the *blind spot* of this model is the non-consideration of complementary goods, which means that at the analysis of industries, required elements that help to achieve maximal performance levels of certain products are not taken into account.²⁴ As the economy over time becomes more saturated with fierce competition and everyday changes, the need for other strategic models besides the industry environment analysis is rising. In order to repair imperfection from the 80s, researchers indicate the importance of focusing on internal company situations, resources and competencies. Such changed way of thinking led to the development of a new strategic theory called the resource-based view explained below. In the end despite the identified weaknesses of this theory, it is still necessary to analyze the industry and the environment where the company is doing business. Thus, best solution is to use it in order to widen managers' horizons and change their point of view, where it should be used as a complementary to other theories and not substitute, still having in mind all mentioned issues.

2.3. Resource based view

Resource based theory is considered as one of the most prominent for explaining organizational relationships and just like every theory, this one went through evolutionary processes.²⁵ Back in time organizational resources have been identified as important but development and shaping of the resource based view started just from 1980s. Porter's²⁶ five forces were the top theory in that decade, covering environmental and industrial situation, while the RBV redirected the attention inside the organization.²⁷ Firm resources have gained significant importance after dissatisfaction with the static framework of the industrial organization.

²⁴ Schneider, J. and Habasche, F. (2014) Sind Porters Five Forces Heute Noch Relevant: Eine Neubewertung grundlegender Tools zur strategischen Analyse. *The Power of Insight* 2: 1-12.

²⁵ Levitt, T. (1965) Exploit the product life cycle. *Harvard Business Review* 43: 81-94.

²⁶ Porter, M. (1980) *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press, New York

²⁷ Hoskisson, R. E., Hitt, M. A., Wan, W. P. and Yiu, D. (1999) Theory and research in strategic management: Swings of a pendulum. *Journal of Management* 25: 417-456.

All concepts and models explaining the success of a company among competitors through owning specific and special resources are covered by the resource based view. Also, this model renewed the importance toward older theories covering topics about profits and competition coming from economists such as David Ricardo, Joseph Schumpeter and Edith Penrose.²⁸

2.3.1. Development of the resource based view

Penrose is considered as one of resource based view initiators and she defined the company as a *bundle of competences* that can further be defined as combination of knowledge, abilities, experiences, technologies and skills used in optimal proportions rather than just discrete and separated attributes mentioned above.²⁹ Andrews phrases the traditional strategy concept as strengths and weaknesses of the company or in other words the resource position.³⁰ Thus, it is said that resources can be represented as strength or weaknesses of a company. Research focus regarding importance and reason for long-term competitive advantage in the field of strategic management was not long time ago.

Wernerfelt did not fully agree with Porter's focus, which was especially on the industry and market structure, but he referred to internal company resources, capabilities and the overall situation. Also, the focus was related to strategic concepts of Andrews and Penrose where they pointed out the importance of resources.³¹ This importance has been covered in the corporate strategy level and business strategy level. Boundaries of company activities industrially and geographically, as well as the competitive imitation, innovation, imperfect information and resource accumulation are referred as the resource-based view of a company.³² However, rapid application and development of the RBV was only after the papers of Rumelt³³ and Barney.³⁴

2.3.2. Resources and capabilities as sources of competitive advantage

Basic division of resources is on tangible and intangible, connected to the company such as brand name, in-house technology knowledge, machinery, capital, personnel, etc.³⁵ Also, Barney³⁶, Schoemaker³⁷ and Grant³⁸ separated resources as tangible and intangible, adding

²⁸Ricardo, D. (1891) *Principles of Political Economy and Taxation*. London: G. Bell; Schumpeter, J. A. (1934) *The Theory of Economic Development*. Cambridge, MA: Harvard University Press; Penrose, E. (1959) *The Theory of the Growth of the Firm*. John Wiley and Sons, New York

²⁹Helfat, C. E. and Peteraf M. A. (2003) The dynamic resource-based view: capability lifecycles. *Strategic Management Journal* 24(10): 997-1010.

³⁰Andrews, K. R. (1971) *The Concept of Corporate Strategy*. Homewood IL, more in: Huemmer, B. (2001) *Strategisches Management von Kernkompetenzen im Hyperwettbewerb*. Deutscher Universitaets Verlag, Wiesbaden: 50.

³¹Penrose, E. (1959) *The Theory of the Growth of the Firm*. John Wiley and Sons, New York

³²Teece, D. J. (1980) Economies of Scope and the Scope of the Enterprise. *Journal of Economic Behavior and Organization* 1: 223-247; Chatterjee, S. and Wernerfelt, B. (1991) The Link between Resources and Types of Diversification: Theory and Evidence. *Strategic Management Journal* 12: 33-48.

³³Rumelt, R. P. and Lamb, R. B. (1984) *Towards a Strategic Theory of the Firm*. *Competitive Strategic Management*, Prentice-Hall, Englewood Cliffs, New Jersey: 556-570.

³⁴Barney, J. B. (1986) Strategic Factor Markets: Expectations, Luck and Business Strategy. *Management Science* 32(10): 1231-1241.

³⁵Caves, R. E. (1980) Industrial organization, corporate strategy and structure. *Journal of Economic Literature* 58: 64-92.

³⁶Barney, J. B. (1991) Firm Resources and Sustained Competitive Advantage. *Journal of Management* 17(1): 101.

human resources as well. Barney suggests the differentiation between financial, physical, human and organizational while Grant expands the division for technological resources and reputation.

Tangible resources are considered as all physical and financial resources that are relatively inflexible because they can be used in a small number of similar industries. On the other side financial resource is the access to internal and external financial sources, including general company financial strength. However, usage of tangible assets requires also usage of intangible resources that in turn force companies to give more attention to intangible resources that may hide high potential for the company success. But intangible assets are more likely to be sources for competitive advantage than tangible assets and they will be briefly explained below.³⁹

Intangible resources have been covered frequently in previous years as methods of developing competitive advantage. Porter classifies resources as human, physical and know-how based resources together with the infrastructure. However, just few company assets are considered as strategic resources (reputation, company culture, brand and intellectual property rights) that can be used to achieve competitive advantage.⁴⁰ Intangible resources are technological knowledge, company culture and company reputation that at the same time represents reputation of goods and services. Such resources in a company exist thanks to its human resources and companies are not able to trade their intangible resources except using patents through licenses, because such markets are incomplete and not developed or do not exist at all.

Companies in order achieve competitive advantage need to differentiate themselves from others. According to the resource based view they should own specific resources or to be more precise they need a combination of specific resources and capabilities. Capabilities develop through transfer of information in the company with the help of its employees as an interaction process of physical, human and technological resources. Wernerfelt, Grant, Collis and Montgomery observe specific company capabilities, created from a combination of many resources, representing the true source of resource based competitive advantage. Similarly is argued by Porter who said that resources alone do not create value of any kind for the company.⁴¹ Barney suggested that the distribution of resources and capabilities among firms is heterogeneous and imperfectly mobile. Furthermore, he also posits that resources in order to attain sustained competitive advantage should be (VRIN) valuable, rare, inimitable and non-substitutable.⁴²

³⁷Amit, R. and Schoemaker, P. J. (1993) Strategic Assets and Organizational Rent. *Strategic Management Journal* 14: 33-46.

³⁸Grant, R. M. (1995) *Contemporary Strategy Analysis*. Cambridge (MA), Oxford: 121.

³⁹Brush, C. G., Greene, P. G., Hart, M. M. and Haller, H. S. (2001) From initial idea to unique advantage: the entrepreneurial challenge of constructing a resource base. *The Academy of Management Executive* 15: 64-78.

⁴⁰Amit, R. and Schoemaker, P. J. (1993) Strategic Assets and Organizational Rent. *Strategic Management Journal* 14: 33-46; Kaplan, S., Schenkel, A., von Krogh, G. and Weber, C. (2001) *Knowledge based theories of the firm in strategic management: a review and extension*. MIT Sloan Working Paper 4216-01; Kogut, B. (2000) The network as knowledge: generative rules and the emergence of structure. *Strategic Management Journal* 21: 405-425.

⁴¹Wernerfelt, B., (1984).; Grant, R. M., (1995) and Collis, D. J. & Montgomery, C. A., (1995)

⁴²Barney, J. B. (1991) Firm resources and sustained competitive advantage. *Journal of management* 17(1): 99-120.; Barney, J. B. (2001) Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review* 26: 41-56.; Priem, R. L. and Butler, J.E. (2001) Is the resource-based "view" a useful perspective for strategic management research? *Academy of Management Review* 26: 22-40.; Wernerfelt, B. (1984) A resource-based view of the firm. *Strategic Management Journal* 5: 171-180.

Therefore, to achieve competitive advantage resources need to be:

- valuable - the resource has to be both, limited in quantity and should provide additional value to customers. However, value of the resource is decided by the market, which means that also the competitive advantage is provided by the market
- rare - as the word says these resource are scarce or do not exist. Theoretically and strategically, scarce resources are the one where the number of companies owning them is lower than the number of companies buying them. However, not always do rare resources provide competitive advantage, if they have substitutes or resources that can fulfill the same function, than they are taken over.
- inimitability - the resource is providing greater potential and effect if they are very hard to be copied or imitated. If that resource is easily imitated than they cannot provide long term competitive advantage but only a time limited function. Researchers do not talk about absolutely inimitable resources but about making limitation of competition doing that.
- non-substitutable - it is important that the resource cannot be changed by some other. The whole competitive advantage of a company would be destroyed if its resources could be substituted and easily imitated.

Not all resources are strategically significant and that is why it is important to figure out what kind of resource the company owns, so it would potentially create competitive advantage. For the company to create core competences, their resources are supposed to positively answer to above mentioned characteristics of VRIN, which is actually a managerial tool for easily creating core competences. Further papers state that VRIN resources and capabilities are not enough for achieving competitive advantage but companies should be organized in such way that their resources can be used in full potential.⁴³

Human resources are very important where besides mutual knowledge and skills of employees, their motivation is also an elementary part. When employees are motivated and have a great working environment, they might be able to create potential trust between the company, buyer and supplier through communication and interaction that in turn can create a competitive advantage. Such kind of potential trust between different sides in the market is an integrated part of intangible resources e.g. company culture. Above mentioned tangible and intangible resources represent the base for creating and establishing competitive advantage for a company. To achieve this, resources have to be transformed, and this is achieved only if the company possesses specific capabilities. These capabilities are for instance, managing and integrating resources as inputs and transforming them into outputs whose purpose is to achieve a particular goal. Therefore knowledge and skills of employees in the company or in other words the human capital is considered as the most important organizational competence and the true base for any competitive advantage.

2.3.3. Critics on the resource based view

The resource based view has been around for a very long period and it has not been a substitute for the industrial organization theory but rather a complementary segment. As

⁴³Barney, J. B. and Wright P. M. (1997) *On becoming a strategic partner: The role of human resources in gaining competitive advantage*. CAHRS Working Paper #97-09. Ithaca, Cornell University, School of Industrial and Labor Relations, Center for Advanced Human Resource Studies. New York

mentioned above, the criticism on the industrial organization theory was its main focus on external factors and the industry environment but on the other side the critique for the resource based view is its strict internal focus. Further issues with this theory are that the RBV followers cannot explain the distinction between resources where answers vary between each follower. Thus, this non-generalization makes a problem in defining the distinction between resources and competencies.

A specific problem occurs with intangible resources because its value cannot be quantified and defined easily, as knowledge and skills of employees develop the brand value and company reputation every day. Similar critic is made to Barney, precisely on his remark that resources should be valuable and rare. It is hard to distinguish from what point a resource is tangible or intangible, valuable or rare. As well the critic is on resources being non-imitable and non-substitutable whereas it should state that it is costly to imitate or substitute, referring to the cost condition for acquiring these resources. Additional critique is that managerial implications are not mentioned and how the company should obtain and develop such resources.⁴⁴ Further, it does not mean that companies will only be successful and have competitive advantage if the answer on all four (VRIN) attributes is positive. It may also happen that through imperfections companies achieve great performance and it all depends on different future expectations. Important limitation for resource based view application is that it is only applicable until the market situation remains constant or relatively fixed. Hence, if the environment becomes unpredictable and uses technology that changes resource value, it is concluded that this theory is not well suited. Foss and Knudsen say that in order to achieve sustainable competitive advantage it is not important to have VRIN. They argue that in the process of creating sustainable competitive advantage, immobility and uncertainty are the basic requirement.⁴⁵

From the reader perspective there is a feeling that the resource based view is focusing just on internal resources and that maximum performance will be achieved by just adding capabilities. Innovation cycles, technology development and quick changes in the market show that this is not true. Therefore, dynamic strategies are used daily, that besides above mentioned functions, focus also on potential future changes. These *dynamic capabilities* show the possibility of the company to adapt fast in today's changing and uncertain environment, and be effective in achieving competitive advantages. In the next section the dynamic capability theory that expands the functionality of the resource based view in turbulent and dynamic environment will be explained in detail. Two meanings can be taken out from the name. The first part is *dynamic*, that refers to competences and company capacity to be persistent in pursuing goals in a changing business environment characterized by rapid technological change, high innovative activities, great time management, unknown behavior of competition and changing market conditions. The second term is *capabilities*, which makes a connection between internal and external company skills, adaptable strategic management and resources adapted to the ever changing environment.

2.4. Dynamic capability theory

Goal of strategic management is to find out how firms achieve and sustain competitive advantage. Thus, the goal of every firm is to achieve and have sustainable competitive

⁴⁴Miller, D. (2003) An asymmetry-based view of advantage: Towards an attainable sustainability. *Strategic Management Journal* 24: 961-976.

⁴⁵Foss, N. J. and Knudsen, T. (2003) The resource-based tangle: Towards a sustainable explanation of competitive advantage. *Managerial and Decision Economics* 24: 291-307.

advantage. For this issue the dynamic capability theory is used and it is an extension of the resource based view, sharing similar assumptions. The advantage of the dynamic capability theory compared to the previous is its focus on the firm capability to change resources according to the situation in the environment and they can do it persistently. Therefore, it became attractive for many academics, researchers and practitioners where the number of journal articles, conferences and presentations rapidly increased covering this specific topic.

2.4.1. Development of the dynamic capability theory

First contribution to the dynamic capability theory came from the working paper of Teece et al.⁴⁶ Compared to the RBV they suggested that besides resources as a bundle, different mechanisms of learning and accumulation of new capabilities and skills is needed for competitive advantages. Disadvantage of the RBV is that it was not able to explain how some companies could demonstrate rapid and flexible innovations, meet the perfect timing and together with managerial capability coordinate internal and external competences. The importance lies in the changing nature of the environment and also the role of strategic management, whose task is adaptation, integration and reconfiguration of internal and external organizational elements.⁴⁷ The reason for such argument is that a greater number of once successful and influential companies struggle or fail in periods of changing environments because they had difficulties to adapt. The mentioned internal and external elements include skills, resources and effective competences facing dynamic, turbulent and changing business environments.⁴⁸

We could say that the dynamic capability theory is covering a range of theoretical perspectives and together with them the evolutionary economics, as they are trying to understand company growth and survival in the industry. There is a connection to Schumpeter's work with his creative destruction process and competition based on innovative activities, which will be in detail explained in following chapters. As mentioned above, companies in order to achieve sustainable competitive advantage have to renew their valuable resources in the moment their external environment changes. Thus, the relationship between VRIN resources and capabilities enables such process to achieve this goal. However, if the company has valuable, rare, inimitable and hard to substitute resources, but does not use any of its dynamic capabilities, it cannot achieve any superior return in environments characterized with continuous changes. Because of such potential hardships, companies follow the dynamic capability theory in order to continually seek and achieve competitive advantages; it may even help the company to prepare itself by avoiding development of a rigid organization, with stiff innovation processes and inertness.⁴⁹

Dynamic capability consists of both tangible and intangible assets where the most important asset identified through research is organizational knowledge. Precisely, it is divided into Knowledge Management and Knowledge Sharing where its accumulation, organization and

⁴⁶Teece, D. J., Pisano, G. and Shuen, A. (1990) *Firm capabilities, resources and the concept of strategy*. Economic Analysis and Policy Working Paper EAP 38, University of California

⁴⁷Teece, D. and Pisano, G. (1994) The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change* 3: 537-556.

⁴⁸Harrell, J. B., O'Reilly, C. A. III and Tushman, M. L. (2007) Dynamic capabilities at IBM: driving strategy into action. *California Management Review* 49: 21-43.

⁴⁹Leonard-Barton, D. (1992) Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal* 13: 111-125.

distribution are in focus.⁵⁰ Learning mechanisms impact the evolution of company capabilities that in turn affects innovative thinking, making it hard for competitors to imitate and therefore create competitive advantage.⁵¹ Organizational learning theory suggests specific differences in the process of strategic renewal that involves a strict relationship between new knowledge creation (exploration) and usage of existing knowledge (exploitation).⁵² Further, the enhancement of dynamic capability comes from careful exogenous knowledge management about customers, competitors and suppliers, which is highly relevant for company's effective and efficient market knowledge application. This knowledge helps the company to precisely align its strategy and theory with existing situation in turbulent and dynamic business environment. All these factors affect that the company behaves properly trying to increase efficiency and effectiveness, reduce lead time, and adopt new technologies that might be evolutionary or revolutionary in engineering terms. In the end, mentioned knowledge gives all necessities for a company to survive its fierce competition in a harsh environment.

2.4.2. Core competences

Newbert mentioned in his research that capabilities and core competences indeed significantly affect company performance, while on the other side resources do not.⁵³ This statement is opposite to Barney's suggestion that both, resources and capabilities have strong influence on company performance.⁵⁴ In the 1990s, the model was further developed in the paper of Hamel and Prahalad. Main idea is that after all, that the company policy focusing on key competences leads to the development of competitiveness, increase in market share and sale level above industry average.⁵⁵ Owning resources is an important factor but far from the situation to be a sufficient condition for making profits. Companies should be seen as systems for resource transformation and having variety of resources does not guarantee competitive advantage.

Combination of resources and capabilities is considered to be the core competence of a company that provides long term competitive advantage. Hamel and Prahalad developed the most popular concept for the analysis of company key competences. This concept gained great popularity in the last period because the way of doing business and dynamics in them had changed in such manner that suits this method. However, they were not the first who developed this method but it was Penrose in the 1950s that created the backbone of the resource based view. Great influence for the development of the competences model was the change in the market environment becoming more turbulent. Therefore, in order to adapt to everyday changes companies consider that capabilities should be optimized and developed to not lose market position as the technology and knowledge is developing daily. Such rapid changes require organic company structure so that they are more flexible, faster and efficient

⁵⁰Cepeda, G. and Vera, D. (2007) DC and operational capabilities: A KM perspective. *Journal of Business Research* 60: 426-437.

⁵¹Zollo, M. and Singh, H. (1998) *The impact of knowledge codification, experience trajectories and integration strategies on the performance of corporate acquisitions*. San Diego, CA: Academy of Management Best Paper Proceedings.

⁵²Zahra, S. A. and George, G. (2002) Absorptive capacity: A review, reconceptualization and extension. *Academy of Management Review* 27: 185-203.

⁵³Newbert, S. L. (2007). Empirical research on the resource-based view of the firm: an assessment and suggestions for future research. *Strategic Management Journal* 28(2): 121-146.

⁵⁴Barney, J. B. (1991) Firm resources and sustained competitive advantage. *Journal of Management* 17: 99-120.

⁵⁵Prahalad, C.K. and Hamel, G. (1990) The Core Competence of the Corporation. *Harvard Business Review*: 79-91.; Prahalad, C. K. and Hamel, G. (1991) Nur Kernkompetenzen sichern das Überleben. *Harvard Business Manager* 13(2): 66-78.

for surviving in the market. That traditional organizational structure happens to be too strict and static which is harmful for companies today.

Hamel and Prahalad in their paper published in the Harvard Business Review (1990), called *The core competence of the corporation*, became the most purchased and read paper in the history of that magazine. They suggest that key competences are a unique combination of technical skills important for the company efficiency. At the first place regarding the success of every organization are search, development and organizational learning.⁵⁶ These key competences are very important in the market because they distinguish companies from each other. It is also defined as a field of expertise that balances technology development and employee know-how. All these mentioned processes have the goal to create something unique that can be only provided by this single company, which in turn provides additional customer value, their satisfaction and in the end greater profits. Thus, followers of this concept believe that companies can achieve competitive advantage and greater return on investment if they can focus on their competences that should provide greater value to the customers and increase their business efficiency. It is said that key competences are a combination of resources and capabilities where according to the VRIN concept they answer all questions positive. As it is the case with the smartphone industry, where for instance great processing power is considered as a technological success based on capabilities in technical progress and lower prices due to greater efficiency, despite innovation processes. These capabilities are considered as valuable, rare, hard to imitate and non-substitutable (VRIN).

In order to check whether company competences have created competitive advantage, according to Tampoe it has to fulfill several requirements. Therefore, key competences have to be:

- the key factor of long term and short-term company survival
- hard to detect and imitate by rivals
- the combination of different resources
- the long-term company capability
- the base for strategic decision (whether to diversify or engage in joint venture)
- rare.⁵⁷

The function of core competences is to group company resources accordingly and focus in customer problem solution by using specific skills and knowledge. Therefore, it is said that successful companies use their resources and capabilities in order to integrate in a dynamic environment and further develop, whose effect is enhanced by combining them, which in turn creates the specific company core competences that can make a difference between companies that exist in the same industry. Many followers of this model suggest that there is a great potential for innovativeness and diversification which is an important factor for growth or at least holding current market position. Also, one of major benefits concerning key competences is its transferability function where it can be moved to different regions, market niches or different products that in turn increase synergetic effects. Thus, benefits of the company having key competences are having the possibility of covering many segments of the industry both, geographically and economically allowing companies to move around and not stagnate or be fixed to a single market type. This situation increases efficiency in companies by using fewer resources for achieving the same result or more than its competition.

⁵⁶Prahalad, C. K. and Hamel, G. (1990) The Core Competence of the Corporation. *Harvard Business Review*: 82.

⁵⁷ Thiele, M. (1997) *Kernkompetenzorientierte Unternehmensstrukturen*. Gabler Verlag, Wiesbaden: 69-70.

Company core competences are a good way of communication between strategic business units and employees, as well there are involved cross organizational segments. All functions involving people from different organizational levels have to collaborate with each other in order to have a functional organization that creates long term competitive advantage by not focusing narrowly, but using different opportunities. Important to indicate is that core competences are not spent over years like other assets, but they have to be protected, applied and shared. Major problem is that even it does not diminish over time; it can be forgotten if it is not regularly used. Great example for core competences is that it can be seen as glue that connects all businesses and as an engine that moves the organization toward creating new types of businesses.⁵⁸

2.4.3. Dynamization of core competences

In previous parts the focus has been on the dynamic capability model, which is an extension of the resource based view. With its help companies are able to create and achieve long-term core competences, and to understand the whole process it is important to cover the dynamization process. As environments become more dynamic and turbulent, leading a company becomes a very difficult and complex task. Usually it is suggested that internal company changes are necessary for coping with environmental dynamics and it is not important whether changes happen suddenly, revolutionary or evolutionary through continuous long-term changes. It is more important to observe that the company is willing to change or that it creates and forces change. Ability to adapt in dynamic environments comes from the dynamics of core competences that a company developed through learning processes, because if companies do not adapt to the environmental dynamics and uncertainty, it can become dangerous for the organization. Therefore, different abilities and processes such as flexibility, innovativeness and continuous improvement of business elements are very important for companies to survive in these environments.

This concept has the goal of using company specific capabilities in order to achieve long-term competitive advantage that is one of major goals for every company in order not to be left behind by competitors. Because of the dynamic capability method and the process of achieving this level, it means that the company can react in the most optimal way even if radical changes happen in the environment. The need of having flexible resource adaptation relative to environmental conditions is becoming stronger, also in the segment of strategic management whose goal is fast reaction and preparation of the available resource base. In other words the task of management is to create a portfolio of different company core capabilities that can be available any time and used according to current environmental changes. For the company it is not enough to stay still but it has to find new industries or markets in order to secure their position and competitive position. All processes mentioned above can be done by companies that are considered as innovative but it requires time, good resource base and capabilities.

Changes have to be observed as a process where the company has to make its organization better through continuous learning. Therefore, companies today are also called as *learning companies / organizations*.⁵⁹ The capability of a company to continuously learn is an attribute

⁵⁸Prahalad, C. K. and Hamel, G. (1990) The Core Competence of the Corporation. *Harvard Business Review*: 79-91.

⁵⁹Sattelberger, T. (1991) *Die lernende Organisation-Konzepte für eine neue Qualität der Unternehmensentwicklung*. Gabler Verlag, Wiesbaden: 193.

required by modern companies as they have to adapt to different market changes and confront crises'. It can be said that learning capability is a precondition for a company to achieve and create new capabilities, and the best way to make it is through experience. These learning processes and creating capabilities vary in different product life cycles. Thus, in the maturity stage there is least probability of success and companies have to make a solution. The best way is to be creative and real core competences are characterized as being transferrable from one product to another. Companies with significantly strong core competences are reacting on time where they move more resources to R&D processes making a good example in the smartphone industry as they are transferring technology of one model to create another. With this process companies can make certain innovations that can attract new customers and in this example investment risks are minimized.

From this example it can be seen that core competences have a greater life expectancy than it is for products but the first has also its limits. The life cycle curve of core competences will fall if they are connected to the ever changing technology and its life cycle. Because of these threats, managers need to consider this and follow the S-curve for technologies that represents its application level over time. Worth to mention is that for small and medium size companies the life cycle of core competences is connected to the person on the top. If the manager capability and knowledge is changed by some inexperienced one, this company can find itself in danger. Therefore, it is important to detach the company needs toward that single person in charge in earliest stages. In order to avoid such situation of moving toward the curve end, it is necessary to have continuous adaptation. As it could be concluded, the process of creating relevant core competences is very difficult, but from the moment it is created only small changes are required as the trends are changing as well. Competitors also exist in the market and to remain competitive companies should check, develop and adapt their competences and capabilities all the time.

3. Creation and application of the Red Queen

From the novel *Through the Looking-Glass* by Lewis Carroll (1871) coming from a sequel to *Alice's Adventures in Wonderland*, little Alice goes through a wall mirror into a parallel world where she talks to other creatures. Everything is alive and is able to talk, starting from plants, unicorns, birds, sheep, lions and also chess figures. The Red Queen, a chess figure, is also broad to life where in the story Alice herself is being a pawn. In England in the second half of the 19th century the game of chess was red against white, compared to white against black today. Further, Carroll explains in his book how little Alice and the Red Queen are trying to get from one place to another.

There are some parts from the book:

„Just at this moment, somehow or other, they began to run [...] hand in hand, and the Queen went so fast that it was all she could do to keep up with her: and still the Queen kept crying “Faster! Faster!” but Alice felt she could not go faster though she had no breath left to say so. The most curious part of the thing was, that the trees and the other things round them never changed their places at all: however fast they went, they never seemed to pass anything.

*“I wonder if all the things move along with us?” thought poor puzzled Alice. And the Queen seemed to guess her thoughts, for she cried,
“Faster! Don’t try to talk!”*

*„Are we nearly there?“ Alice managed to pant out at least.
“Nearly there!” the Queen repeated. „Why, we passed it ten minutes ago! Faster!“ And they run on for a time in silence, with the wind whistling in Alice’s ears and almost blowing her hair off her head she fancied.*

“Now! Now!” cried the Queen. „Faster! Faster!“ And they went so fast that at last they seemed to skim through the air, hardly touching the ground with their feet, till suddenly, just as Alice was getting quite exhausted, they stopped, and she found herself sitting on the ground, breathless and giddy. The Queen propped her up against a tree, and said kindly, “You may rest a little now”. Alice looked round her in great surprise.

*“Why, do I believe we’ve been under this tree the whole time!
Everything’s just as it was!”*

“Of course it is,” said the Queen: “what would you have it?”

“Well in our country,” said Alice, still panting a little, “You’d generally get to somewhere else--- if you ran very fast for a long time, as we’ve been doing.”

“A slow sort of country!” said the Queen. “Now, here, you see, it takes all the running you can do, to keep in the same place.

After she met the Red Queen, she explains little Alice how to move forward and how hills become valleys and vice versa. In that moment Alice understood the Red Queen dynamics and when she tries to speed up, she does not only return to the same place, but she also crashes. At top of a hill both start to run as fast as possible but it seems to Alice that they are not moving at all. The moment they stop running they are in the same place, which explains the co-evolutionary effects, where Van Valen created the *Red Queen* hypothesis that states, species or in our case companies have to constantly run / evolve as hard as possible just to remain at the same place. The application of Red Queen in science and everyday life will be further explained below.

3.1. Red Queen as theory and practice

Terms of continuous need for change, movement and progress have been under observation process by different researchers and scientific fields. As every day there is need for improvement and becoming better than others the Red Queen effect has been observed, which has its influence in social and natural sciences especially where in biology, physics, anthropology, and its origin in the army will be covered, as well as its significant influence in economics and business.

3.1.1. Red Queen in sciences

In natural sciences the term "*Red Queen*" was first applied by Leigh Van Valen an evolutionary biologist, who proposed this hypothesis to explain the evolutionary arms race, where species had to run just to stay alive. He observed that the mortality rate between species remained constant but between specific groups he realized certain distortions and variations, which was connected to the Darwinian evolutionary theory. His observation was that the probability of one species extinction is independent to its existence time period, which is seen in fossil remains and they indicate that the existence period of one species has nothing to do with dying out.⁶⁰ So, the Red Queen hypothesis as well as the effect can be described as an advantage of one species relative to its environment but only for a short period. After that short period, the environment catches up to establish a new balance.⁶¹

"The rabbit runs faster than the fox, because the rabbit is running for his life while the fox is only running for his dinner." - Aesop⁶²

Physicist also recognized the Red Queen phenomena starting from the micro level up to the molecular macro level. In the micro level Andersen realized that the magnetic effects of opposing forces are making a dynamic environment whereas in the macro level they provide significant stability for the whole system. Further, physicists confirm that thanks to the Red Queen they are able to predict attacks during wars. Through computer models and simple equation, prediction of conflict-ridden future is possible, which is explained by the arms race covered in the Red Queen hypothesis.⁶³

Ridley covers the Red Queen theory in the field of anthropology, where the best human strategy to survive constantly mutating internal (organic) predators is sex. Considering the

⁶⁰Sole, R. V. and Sardanyes, J. (2014) Red Queen Coevolution on Fitness Landscapes, Recent Advances in the Theory and Application of Fitness Landscapes. *Emergence, Complexity and Computation* 6: 301-338.

⁶¹Van Valen, L. (1973) A New Evolutionary Law. *Evolutionary Theory* 1: 1-30.

⁶²Dawkins, R. (2006) *The Selfish Gene: 30th Anniversary Edition*. Oxford University Press: 250.

⁶³<http://arxiv.org/ftp/arxiv/papers/1101/1101.0987.pdf> (access: 26. 01. 2016.)

culture and general human nature, in his book he covers different traditions of marriage and the fact that a woman is likely to conceive a child from adulterous action than by her husband due to genetic mutation and its evolutionary importance.⁶⁴

Robson covers the Red Queen theory from the human rationality point of view considering evolutionary development of intelligence, mind and thinking. Rationality of human behavior and goal maximization make the relationship with the Red Queen as there is need to dominate a certain race or culture. Asymmetric information held by members and their zero-sum game forces them to behave in a certain manner which establishes balance and everyone achieves an optimal strategy. Thus, the Red Queen shows that it is able to establish strategic evolution of individual's rationality.⁶⁵

Sciences have always been interrelated and certain discoveries in one can be very helpful in the other. It is interesting to see that even some hypothesis and in this case the Red Queen effect finds its existence in different fields of research. Therefore, it is important to broaden the horizon and interest in different sciences, especially for an economist as he must possess variety of skills and a combination of gifts.

3.1.2. Red Queen in business and war

Greatest application and the most interesting aspect for this paper are seen in economics and business where companies have to fight for scarce resources and try to survive in a turbulent environment. If we consider the Red Queen in a business context, it means that company performance depends on its ability to equalize or overtake rivals. The increase of performance level is achieved mainly through innovative actions that reduce the same for the other company. Most companies are forced to compete and it is considered as a constraint that induces resource scarcity. In other words if the focal company would not experience competition, everything remaining same, it would enjoy great benefits and access to all resources, which is not the case when competitive battle occurs.

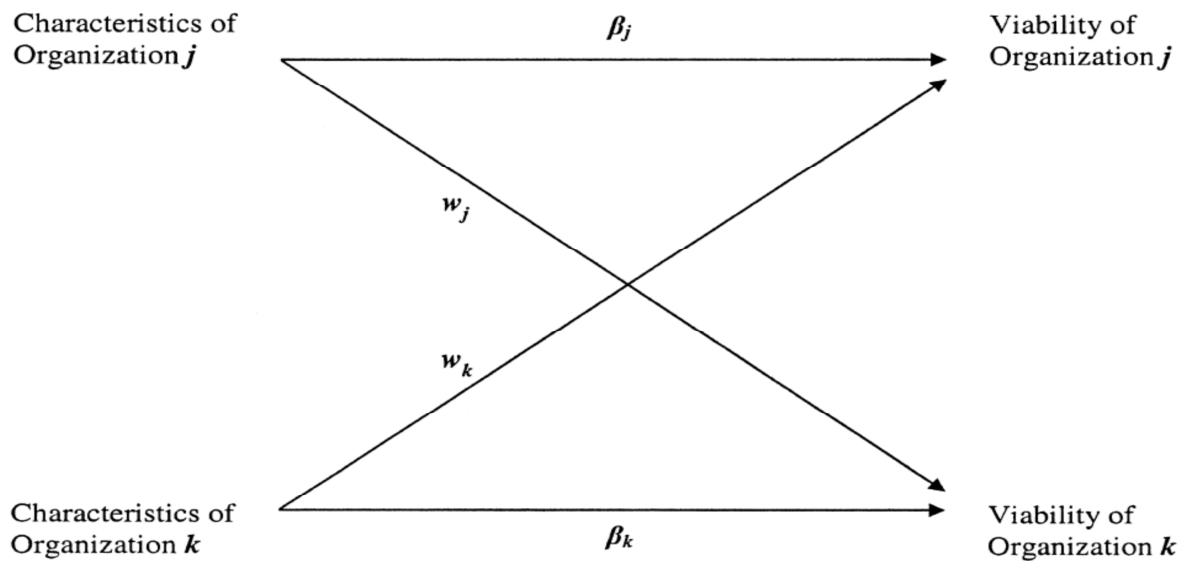
Resource scarcity happens even with indirect competition but in direct competition there is the zero-sum game stating that one company's gain is the others company loss. People are aware of competition and managers are creating different strategies in order to properly cope with them, but sometimes they even find ways to make mutual benefit through partnerships. As mentioned above, companies in a competitive market have to engage in a battle for scarce resources that requires dynamic changes and capabilities for adaptation. The competitive pressure increases as well, as competitors increase their adaptation skills over time. The rival decision depends on observation and learning from actions of the focal firm⁶⁶ and this increasing competitive level between companies is explained in figure 2.

⁶⁴Ridley, M. (2003) *The Red Queen: Sex and the Evolution of Human Nature*. Harper Collins Publishers, New York

⁶⁵Robson, A. J. (2003) The Evolution of Rationality and The Red Queen, *Journal of Economic Theory* 111: 3.

⁶⁶Young, G., Smith, K. G. and Grimm, C. M. (1996) Austrian and industrial organization perspectives on firm-level competitive activity and performance. *Organization Science* 7: 243-254.

Figure 2. Competitiveness and viability between companies



Source: Barnett, W. P. (2008): 4.

This example considers two organizations with different characteristics and probably they would be different in viability as well. These companies are denoted with both, letter j for company one where together with β it represents adaptation capability inside a particular market whereas letter k together with w represents the competitiveness of the second company. In the figure, β_j is larger than β_k which means that the characteristics from company j are more viable than from company k . Therefore, as company j is stronger than company k it means that the competitive effects on $k(w_j)$ are much stronger than vice versa. The Red Queen theory can be used to explain this situation where differences occurred due to different historical events both companies experienced. Also, as the weaker company is under stress because of competition, its exposure can make it stronger and more viable as it tries to hold its place or at least survive in the market. The conclusion is that the Red Queen effect will force competitors to run harder and become better, but on the other side there are companies that try to avoid competition entirely and try to gain monopolistic power.⁶⁷

In order to be better, companies seek competitive advantage and create capabilities that can be achieved by improving their position relative to its rivals. This can be achieved by choosing the right decision and countermoves relative to information they own in order to constrain competitor decisions. In today's turbulent and fast moving environment it is best to consider the dynamic approach, which is the work of Schumpeter and mainly supporters and initiators of the Austrian school. According to them, competition is rather a process of discovery than just a state in the market or a situation.⁶⁸ Schumpeter argued that continuous innovation and learning processes of the company are linked to the interdependent nature of the competitive market. So, if a company stays still and does nothing, while others find new activities that appeal to the market, it will erode the position of the first company. To avoid this situation, they have to continually introduce new methods, products and initiatives where profit is just the result of these actions. According to Schumpeter a company that is slow or lethargic but efficient will anyways be eliminated in short period. Thus, profit and success is coming from

⁶⁷Barnett, W. P. (2008) *The Red Queen Among Organizations - How Competitiveness Evolves*. Princeton University Press: 4.

⁶⁸Mises (von), L. (1949) *Human action: A treatise on economics*. New Haven, CT: Yale University Press; Jacobson, R. (1992) The "Austrian" school of strategy. *Academy of Management Review* 17(4): 782-807.

implementation of new products, new industries, new market niches, new technology and new organization types. These innovation and action induced rivalry, as well as rival counteractions have certain negative effects that he called *creative destruction*. This term represents new results visible by competitors created by innovation that at the same moment engages rivals reaction in order to survive in the market. This explains the ongoing cycle of creation and destruction processes, where ignoring the focal firm activity is not affordable for rivals if they want to survive in the marketplace. Thus, they need to react and act creatively, which establishes an interaction of firms where both have the same goal to maximize profit and market share. The Austrian school approach however is not that radical as Schumpeter, and according to Kirzner⁶⁹ the company actions are mainly opportunity based driven with quick reaction to market changes rather than dramatic change of the market through radical innovation. Hayek further suggested that competition is rather a situation where companies discover important activities that are relevant for achieving company specific purposes.⁷⁰ Considering the above, it can be concluded that the Red Queen effect finds its roots in the Schumpeterian philosophy and the Austrian school, which gives us a different and new approach of considering competition and this interaction is the key source of economic growth, technological progress and market expansion.⁷¹

As strategy and the way of thinking in economics and business come from the military, it is worth to mention that also the Red Queen effect finds its roots from military. Hence, it can be said that the same logic occurs in this particular field starting from historic periods such as, the Roman Empire, Dark Ages up to the Cold war and all the tension that is still happening today. In order to be safe, one army is stocking weapons that will force the opposite side to do the same and it indicates that the Red Queen is clearly military related through the so called arms race. This psychological game is very important in the military, which can be seen in the saying that if you want to live in peace you have to be ready for war - famous Roman principle that controlled the war in general and it's financing.⁷² The same happened in the European middle ages during the feudal system, where rulers in order to feel safe started to buy and stock their weapons. From the other side the same story, not to be left behind in the military power the arms race kicked in again and they caught up. Thus, a spiral effect started to appear, where military power remained relatively constant but everything started to become too expensive. Leaders realized that trade has in military as in economic terms the same force of actions and reactions. Therefore, to get out of the spiral effect of continuously buying weapons and becoming financially unstable, politicians started to put stronger control on the budget that started in France in the 18th century.⁷³ Unfortunately, this spiral effect still exists in the modern era where the military budget in some countries is much higher than its budget for education and health system combined.

From the above it can be concluded that there is a parallelism between biology, social sciences and economics in general. Because the environment of both, life and species, companies and markets is characterized by resource scarcity. Therefore, fighting in both cases

⁶⁹Kirzner, I. M. (1997) Entrepreneurial discover and the competitive market process: An Austrian approach. *Journal of Economic Literature*, 35(1): 60-85.

⁷⁰Hayek, F. A. (1978) *New studies in philosophy, politics, economics and the history of ideas*. Chicago: University of Chicago Press

⁷¹Schumpeter, J. A. (1976) *Capitalism, socialism, and democracy* 5. London: George Allen and Unwin: 84-85.

⁷²Baumol, W. (2004) Red Queen Games: Arms race, rule of law and market economies. *Journal of Evolutionary Economics*, Springer: 237.

⁷³Hadjigeorgidi, G. W. (2008) *Koevolutionäre Red Queen-Effekte in der Automobilindustrie*. Master thesis at University of Vienna: 48, more in: Wallerstein, I. (2004) *Das moderne Weltsystem. Die grosse Expansion* 3. Promedia Verlag Gesellschaft, Wien

for existing resources and staying alive in the market or nature is one of the biggest characteristics of the Red Queen.

3.2. Industry factors influencing the Red Queen effect

Different factors can influence competitiveness level which automatically affects the Red Queen effect. The Schumpeterian and competitive dynamics perspective of the Red Queen competition are not suitable for explanation of factors that motivate competitive processes as well as different changes and characteristics that an industry can offer. In order to understand why companies behave accordingly, it is important to observe in what situation specific decisions are made and what forces them to such actions. As there might be specific performance differences between companies, managers consider different forces that might influence it. Therefore, these factors that affect performance level and the Red Queen effect as well are both, internal and external, making it predictable for managers who are looking for the next step.

3.2.1. Industry concentration and Red Queen

Industry concentration is an indicator for the business sector that shows the domination rate of few largest companies in the whole industry. In other words, it shows the industry market share as percentage owned by m (usually four) companies. It is a very important characteristic calculated with the Herfindahl-Hirschman Index (HHI) or concentration ratio. These results are helpful for managers, investors, strategists and governments as they want to consider whether the industry has high concentration (few large companies) or low concentration (many companies) level. Theory of economics suggests that few large companies will understand the importance of others by depending on each other and will engage in existing or new activities that should increase market entry barriers. Such coordination is required due to the increased market competition that in turn raises costs and performance ability of a company. It is hard to limit entrance of new market competition and increase entry barriers, so companies are forced to increase their activities such as searching and learning new ways to survive.⁷⁴ When these conditions appear to a company, it is hard and challenging to find new opportunities and learning processes.

It is argued that in industries with high concentration levels, above mentioned activities become greater. Therefore, having only few large companies leaves customers with limited options that will force them to be attracted by the market leader and its new activities. Higher industry concentration leads to greater learning and adaptation promotions through stronger competitive relations. Therefore, when the company is confronted with fewer competitors the Red Queen effect has less negative effect compared to companies where they have to confront larger number. Company performance and number of activities will be greater in highly concentrated industries where concentration ratio and effects of rival actions are greater, while at the same time customer choice is limited. Such industry types have a better effect on all companies because of the greater mutual awareness, where rivals tend to react faster to changes of the focal firm in order to show other competitors that any undesired move will be punished.⁷⁵

⁷⁴Williamson, O. E. (1965) A dynamic theory of interfirm behavior. *Quarterly Journal of Economics* 79: 579-607.

⁷⁵Bain, J. S. (1951) Relation of profit rate to industry concentration: American manufacturing, 1936-1940. *Quarterly Journal of Economics* 65: 293-324.

On the other side in less concentrated industries or where there are many competitors, responses to any rival activity will happen less likely because companies are not aware of any actions of their rivals. It can be said that having greater number of players in the industry that reduces the market concentration, companies doing business in such low concentrated industry will just ignore price changes and any other decision of their rivals.⁷⁶ On the other side, companies in highly concentrated industries are mutually aware of each other and observe every movement of others, as any change in the market can be fatal for them. Therefore, activities of the focal firm in concentrated industries will motivate and initiate greater number and speed of rival activities that will also lead to greater speed, number of actions and impact to the focal firm.

3.2.2. Industry demand and Red Queen

The assumption is that the industry demand growth rate influences Red Queen competition. A great win-win situation in high growing industries is that there is no need for concern because companies are able to increase revenues just by maintaining their market share or in other words having everything in constant rates.⁷⁷ This means that companies can also increase their market share by searching and doing activities they know will not affect rival business. However, sometimes industries have lower demand which in turn initiates war between companies. Reaction to that would be having a goal of finding new demand generation ways, mainly by price cutting or new marketing campaign.⁷⁸ It is also suggested that firms provide additional actions to create demand in these high demand growth industries and these actions create benefits for everyone in that industry.⁷⁹

Considering the Red Queen competition, learning and searching process for new opportunities, ways to increase entry barriers and reduce influence of negative competitive effects, have fertile ground in environments with high growth rates. But companies that are in industries with greater competition and fewer resources have performance increase and gains at expense of other companies that forces them to become better. Thus, if companies are doing business in industries with increasing growth rate, it weakens the Red Queen effect.⁸⁰ It implies that growth in industry demand positively affects the focal firm activity, performance and reaction speed but has negative effect on the Red Queen.

3.2.3. Market position and Red Queen

The Red Queen effect suggests that market leaders are not as much affected as are other companies in competitive activities. It was found that market leaders were more likely to develop new products and new, usually better, ways of doing business. Market leaders tend to eliminate large number of rivals and can later get in a situation where they are isolated from

⁷⁶Scherer, F. M. and Ross, D. (1990) *Industrial market structure and economic performance*. Boston: Houghton-Miller: 277.

⁷⁷Bothwell, J. T., Cooley, T. and Hall, T. (1984) A new view of the market structure-performance debate. *Journal of Industrial Economics* 32: 397-417.

⁷⁸Caves, R. E. (1980) Industrial organization, corporate strategy and structure. *Journal of Economic Literature* 58: 64-92.

⁷⁹Agarwal, R. and Bayus. B. (2002) The market evolution and take-off of new product innovations. *Management Science* 48: 1024-1041.

⁸⁰Barnett, W. P. and Hansen, M. T. (1996) The Red Queen in organizational evolution. *Strategic Management Journal* 17: 139-157.

competition and lose the ability to survive.⁸¹ Leaving the fact of possibly being isolated from competition that negatively affects performance, market leaders search, act and learn more effectively and faster than their competitors.⁸² Also, greater returns due to the experience, more efficient search and routines are enjoyed, meaning that they managed to establish such infrastructure and resource availability to enjoy effective search, action and learning processes. Thus, having a larger customer base relative to followers and provide actions more visible to customers, helps the firm to benefit from significant scale effects.⁸³

Major impact to rival reaction speed or imitation of followers concerning market leader, is fear from increased entry barriers and more difficult business climate. Interestingly, relationship between the market leader and rival is assumed to disappear or at least be short because of the fear of punishment. Also, if speed and frequency of rival actions increases, it is said to have more influence on non-leader performance than on the market leader. The reason mainly is that its customers are more loyal, which is connected to stronger brand reputation and switching costs.⁸⁴ Also the reason of lower influence is that market leaders are more effective. However, all of the above can turn out to make negative effects because market leaders have the tendency to not provoke their competitors but their actions rather deter over time. This deterrent of actions and competitiveness, leads to fewer and slower activities characteristic to non-leaders.

An important factor of competitiveness is its experience level, where companies with recent competition experience are likely to survive and their failure rate is much lower. It is due to the fact that these companies with longer experience are well placed to observe and optimize competitive position through learning and implementing specific actions.⁸⁵ As mentioned above, companies with less experience in the competitive market are more likely to fail compared to ones with greater experience. The latter uses these skills and through extensive competitive experience they develop and use new specific skills and resources in order to react to competitive pressure. These new skills and resources can establish entry barriers for potential new competitors in the market which can be an advantage in the short-term period and at least give the incumbent firm needed time to prepare itself for incoming new competitors.

3.2.4. Internal company factors and the Red Queen

Besides factors coming from the environment, also internal company factors are important as they set limitations on the Red Queen. Most companies are facing competition and the best way for engaging them is to search different ways to improve performance. These different ways initiate learning that is likely to increase company performance and competitive strength, which on the other side sends signals and forces competitors to learn more which makes rivals even stronger. In this way, companies are forced to learn over time in order to

⁸¹Barnett, W. P. and McKendrick, D. (2004) Why are some organizations more competitive than others? Evidence from a changing global market. *Administrative Science Quarterly*, (49): 535-571.

⁸²Smith, K. G., Ferrier, W. J. and Ndofor, H. (2001) Competitive dynamics research: Critique and future directions, more in: Hitt, M. A., Freeman, R. E. and Harrison J. S. *Handbook of strategic management*, UK: Blackwell, Oxford: 315-361.

⁸³Smith, K. G., Grimm, C. M. and Gannon, M. J. (1992) *Dynamics of competitive strategy*. Sage. London

⁸⁴Scherer, F. M. and Ross, D. (1990) *Industrial market structure and economic performance*. Boston: Houghton-Miller

⁸⁵Barnett, W. P. and Sorenson, O. (2002) The Red Queen in organizational creation and development. *Industrial and Corporate Change* 11: 289-325.

respond competitors activities, that further intensifies competition and self-reinforcing activities.⁸⁶

This is known as the Red Queen effect that has positive and negative impacts where through incremental but constant processes of forcing themselves provides long-term advantages and development of strategic capabilities. To further continue it is important to discuss about two major Red Queen effect constraints:

- history constraints
- facing rivals with different history.

The history constraint, in other words represents problems companies have been facing and lessons learned from past. The greatest problem for companies is when facing new issues and new developments, they use norms learned and applied in the past in different environments. These constraints hinder companies to think and do precisely what is necessary in that specific situation because there has been a similar one that was solved differently. Similar issue is when they face new competitors that previously entered the market. As companies that have been longer in the market usually know their competitors, they will apply certain strategies without any additional effort regarding research and analysis, and will be equally effective. On the other side when new players come to the market, first companies are not sure how to behave and reactively decide common strategies from the past and these will provide very bad results.

These constraints are a great issue for companies, especially the ones that have been longer in the market and became lethargic. However, it is the case not only for issues but also for different opportunities the company might face. Companies react to market opportunities through appropriate actions and they are sending signals to other firms to react in a specific manner. Other companies perceive this new information as effective and they will behave by following this appropriate action that may facilitate learning processes and create innovative strategies.⁸⁷ Further, this process can lead to development of new products or business models based on strategic innovation.⁸⁸ Barnett et al. suggest that the goal of every company is to survive and when it is achieved, the company wants also to preserve its position by being better suited and adaptable to environmental changes that is held through increasing operating capacity.⁸⁹ Flexible companies are likely to increase their performance. If they find themselves in a bad situation and lose competitive advantage through continuous adaptation to current situation and environment can provide and maintain their level of performance.⁹⁰ Considering performance, companies are not able to hold the first market place for a longer period. This problem of not being able to hold enhanced long term performance is not due to the available competitive advantage but rather the lack of continuous adaptation and change relative to market needs. It is important to continually evolve and adopt new resources that will provide the company advantage and opportunity to stay between leaders in this market race.

⁸⁶Beinhocker, E. (1997) Strategy at the Edge of Chaos. *The McKinsey Quarterly* 1: 24-39.

⁸⁷Barnett, W. P. and Pontikes, E. G. (2008) The Red Queen, success bias, and organizational inertia. *Management Science* 54(7): 1237-1251.

⁸⁸Derfus P. J., Maggitti, P. G., Grimm, C. M., and Smith, K. G. (2008) The Red Queen effect: Competitive actions and firm performance. *The Academy of Management Journal Archive* 51(1): 61-80.

⁸⁹ Barnett, W. P. (2008) *The Red Queen Among Organizations: How Competitiveness Evolves*. Princeton University Press, Princeton. New Jersey: 1237-1251.

⁹⁰Venkatraman, N. and Henderson, J. C. (1998) Real strategies for virtual organizing. *Sloan Management Review* 40(1): 33-48.

Scholars of the evolutionary theory examined consequences of the Red Queen competition on performance. It has been argued that an increase of focal firm performance will lead to reaction of their competitors to look for new opportunities just to catch up.⁹¹ The waking of rivals may be considered as a relatively bad move because their position and performance increase at expense of the focal firm. Above, it was said that competitive experience of the focal firm increases its chances for survival and success, while aggregated relative experience of competitors decreases its success. The major issue when companies are confronted with competition and new developments is their reaction to those changes with old actions learned from their history and experience.⁹²

⁹¹Barnett, W. P. and Hansen, M. T. (1996) The Red Queen in organizational evolution. *Strategic Management Journal* 17: 139-157.

⁹²Ingram, P. (2002) Interorganizational learning, in J. A. C. Baum (Ed.), *Companion to organizations*, Oxford, UK: Blackwell: 642-664.

4. Innovation and imitation as most important parts of the Red Queen

"Make products that others want to imitate"
Tokuji Hayakawa - Japanese businessman

For the innovation theory, the Red Queen is a competition for products or processes in order not to fall behind competitors. Companies have to be aware that "...it takes all the running you can do, to keep in the same place",⁹³ because competition never sleeps. If the same makes an innovation which establishes a competitive advantage, the focal firm has to work twice as hard just to catch up. To not fall behind, the company has two options available: to make specific upgrades and adaptations on available products or to innovate own products (much riskier). The conclusion is that companies should not let everything *go with the flow* but actively work on problem solution, catch up with competitors and become the market leader with their own competitive advantages. Also important for a company to consider is the risk reduction process where it should observe and create several innovative concepts before investing too many assets. As there are different personalities in humans, the same rule goes for companies where some will only imitate and others will make their own innovative counter pressure. This cycle will go on repeatedly as companies struggle to increase market share and profits that push industry, market and evolution growth.⁹⁴ Negative consequences can appear from the Red Queen effect, where one organization action and solution can make problems for the other firm. Therefore, the Red Queen competition provides narrow option for companies and fierce rivalry is activated, which sometimes gives limited short term benefits for everyone.⁹⁵ The difference between innovation and imitation is represented in table 1.

Table 1. Innovation versus imitation

Decision	Innovation	Imitation
Intention	- competitive advantages based on new value creation models - greater autonomy due to innovative advantage "easier" to increase market share	- optimization of current success concepts - achieved continuity by taking already existent - avoiding "dead ends"
Consequences	- frequent strategy audits - frequent restructuring "organizational slack", for free innovation activities	- competition focused at suppressing - loss of innovative potential - image of an imitator
Capabilities	- creativity - flexibility - risk friendly - market creation - confidence	- monitoring - decision of "right" changes - high response capability - expressed planning possibilities - know-how standardization
Risks	- illusion (miscalculation) of own innovation capabilities - imitator pressure for standardization - value creation model does not lead to competitive advantages	- adaptation expressed as personal weakness - structural crisis usually recognized late - price war

Source: Mueller-Stewens, G. and Lechner, C. (2003) *Strategisches Management – Wie strategische Initiativen zum Wandel fuhren*, Schaeffer – Poeschel Verlag, Stuttgart: 434.

⁹³ Carroll, L. (1872) *Through The Looking-Glass, And What Alice Found There*. Macmillan & Co, London: 42.

⁹⁴ Stowe, C. R. B. and Grider, D. (2014) Strategies for advancing organizational innovation. *Journal of Management and Marketing Research* 15: 1-17.

⁹⁵ Barnett, W. P. and McKendrick, D. (2004) Why are some organizations more competitive than others? Evidence from a changing global market. *Administrative Science Quarterly* 49: 535-571.

Both extremes require significant organizational capabilities and creativity. As well, it is important to be flexible and risk friendly if the environment is dynamic and fast. Both strategic decisions have consequences and risks, but in the end there is a possibility of great reward companies are willing to go for.

4.1. Term and importance of innovation

Innovation as a word is one of the most used in scientific literature and as term it is used in everyday life but the origin did not start in the modern period. Today to be innovative means introducing new ideas, things or methods, but the original meaning of the word was not a compliment but an accusation of heresy. Innovation comes from the Latin - *innovatus* with first known use in the Middle Ages, precisely in 1548 and it has been used in the literature for over half a century whose meaning changed many times since.⁹⁶ The first definition was made by Schumpeter where he suggested that innovations are changes in factors, which was vague for his period.⁹⁷ However, this term had an evolutionary development over years saying innovation is application of new technological, economical, organizational and social problem solutions that are focused to create organizations in new and better ways.⁹⁸

Peter Drucker said that innovation is an activity that fills resources with new capacities in order to create wealth. In other words, innovation creates resources that can provide an economical value through work. He also defines it as a specific tool of an entrepreneur that is used mainly in changing environments and it is a key element of entrepreneurship. If a company has no innovative activities it is doomed to fail or in other words, a company doing business in today's environment with such fierce competition has to "*innovate or die*".⁹⁹ Christopher Freeman suggests that under the term of innovation are segments of design, production, management, sales, marketing and other factors that can affect creation of new and upgraded products. Freeman realized the importance of innovations for a company and he had similar thoughts as Peter Drucker saying: "*not to innovate is to die*".¹⁰⁰

Most things can be put under the term of innovation such as new goods, new production methods, new distributive channels, new markets and new ways of doing business.¹⁰¹ Further definition of innovation says that it is a new combination of existing resources where they can also help to use new resources that did not have any value, create ones that did not existed before or provide new methods of using these resources. However, the latest and most adaptable international definition comes from the Oslo Manual established by the OECD (Organization for Economic Cooperation and Development): "*The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*".¹⁰²

⁹⁶ <http://www.merriam-webster.com/dictionary/innovate> (access: 20. 01. 2016.)

⁹⁷ Schumpeter, J. A. (1939) *Business Cycle - A Theoretical, Historical and Statistical Analysis of Capitalist Process*. New York: McGraw-Hill 1: 87.

⁹⁸ Vahs, D. and Burmester, R. (1999) *Innovations management, von der Produktidee zur erfolgreichen Vermarktung*. Schäffer-Poeschel, Stuttgart: 1. more in: Mitterdorfer-Schaad, D. D. (2001): 14

⁹⁹ <http://www.druckerinstitute.com/2010/08/innovate-or-die/>

¹⁰⁰ Freeman, C. (1997) *Economics of Industrial Innovation*. Vol. 3, Routledge, Abingdon, Oxon

¹⁰¹ Schumpeter, J. A. (1939) *Business Cycle - A Theoretical, Historical and Statistical Analysis of Capitalist Process*. New York: McGraw-Hill 1: 87-88.

⁴⁷ <http://www.preduzetnistvo.ef.ac.me/dokumenta/tehnologijaiinovacije-skripta.pdf> (access: 12. 02. 2016.)

¹⁰² OECD (2005) Oslo Manuals. Guidelines for Collecting and Interpreting Innovation Data, 3rd edition // OECD, Paris: 46. - <https://www.hse.ru/pubs/share/direct/document/76780100> (access: 23. 01. 2016.)

Importance of innovation is enormous and it leads to technological growth which increases company productivity and is considered as a determining factor of superior business performance.¹⁰³ These processes increase competitiveness among companies and countries, make new work places, develop health care, transportation and other goods and services that provide better life standard. The life of an average world citizen becomes a better place for living and working because of innovations. As mentioned in the previous chapter, companies were able to achieve competitive advantage just by producing more, cheaper, better and faster than its competitors, but today it is not enough. In table 2. is presented how over time different trends emerged in order to achieve the same goal. The movement up to today's question how to become innovative comes from the need to differentiate due to greater market dynamics, turbulences, customer needs and many different aspects that have changed over time or became faster.

Table 2. Process evolution over decades

Period	Trends and goals
60s	How to produce more?
70s	How to produce cheaper?
80s	How to produce better?
90s	How to produce faster?
Now	How to become more innovative?

Source: Rahimić, Z. (2006) *Izgradnja konkurentskih prednosti preduzeća kroz njegova strateška opredjeljenja*, Univerzitet u Sarajevu, Ekonomski fakultet, Sarajevo: 275.

It is nicely seen that the meaning of innovation and its purpose changes over time, where its functionality will be interesting to observe in the future period. All innovations are changes but not all changes are innovations, in other words a change can be considered as innovation for a company if it is used the first time in the market, which means that they are first movers. Thus, innovative changes have the same goal to increase efficiency and effectiveness where the decision of whether innovation will be used to produce cheaper or different products depends on company chosen key competences. Innovative companies are the ones that react to or create sudden changes in the environment that is today characterized as dynamic, turbulent, with shorter life cycles, and fierce competition that leaves no space for companies to relax and be satisfied with achieved performances. The new possibilities of new products do not only change the competition in the market but also newly define the industry in which they are involved. Such products have the capability to increase efficiency, productivity and ease of doing business in many other industries that in turn increases general well-being for the company, employees and customers.¹⁰⁴ In this way companies create new strategies where they offer an intelligent and connected world that will in turn give them a stronger global market positioning.

4.2. Innovation process and decentralization of knowledge acquisition

Generating new ideas about products or services is a starting and critical step in an organization's chain of innovative activities that requires special management. Development of a product or service is connected to the research and development department, but in

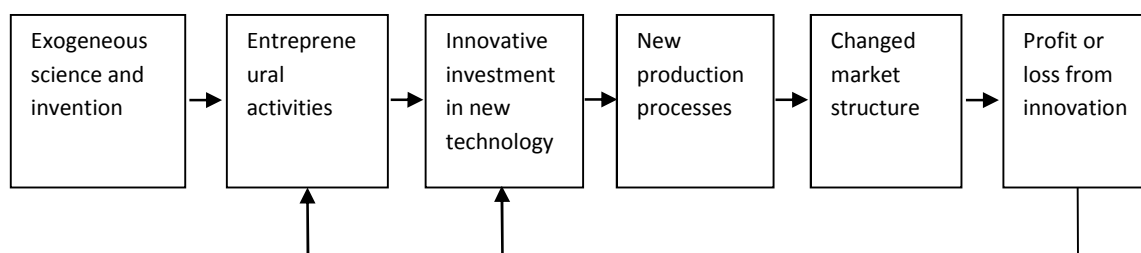
¹⁰³ Gumusluoglu, L. and Ilsev, A. (2009) Transformational leadership, creativity, and organizational innovation. *Journal of Business Research* 62: 461-473.

¹⁰⁴ Porter, M. and Heppelmann, J. E. (2014) Wie Smarte Produkte den Wettbewerb verändern. *Harvard Business Manager* 12: 1-28.

modern and innovative organizations development of product or service, besides R&D is in all other departments such as marketing, finances and product development. Further, usage of science and adoption of existing technology mainly from other companies in the market, together with its dynamics has been changing in different periods.¹⁰⁵ An important factor in innovative activities and organizational innovation in general is its importance of managers where they intertwine resources and new technologies for creation of the best outcome, which is in this case the smartphone.¹⁰⁶ These processes bring multiple benefits and challenges to the organization that controls changes of internal company forms and managerial practices.

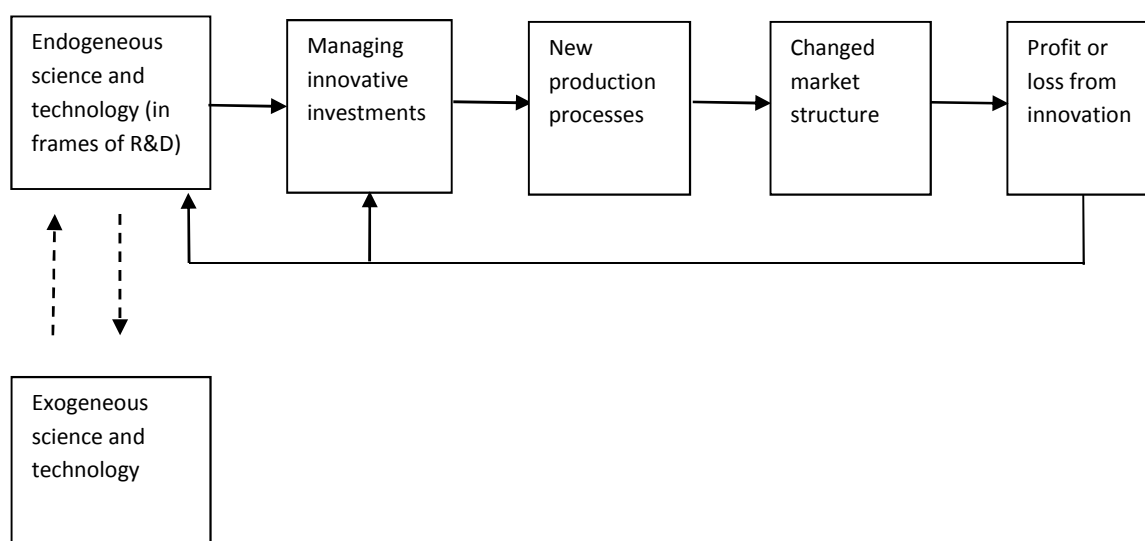
Schumpeter suggested two models and periods of innovation coming from his work "*Theory of Economic Development*" from 1912 and book "*Capitalism, socialism and democracy*" from 1943. The first model had the focus on technological innovations and economic development in the period before WW2 (figure 3.). This period was known to have fast and radical innovations independent from market demand. Some entrepreneurs were ready to take the risk and used invention directly in the production process and have seen potential for enormous profits.

Figure 3. Dynamics and impact of entrepreneurial innovation - Model I



Source: Lajovic, D. and Vulic, V. (2010) *Tehnologija i inovacije*. Ekonomski fakultet, Podgorica: 60

Figure 4. Dynamics and impact of entrepreneurial innovation - Model II



Source: Lajovic, D. and Vulic, V. (2010) *Tehnologija i inovacije*. Ekonomski fakultet, Podgorica: 60.

¹⁰⁵ König, M. D., Lorenz, J. and Zilibotti, F. (2015) *Innovation vs. Imitation and the Evolution of Productivity Distributions*. Department of Economics, University of Zurich - Switzerland / Jacobs University Bremen - Germany: 1-59.

¹⁰⁶ Razavi, S. H. and Attarnezhad, O. (2013) Management of Organizational Innovation. *International Journal of Business and Social Science* 4(1): 226-232.

The second model (figure 4.) is more adapted for the period after WW2, where development of companies and internal research was connected to technological developments and scientific improvements that happened exogenously. In that way innovative activities were institutionalized by big companies whose profits would be generated back to scientific research. This secured a situation where there are rather continuous technological and scientific developments than rare and radical ones.

The second model is very important because in the end of the 1990s and beginning of 21st century, big companies started massively to invest in research and development where they became carriers of global technological and scientific growth. Such visionary model of Schumpeter was correct and today it can be seen that big companies invest largely in research and development, and the same story can be applied for the Smartphone industry having Microsoft, IBM, Nokia, Samsung, Apple and many others spending millions of US dollars.

4.2.1. Strategies and commercialization period for new innovation

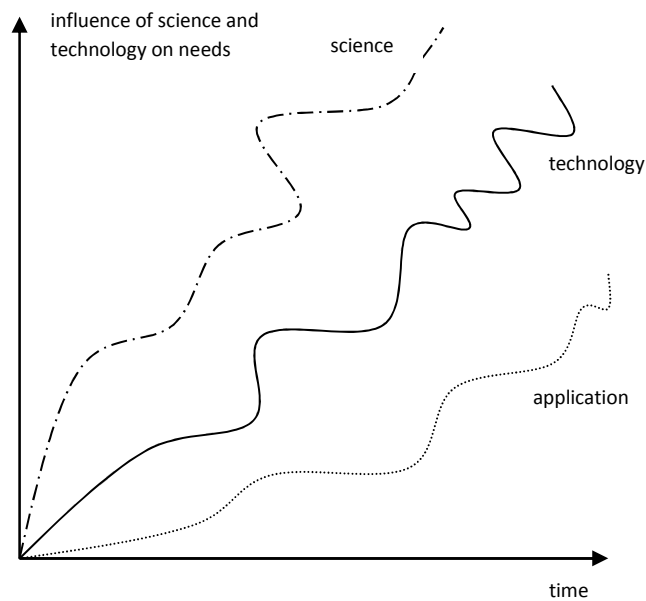
The process of innovation is engaged only by few entrepreneurs who might create profit and also provide better living conditions for the whole society due to the interconnectivity of different innovations. The increasing global competition in science and technology forces companies to invest more in R&D in order to transform innovative ideas into successful new products and technologies. So, new products create new markets that generate demand for new resources and materials that in turn motivate development of innovative technologies. Further, companies that are innovators are mainly first movers that can also experience social identity advantage as it is identified as the original product, and not some copy with low quality.¹⁰⁷ It could be said that entrepreneurship is based on innovative activities, and it was mentioned by Joseph Schumpeter who was the first that made a relationship between innovation with economic growth and technological development.

Technological innovation important for economic growth is initiated by demand and scientific discoveries that change technology for the production process in its early stages. After a certain period, when the industry reaches its maturity stage, characterized by new technologies, demand becomes greater and more important. Thus, new increase in product demand directly affects the development of technological innovation.

From figure 5. it can be concluded that there is a huge spread over time between science (theoretical and mathematical possibilities), technology (created mostly for military purposes) that is not available or currently too complex for commercial use and commercial mass application. Companies have two strategies where they introduce adapted or adopted technologies for their customers that will be covered below.

¹⁰⁷ Barnett, W. P., Feng, M. and Luo, X. (2013) Social Identity, Market Memory, and First-Mover Advantage. *Industrial and Corporate Change* 22(3): 585-615.

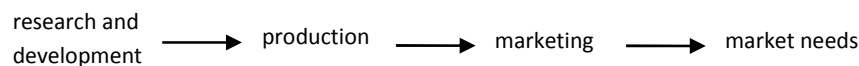
Figure 5. Spread of scientific discovery, existing technology and application



Source: Zelinski-Matunec, S. (2002) *Od ideje do profita: vodič za inovatore - poduzetnike*. Ministarstvo za obrt, malo i srednje poduzetništvo, Zagreb: 12

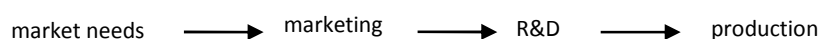
There are almost no activities today not related to innovation in every segment, and technology represents the main ingredient for its progress, as well as the key factor of economic development. There are two ways of looking at the strategic relationship between technology and organization known as technology push and market pull, and these are two ideas that affect company strategy. Technology push is a situation where R&D or some technology breakthrough drives launch of a product, which means that technology is interesting and valuable to customers and the market place. In the smartphone industry it can be observed in the touch screen option that was in a certain level a market necessity. Strategy technology push is easily explained with a model where discovery (idea, invention) moves through the chain of innovative activities, which will end with the application and innovation diffusion. It is considered as a business strategy suggesting that new innovation/invention goes through R&D, production and sales, but it does not take into account customer satisfaction.

The technology push strategy is easily shown as:



The second strategy is market pull also known as strategy pull or demand pull model. It suggests that certain needs or requirements from the market place demand different products for the problem solution. Companies receive information about these needs through different market research methods or potential customers, but it does not only involve development of new products but also improvement and modification of existing ones. It was developed because most cases in the market where technological innovation was applied gave results in practice but they were not verified by the market. That specific market verification is indicated by the expected business success.

The market pull strategy is shown as:



The cycles of technological progress and its life expectancy are segments of analytical techniques that are used by managers. They use it to easier perceive strategic questions for technology development and analyzing consequences of strategic decision.¹⁰⁸ Customer needs are an important segment, but besides them the market knowledge is also important for engaging innovative activities. Beginning is always the hardest, which is shown as the confrontation of technological feasibility and future customer demand that leads to creation of optimal product attributes as well as fine balance between *market pull* and *technology push*. This process is not only applied for products but also for services that can provide additional value to customers, creating their satisfaction, which can lead to greater profits for the company.¹⁰⁹ Innovation process is an integral part of product development and practical application of new ideas. This is a process of transferring invention (new knowledge) in new methods, techniques, technological processes, technologies and new or improved products.¹¹⁰ Today there is a rapid growth of the innovation number and their commercialization period is shorter every day. Therefore, companies need to know that innovation, new technology development and new methods are becoming their core competitive advantage.

Table 3. Time needed from idea to its commercialization

photography	112 years	(1727 - 1839)
telephone	56 years	(1820 - 1876)
radio	35 years	(1867 - 1902)
television	12 years	(1922 - 1934)
atomic bomb	6 years	(1939 - 1945)
transistor	5 years	(1948 - 1953)
integrated circuits	3 years	(1958 - 1961)

Source: Buble, M. and Klepic, Z. (2007) *Menadžment malih poduzeća – osnove poduzetništva*. Sveučilište u Mostaru, Ekonomski fakultet, Mostar: 92.

Concerning the innovation tempo it has to be emphasized that present-day markets posses a greater number of innovation and shorter time for its application. In 1914, knowledge transfer from development to production was about 50 years, between 1920 and 1940 the time needed was 16 years, whereas after 1945 the time became shorter and fell to 9 years. Even less time was needed in 1972 with seven years and the trend of shorter time required can be seen from the table above. Main reason why the cycle is getting shorter is the goal of first movers to bring competitors / imitators in to so call time trap. It means that innovators want to shorten these periods so that slow competitors are unable to enjoy great returns. Dynamics in the environment and great scale of production from the beginning puts followers in such position that if they are unable to reduce costs and application time, certainly will be eliminated and pushed out of the market.

¹⁰⁸Godin, B. and Lane, J. P. (2013) "Pushes and Pulls": The Hi(story) of the Demand Pull Model of Innovation. *Project on the Intellectual History of Innovation*, Working Paper No. 13: 1-39.

¹⁰⁹Toivonen, M. and Tuominen, T. (2009) Emergence of Innovations in Services. *Service Industries Journal* 29(7): 887-902.

¹¹⁰Buble, M. and Klepic, Z. (2007) *Menadžment malih poduzeća – osnove poduzetništva*. Sveučilište u Mostaru, Ekonomski fakultet, Mostar: 92.

4.2.2. Technological evolution and the S-curve model

Observing technological segment, the focus will be to the case that was implemented by the consulting company Arthur D. Little where they wanted to show the evolutionary development of technology inside a system. As its development rises the gap between service and manufacturing sector will shorten.¹¹¹ Also with these representations it is possible to predict future evolutionary steps and its limits for further technological development where it is also stated that the S-curve shows the speed of innovation implementation for given technologies.

The S-curve concept is an extension of the innovation theory within the whole industry and is essentially determined by the speed and relative advantage a company has concerning existing products. Its characteristic form has specific technological parameters observed through performance measures such as processor speed, camera resolution, storage, etc. represented in the time function.¹¹² It is also a visual manifestation of how technology development over time affects businesses processes, products or services, and it is used for over 50 years as a managerial tool. Further, it represents potential improvement over time and effort required for technological improvement in certain stages that is closely related to industry evolution. At the beginning of the curve birth, existence or new market opportunities are represented, characterized with slow growth (curve going up) until the whole process is better understood, while the end of the S-curve is seen as death or saturation in the market (reaching its peak) that is characterized with the development and existence of a new S-curve. In other words, emergence of a new S-curve is harmful to the existing process, which can be used by competitors to take over competitive advantage and market position.

Foster observed the S-curve and managed to explain the phenomenon of Henderson, where new radical technologies are brought to the market mainly by new entrants rather than by existing firms. Foster also points out that market leader has an issue in recognizing the occurrence of new S-curves and to protect their existing technology, which is the main reason why market leaders lose their dominance.¹¹³ There are several reasons why companies do not identify and fail not only to see development of the new S-curve but possible harmful implications to the focal firm as well. First issue is the lost ability to see market changes together with customer needs, and in the meantime the focal firm stops to focus and invest on development of new technologies and processes. Lack of capital and knowledge could hinder research and development of new products, processes, service or technology but many times the company fails to defend its existing business model and technology usually because they ignored legal rights e.g. patents. Further, they might be satisfied with the current situation and do not plan or are unable to create new markets or enter new markets to offer same goods in order to increase market share and reputation.¹¹⁴

The smartphone industry considers the technological environment as the most important segment that led to its rapid growth in recent years. As it is mentioned that disruptive innovations lead to merging of different industries, today the smartphone provides different

¹¹¹ Carlborg, P., Kindström, D. and Kowalkowski, C. (2014) The evolution of service innovation research: A critical review and synthesis. *Service Industries Journal* 34(5): 373-398.

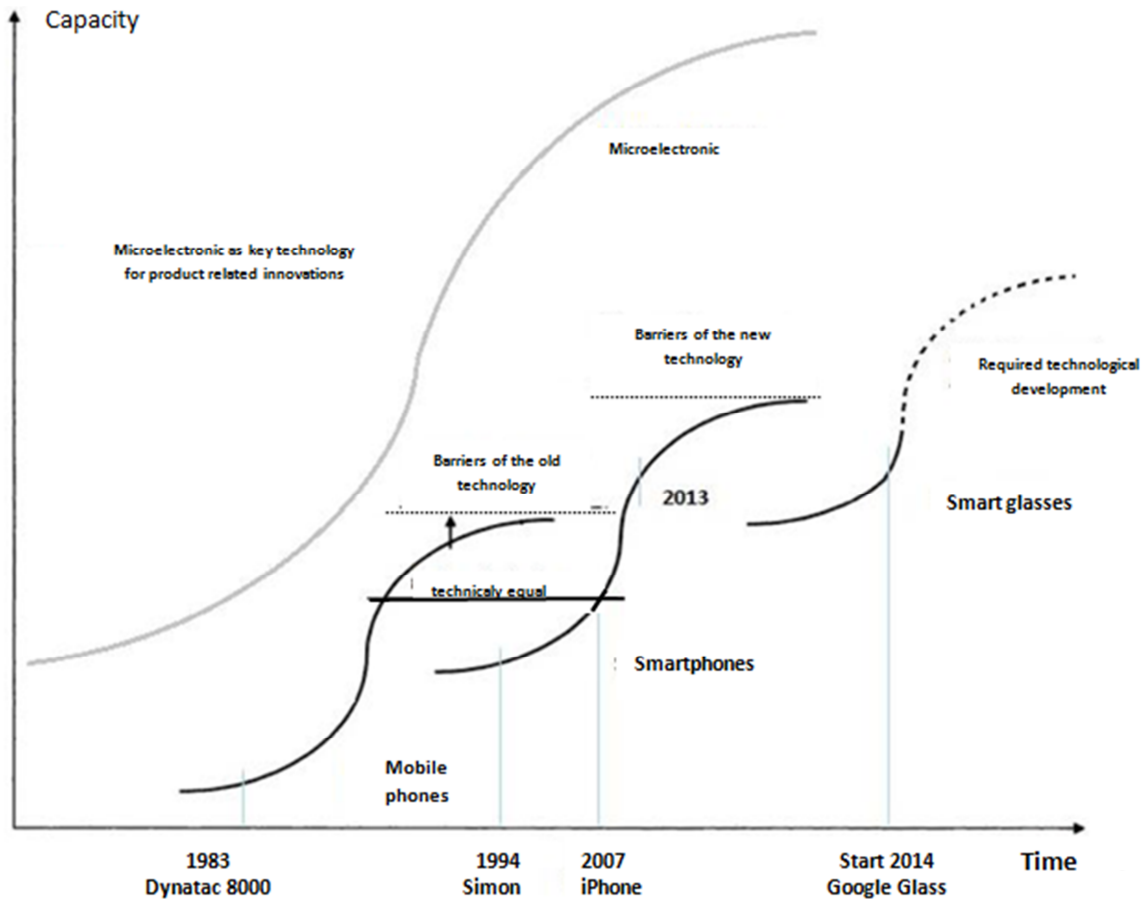
¹¹² Specht, G., Beckmann C., and Amelingmeyer, J. (2002) *F&E - Management: Kompetenz im Innovations – Management*. Schäffer - Poeschel Verlag 2, Stuttgart: 66.

¹¹³ Foster, R. (1986) *Innovation: The Attackers Advantage*. Summit Books, New York; Henderson, R. (1988) *The Failure of Established Firms in the Face of Technological Change*, Ph.D. Dissertation, Harvard University, Cambridge, MA.

¹¹⁴ http://www.innovation-point.com/Innovation_Lifecycles.pdf, (access: 03. 02. 2016.)

products and services coming from different industries.¹¹⁵ Technological progress in such globalized industries cannot be localized but it is spread globally. The S-curve concept seen below represents technological development, adapted to the smartphone industry, which considers the technological capacity that an industry experienced.¹¹⁶

Figure 6. S-curve of technology performance¹¹⁷



Source: Jung, R., Bruck, J. and Quarg, S. (2013) *Allgemeine Managementlehre: Lehrbuch für die angewandte Unternehmens- und Personalführung*. Berlin: 492

As it can be seen in figure 6, classic mobile phones, smartphones and the future product are shown. Different products are put into individual technological groups, seen as multiple S-curves over time, which shows how a certain product evolves over time and from the moment it reaches its limits, new and better technology is taking over. To explain more in detail the S-curve concept, it is important to focus on the above figure but only on individual curves, where it will be explained what their shape means. At the beginning the curve is flattened which is explained by large investments of capital, time, effort and other resources but little improvement in the new technology is achieved. However, after some time knowledge is accumulated, different technological difficulties overcome having the result of exponential growth. This phase is known that it does not require much effort and resources but will

¹¹⁵ Steinmann, H. and Schreyögg, G. (2005) *Management: Grundlagen der Unternehmensführung - Konzepte-Funktionen-Fallstudien*. Gabler Verlag, Wiesbaden 6: 179.

¹¹⁶ Bea, F. X. and Haas, J. (2013) *Strategisches Management*. UVK, Konstanz / München 6: 535.

¹¹⁷ Jung, R., Bruck, J. and Quarg, S. (2013) *Allgemeine Managementlehre: Lehrbuch für die angewandte Unternehmens- und Personalführung*. Erich Schmidt Verlag, Berlin 5: 492.

provide great results seen through increased gains in performance. Unfortunately, as every life experiences it slowdown and in the end possible death, the physical limitation of technology starts to push down performance growth and further increase becomes difficult. Also, disruptive technology might displace and eliminate returns with each new S-curve in the cycle. Such new technology can change the market competitive structure and general situation in the industry, where winners and losers change position. This situation brings us back to Schumpeterian creative destruction process which is said to be the main reason for progress in a capitalist society.

In the S-curve concept, situation where technological development starts to decline, both the technology and its users are in a bad situation where the probability of being overtaken by competitors that offer new technologies and products increases.¹¹⁸ Therefore, role of the management is to follow company development and position on the S-curve. When the time comes they should engage into search and development of technology that should improve its current position. However, the traditional model has some weak points where forecasting and mathematical models were too simplified, which forced managers and researchers to implement new, more complex but reliable models.¹¹⁹ Observing the S-curve it can be seen that the other right half is characterized by reduced research and development. In this case the company has to make the move of abandoning existing technology and make a new one. This situation is very risky and difficult to recognize because at that moment there is no need to engage in, and have additional activities and expenses, where at the same moment it experiences maximum performance levels.¹²⁰ But companies usually underestimate technological changing speed that might be harmful for future performance.¹²¹ Each phase is characterized by typical styles of management, covering different challenges and problem solutions. The life period is getting shorter each time due to technological progress and fierce competition where it can be said that each phase has not same duration and importance to the company.

4.2.3. Disruptive innovation

Every industry has a performance improvement period that has to be utilized and absorbed by customers. Some are very demanding where they are willing to purchase products that are luxurious, expensive and have great performance where on the other side, there are customers only ready to purchase or are satisfied with inexpensive and low performing products. The concept of disruptive innovation means that the technology used in this process is changing the industry. Customer needs and wishes regarding product characteristics are also changed where all mentioned should affect the situation regarding market competitiveness.¹²² Old industries and markets have been revolutionized through new technologies and processes as it was the case with the mobile industry changed by Apple. This change is mostly due to disruptive innovations and there has to be a differentiation whether they are traditional or disruptive.

¹¹⁸Christensen, C. M. (1992) Exploring the limits of the technology S-curve, parts I and II, *Production Operational Management*. 1: 334-357.

¹¹⁹ Czarnigowska, A., Jaskowski, P. and Biruk, S. (2011) Project Performance Reporting and Prediction: Extensions of Earned Value Management. *International Journal of Business and Management Studies* 3(1): 11-20.

¹²⁰ Becker, R. H. and Speltz, L. M. (1986) Making more explicit forecasts. *Research Management*: 31-33.

¹²¹Twiss, B. (1986) *Managing Technological Innovation* 3. Pitman Publishing, London.

¹²² Christensen, C. (2008) Disruptive Innovation and Catalytic Change. *Harvard Business School*: 1-4.

Great definition of disruptive innovation is a situation that changes the industry and brings the market leader in a worse position. It is important to consider that these innovations are not supposed to be put in the same place with all other industry changing innovations as each of them has different strategic approaches. Usually, it is a smaller company that manages to create something totally different out of minimum resources and challenges existing companies in the market. It is observed that market leaders put all their force in servicing companies that represent the majority of their income and ignore the demand from other customer types, which is understandable as they do not want to disperse their energy for an unimportant segment. However, new players are focusing on the ignored segments that makes them stronger, where after some time these *small* companies are heading toward the mainstream customer group and also own customers that were not important for the market leader. Traditional innovations have mainly gradual and evolutionary process development as they are done in existing companies and have not much room for more changes without increasing the risk. General description of such companies is that they seek great profits and focus on their most profitable customers opposed to companies engaging in disruptive innovations. Customers in the first innovation type are not interested in products from the later company as the quality or performance is not high, but the moment the newly innovated product matches their expectations, they will just accept it and turn back from the market leader. From that moment the market leader strategy starts to malfunction, and when they start to lose customers and profit they know how to become creative and innovative.¹²³

Major difference is that traditional (evolutionary) innovations are the ones where processes and products are gradually changed and improved. On the other side disruptive innovations are the ones that do not experience progress from the beginning as suppliers and distributive channels do not understand the application of that product and whether it is required by customers. In the end, this disruptive innovation will establish a new market and it will attract customers that were using products from the market leader and demand is generated from merging different industries. Great example comes from the smartphone industry where Apple changed the telecommunication industry and it merged different segments such as gaming, computer and mobile industry.¹²⁴ The commonly known characteristic of disruptive innovation is its lack of continuous development but such innovations occur as the company or managers understand the need of customers.¹²⁵ Also, disruptive innovations usually perform worse with new technologies than the existing ones. However, there is a process of performance development that is gradually increased and gains significance in the already existing market segments. Christensen¹²⁶ suggests that disruptive innovation is underperforming, cheaper and simpler in technical terms where on the other side Schmidt and Druehl¹²⁷ indicate that this particular innovation type is more expensive and technologically more complex such as is the case in the smartphone industry.

Traditional innovations are less risky and perform better than disruptive innovations because customers provide signals on their valuation at the market where the later is not popular or actually valued at the moment of its market introduction. In other words, disruptive

¹²³ Christensen, C. M., Raynor M. and McDonald R. (2016) Was ist Disruptive innovation?, *Harvard Business Manager*, Januar: 64-75.

¹²⁴ Knöchelmann, M. (2014) Disruptive Innovation als Erfolgsfaktor am Beispiel Amazon. *Fakultät Medien, HTWK Leipzig*: 1-25.

¹²⁵ Clayton, C. (2011) *The Innovator's Dilemma: Warum etablierte Unternehmen den Wettbewerb um bahnbrechende Innovationen verlieren*. München, Verlag Franz Vahlen GmbH: 6.

¹²⁶ Christensen, C. M. (1997) *The Innovator's Dilemma*. Harvard Business School Press, Boston MA

¹²⁷ Schmidt, G. M. and Druehl, C. T. (2008) When Is a Disruptive Innovation Disruptive? *Journal of Product Innovation Management* 25: 347-369.

innovations are given to customers even though they do not understand the purpose and functionality.¹²⁸ This shows that such innovations create a market for themselves where from the moment it can satisfy customer needs in the mainstream market, it is an open opportunity of this disruptive innovation to invade. However, both types have their limits where in the traditional innovation, companies are satisfying mainstream customer needs and they lose the vision and creativity where they have only seen the path of the existing product.¹²⁹ They also push innovations to the limits for greater achievements and enhance technological speed development, but they cannot succeed if the mainstream customer does not share the same vision and is equally or more satisfied. Thus, market preference is deciding whether or not and what kind of future is coming faster.

It can be concluded that disruptive innovation requires a long period and it does not guarantee that it will be successful, which is the main reason why companies avoid this process. However, most popular disruptive innovation was the iPhone from Apple that changed the whole mobile phone industry and it is considered as the birth of smartphones as we know today. Apple focused directly on customers who were primary to other companies but they offered something better and more attractive compared to others. Their success is not only connected to the product but also to their business model based on an internet platform and creation of its own network for iPhone users. Products or technologies are not necessarily disruptive but companies have the option to choose what path to take. If newcomers have a product with higher quality than it is provided by the market leader and they directly attack in the market, the later will for sure defend himself by lowering prices where it is most likely impossible for the new company to compete with or invest more in R&D where again the market leader has more resources and will likely come out as a winner. Disruptive processes are good for companies when they want to gradually develop their customer base until the moment they can offer something better to mainstream customers and hurt existing companies in the market.

4.3. Term and importance of imitation

In the business world imitation has a bad reputation. However, these companies generate large profits by saving R&D costs as well as the ones that occur in advertisement and marketing. The success of the first mover sends signals to other companies that they should follow the same path and this puts pressure on them to choose imitation as their strategy. When companies have great access to resources and enough time to explore the environment, it is preferred to learn, but if the company is working in an uncertain environment, where fast reaction and safe access to resources is required, imitation becomes the most attractive strategy.

As it could be concluded, time is an important constraint when choosing between imitation or gaining experience through innovation. Usually question arises whether it is better to save time through mimetic behavior or just go through the learning process. In the model of Rosenkopf and Abrahamson, the interaction between imitation, uncertainty and lagged learning is explored. They say that profits of first movers are transmitted to followers after a certain time period that is called time lag, and by having a longer learning period the follower is using its resource (time) wastefully and has huge opportunity costs. It is interesting that the

¹²⁸ Govindarajan, V. and Kopalle, P. K. (2006) Disruptiveness of innovations: measurement and an assessment of reliability and validity. *Strategic Management Journal* 27: 189-199.

¹²⁹ Lucas JR, H. C. and Goh, J. M. (2009) Disruptive technology: How Kodak missed the digital photography revolution. *The Journal of Strategic Information Systems* 18: 46-55.

effects of a greater time lag are greater in environments whose uncertainty is moderate. Companies as late movers in environments with low uncertainty just wait to see whether that specific innovation of first movers is profitable, while on the other hand in dynamic and uncertain environment the profitability information is unreliable.¹³⁰ Thus, firms might realize that in industries where fast reaction is required, the most optimal decision is to imitate, because experiential learning is slow even though mimetic processes have been proven to be highly suboptimal.

Innovation and imitation are closely related and unfortunately the attention has been only given to innovative activities and the value of imitation ignored. It has been usually connected to negative connotations and these strategies are considered as a parasitic process. As innovative companies are considered as better ones, they require protection from copying by establishing different systems together with patent implementation that should regulate the whole market environment.¹³¹ The major goal and principle of imitation is continuous improvement of effectiveness and efficiency regarding production and processes that require learning processes as well, because the goal of imitators is to create a product similar to the original but in order to trick third parties and patent protection, they have to modify that product or offer greater performance. Tokuyi Hayakawa a Japanese businessman suggests that imitation is a process of testing the effectiveness of the innovated product or process.¹³² One of the reasons why companies imitate is that they do not want to fall behind competition or because companies think that certain activities of rivals hold important information. If companies match the rivals actions, this can lead to greater competition and it can create a great environment for additional innovation and emphasize the mistakes of early movers. Creative followers have the ability to overtake the innovator and slow down its diffusion but on the other side followers that are not creative have worse performance and lower efficiency than the innovator.¹³³ Reason why imitation can be considered as a better strategy is that imitating companies is less expensive i.e. lower R&D expenditure, and the product in the market already offers enough information.¹³⁴

Imitation is a great strategy where almost 98 percent of all generated value from innovation comes from imitators and not from innovators. In order to have good imitation, it is important that these companies actively look for new ideas that are worth copying and those companies mainly observe very distant industries and countries. Imitators have also great cost advantage compared to innovators that have on average by a third greater costs. On the other side innovators can be protected through patents but the protection is very costly and limited where followers can implement some small changes on the product and the patent automatically is not anymore connected to the innovators product. Scientists in the past considered imitation as a primitive activity that is used by children or animals but after a more detailed analysis they realized that imitation is connected to intelligent behavior, with whose

¹³⁰Rosenkopf, L. and Abrahamson, E. (1999) Modeling Reputation and Information Influences in Threshold Models of Bandwagon Innovation Diffusion. *Computational and Mathematical Organizational Theory* 5: 361-384.

¹³¹Bessen, J. and Maskin, E. (2000) Sequential Innovation, Patents and Imitation. *Working Paper, MIT-Department of Economics*, Cambridge, MA. more in: Gimenez, G. (2011) Imitations, economic activity and welfare. *Facultad de Economía y Empresa, Universidad de Zaragoza*: 1-33.

¹³²Corniani, M. (2012) Innovation, Imitation and Competitive Value Analysis. *Symphony Emerging Issues in Management* 2: 37-52.

¹³³Venkatesh, S., Carpenter, G. S. and Krishnamurthi, L. (1998) Late Mover Advantage: How Innovative Late Entrants Outsell Pioneers, *Journal of Marketing Research* 35: 54-70.

¹³⁴Schnaars, S. P. (1994) *Managing Imitation Strategies: How Late Entrants Seize Marketing from Pioneers*. New York: The Free Press

help humans as species were able to survive in harsh environments or in other words, this strategy type is very efficient and deserves more attention.¹³⁵ Bearing in mind all of the above it can be said that imitation is very popular despite all negative connotations, especially in IT industries.

4.3.1. Information and rivalry based imitation

Logical behavior for followers is to ignore information they own and in turn imitate decisions others have made. To understand this, it is important to separate managers into good and bad or more precisely superior and inferior. However, people from outside are not involved into the whole process and know nothing about the type of each manager. Only what they assume is that superior managers have informative and better signals while inferior managers are struggling with purely noisy ones. Therefore, inferior managers imitate superior managers and ignore their own information just to be considered and evaluated by investors as the superior type, but also superior managers may receive misleading information which can be harmful for the whole industry.¹³⁶

First movers tend to be rational because they have to risk the most and analyze what the market needs, while followers or late movers have a tendency to seek status and engage just in symbolic activities. Thus, followers do not care or they are not concerned about investing more effort in understanding signals of other players in the market because they save energy and play the safe card by imitating large and prestigious firms. Such moves of followers provide them better bargaining power in the market and in uncertain environments, which is extremely great if the industry they are engaged in has scarce resources. In order to be able to continue with the process of imitation it is important to understand the process of isomorphism, which is explained as a process of homogenization and as a constraining process that forms one unit (company) similar to other units that face same environmental conditions.¹³⁷ Mimetic isomorphism is a process where the organization models itself similar to other organizations in the environment, if the same is uncertain. Inferior companies mostly model themselves according to organizations that are perceived as more successful and they expect cost reduction by reducing search costs and uncertainty.¹³⁸ Thus, mimetic isomorphism is considered as a rational decision by the inferior company, but sociologists suggest that such behavior is mainly due to ritualistic motivations and not ratio. Institutionalization mostly occurs in situations where many companies adopt a specific behavior that in turn becomes institutionalized or just taken for granted. Therefore, companies will adopt a popular behavior without thinking or doing any strategic analysis once there is a critical mass of companies that adopted it.¹³⁹

Imitative activities of companies are a process to eliminate aggressive behavior of competitors, weaken rivalry and risk in the market, and maintain better relative position in the market. Porter suggests that companies behave similarly because if some would engage in a different strategy, this would reduce the average industry profit and company ability to

¹³⁵Shenkar, O. (2010) Copycats: How Smart Companies Use Imitation to Gain a Strategic Edge. *Harvard Business Press*: 1-4.

¹³⁶Palley, T. I. (1995) Safety in Numbers: A Model of Managerial Herd Behavior. *Journal of Economic Behavior and Organization* 28: 443-450; Scharfstein, D. S. and Stein, J. C. (1990) Herd Behavior and Investment. *American Economic Review* 80: 465-479.

¹³⁷Hawley, A. H. (1986) *Human Ecology: A Theoretical Essay*. Chicago, IL: University of Chicago Press

¹³⁸Cyert, R. M. and March, J. G. (1963) *A Behavioral Theory of the Firm*. Englewood Cliffs, N. J. Prentice-Hall

¹³⁹March, J. G. (1981) Decision in Organizations and Theories of Choice. in: Van de Ven A. H. and Joyce W. F. eds. *Perspectives on Organization Design and Behavior* 14(3): 115-136.

coordinate actions efficiently. It is a safe strategy where companies strive to maintain the current situation of matching with the rival in order to hold the status quo.¹⁴⁰ Further, such behavior of following the leader who is the first mover in the market is the result of risk minimization, because if competitors match there is no space of getting better or worse relative to others.¹⁴¹ Thus, the conclusion is that imitation of industry members is likely happening because firms want to maintain the competitive position.¹⁴² However, in environments characterized as the "winner takes all", competitors may limit others in imitation through patent right for a specific technology so others cannot use it, which may lead to over-investments in the industry.¹⁴³ One might think why overinvestment is a bad thing, but customers only see the final product or service. Backstage processes during overinvestment create high fixed and variable costs, where companies have only the option to use economy of scale / scope. However, as production time in markets gets shorter due to overinvestment and over innovation, companies are unable to achieve this options and use the learning curve effect as well.

4.3.2. Distinguishing among imitation processes

Imitation happens mainly because companies want to maintain the same competitive position just from the belief that competitors have better information. This segment will be used to explain why some imitation types are likely in certain conditions, which can be helpful for managers to understand their rivals behavior and their own as well. Such knowledge explains them potential advantages and disadvantages of imitation under different environmental dynamics. Thus, there are:

- environmental conditions - if companies in a market are not rivals then it is assumed that the follower has information-based motives in engaging imitative actions. This mainly happens when companies have different market position, company size or resources, and where the environment is highly uncertain. Such asymmetry between companies limits competition which also might signal that the probability for the firm to have superior information is high. Situation where companies are rivals and compete in the market both imitation types can exist. The problem comes in distinguishing the most probable situation where one or the other imitative strategy occurs. Firstly, the rivalry based motive dominates in environments with low uncertainty and their information is similar to each other, whereas information-based motives dominate in highly uncertain environments and imitation is mainly focused during innovation of larger firms.
- environmental shocks - the above mentioned theories were simulated in environments with no shocks but for further analysis it is necessary to cover imitative behaviors in bad a macroeconomic situation, as recession. In such situations imitative activities also occur, making firms not sure about the level of recession in their industry. Just by observing behavior of their competitor, their announcement of layoffs may be important to overcome the fear of reacting too quickly and lose competitive position. So, from the moment one company starts cutbacks, many others will just follow its steps.

¹⁴⁰Chen, M. J., Smith, K. G. and Grimm, C. M. (1992) Action Characteristics as Predictors of Competitive Responses. *Management Science* 38: 439-455.

¹⁴¹Knickerbocker, F. T. (1973) *Oligopolistic Reaction and Multinational Enterprise*. Boston, MA: Harvard Business School.

¹⁴²Garcia-Pont, C. and Nohira, N. (2002) Local Versus Global Mimeticism: The Dynamics of Alliance Formation in the Automobile Industry. *Strategic Management Journal* 23: 307-321.

¹⁴³Dasgupta, P. and Stiglitz, J. E. (1980) Industrial Structure and the Nature of Innovative Activity. *Economic Journal* 90: 266-293.

- resource and complexity constraints - such constraints show that companies sharing similar resources are actually direct competitors. However, complexity of doing business is also a constraint on imitative activities. Also, companies that have required resources are in a better position to imitate simple operations, but if those are complex, adequate resources and highly skilled labor force are used as help.¹⁴⁴

Imitation can have positive and negative effects on companies and the society as a whole. On the positive side, information based imitation can make innovative processes much faster while rivalry based imitation can stimulate product and service improvement. However, both models of imitation may have negative effects that mainly occur when companies do not eliminate duplicative activities or investments and waste resources.

Empirical research suggests that rivalry based imitation increases competitive intensity in the industry and lowers profits.¹⁴⁵ In such imitation type the process goes through many rounds, where companies are matching moves with each other repeatedly. Such process of imitation at costs of others can make the focal company stronger and this type of competition is referred as the Red Queen effect and it is beneficial to customers because in the longer period it forces innovation, together with falling prices.¹⁴⁶ However, this will lead to elimination and shutting down many companies, where only few of them survive and it can lead to an increased market power. Managers need superior information and luck, so imitation can lead to superior choices through convergence that is mostly socially beneficial. For firms and industries to be stimulated and have fast growth, shared learning and competition is important, and companies may find themselves imitating unnecessary processes where after realizing that they mimic inferior actions, it can create a *competency trap* that spreads industry wide.¹⁴⁷

¹⁴⁴ Rivkin, J. W. (2000), Imitation of Complex Strategies. *Management Science*, 46, 824-844.

¹⁴⁵ Barreto, I. and Baden-Fuller, C. (2002), *Identifying Mimetic Patterns and Measuring Their Consequences among Profit Oriented Firms*. Paper presented at the August 2002 Academy of Management annual meeting, Denver, CO.

¹⁴⁶ Barnett, W. P. and Sorenson, O. (2002), The Red Queen in Organizational Creation and Development. *Industrial and Corporate Change*, 11(2), 289-325.

¹⁴⁷ Miner, A. S. and Haunschild, P. R. (1995), Population Level Learning. *Research in Organizational Behavior*, 17, 115-166.

5. Co-evolutionary processes and the Red Queen effect in the Smartphone industry

"Every once in a while, a revolutionary product comes along that changes everything ...An iPod, a phone, and an Internet communicator. An iPod, a phone...are you getting it? These are not three separate devices, this is one device, and we are calling it iPhone. Today, Apple is going to reinvent the phone"

Steve Jobs,
January 9th, 2007 at the Macworld conference

The mobile industry has always been an interesting sector with much potential, forcing continuous innovative activities. Such activities together with technological and technical change have made this industry extremely dynamic, with fierce competition characterized with few companies having the tendency of takeovers which makes this industry also highly concentrated. Even as great model creation could be observed over years, innovation among companies and development did not stop at any moment but it was progressed further and became more creative. First of all the importance of mobile phones is enormous, people stay in touch, families are connected, problems are solved quickly and everyday life is much easier. However, still in developing countries the penetration of mobile phone users is less than 50 percent of the total population and considering smartphones it is 20 percent. Forecast is that each year until 2018 this industry will have 130 million new mobile phone users.¹⁴⁸

In the following chapter statistical representation of development and growth of innovations through years should point out how dynamic and turbulent the telecommunication industry environment is, precisely the smartphone industry. There will be a critic on smartphone manufacturers by mutual comparison of technical characteristics of different models, where it can be seen that great development was happening in order not to lose its position in the market. However, such competitive activity can trigger the creative destruction where further development of the focal firm initiates actions of competitors, which forces companies to decide between two strategies, price war by undercutting rivals or differentiation.¹⁴⁹ In this case differentiation and innovation will be considered, as they are most optimal in the long-run compared to price wars that have positive effect in the short period. In conclusion it will be explained whether innovation or imitation are the main reasons that companies behave in certain ways and whether it provides different results in same environments.

5.1. The Smartphone industry

The actual definition of a smartphone wherever the source comes from, turns out to be a cell phone that includes additional software functions. Therefore, it means that these devices have many functions of a computer and an operating system that is capable of running applications for specific purposes. Actually, the difference between a “dumb” or regular phone and a smartphone is clear, even though the first is able to perform many of those functions. Therefore, from definitions below it can be concluded that it is a mobile phone with built-in functionality that through third parties and their applications is transformed to a portable computer.

¹⁴⁸ GSMA report on The Mobile Economy: Sub-Saharan Africa (2014): 1-72.

¹⁴⁹ Armstrong, M. and Huck, S. (2010) Behavioral Economics as Applied to Firms: A Primer. *Competition Policy International* 6(1): 1-44.

In order to separate those from normal mobile phones there are two definitions:

- mobile phone with implemented applications and internet access with additional processes such as SMS, email, internet usage, MP3 Player, cameras and videos. Besides these built-in functions there is also a possibility to use different applications that transform the phone to a transportable minicomputer.
- mobile phone that besides phone calls and messaging provides additional functions. Nowadays, most have the ability to take and play photos and videos, sending or receiving e-mails and surf the internet as well. Also, they may use different applications from third parties that offer a new universe of opportunities.¹⁵⁰

Looking at the development of the industry itself, it can be seen that infrastructural investment occurred in its early stages, which enabled further development of devices becoming more user-friendly. Each year smartphones experience exponential sales growth and become more involved in everyday life. Earlier they were considered as luxury but today almost everybody owns one and life without it is unimaginable. From its primary functions of sending and receiving messages, and making phone calls, it evolved to a small hand-held size movable computer with its own operating systems, many new functions and applications. All these functions and possibilities resulted to a rapid and unstoppable growth where together with it the market for applications became one of the fastest growing, but it will not be covered in this thesis and will be left for future research.

5.1.1. Smartphone development

Rapid development of technology in last few decades has been representative in the telecommunication sector as well, starting from the telephone invention in the 19th century, then development of mobile phones up to smartphones today. These devices have been developed relatively long time ago considering today's technological changes and dynamics. Beginning of the era was in 1970s where it was envisioned, but the idea was not real until IBM introduced the first in 1992. Simon Personal Communicator was the name of the first smartphone prototype that had a monochrome touch screen, operated by stylus that allowed sending and receiving fax messages, and a base station for battery charging. Simon had also a calendar, email client and notepad. but the phone was not able to gain popularity because it was too advanced for its days. However, it was just the beginning and it was known that there will be certain issues such as after using data for 60 minutes it was required to charge the phone, but without any doubt this was the first smartphone ever made, despite of being huge and heavy. Next key strategy in that period was the process of minimization and it required one decade to develop a smartphone that is small enough, with high performance and to achieve economy of scale through mass shipment.¹⁵¹ However, this process of minimization lasted until the next key period of introducing the touch screen where customers started to seek for devices with greater size, which will be covered further below.

There were another key moments starting from year 2006, where RIM introduced to the market a device based on BlackBerry and its focus group were business people with the possibility to use email, HTML browsing and instant messaging, where in 2007 Steve Jobs together with Apple introduced the iPhone characterized with continuous creation and modification of phone attributes. The iPhone became a benchmark for other manufacturers, even though it was not the first smartphone. It took Apple only one year (2007) to introduce its device, which was followed quickly by competitors where Samsung also just one year later

¹⁵⁰<http://www.merriam-webster.com/dictionary/smartphone> (access: 13. 02. 2016.)

¹⁵¹<http://pocketnow.com/2014/07/28/the-evolution-of-the-smartphone> (access: 13. 02. 2016.)

(2008) launched the Samsung Instinct model that from the beginning was making problems to Apple. From that moment the competition in that industry was very tough and in order to survive, these companies engaged in constant innovations and because of the need for innovative activities, these manufacturers created many types of models with different performances.¹⁵²

In the period from 2009 many models were using Android operating system that is owned by Google and with cooperation between Sony Ericsson, Samsung and HTC they developed an application store called Google Play. This characteristic of smartphones to use apps from third parties has led to significant success and development, unlike earlier regular phones. IOS, owned by Apple, on the other side had also a great period (after 2011) where together with Android they managed to double the number of applications in one year. Google and Apple cover over 90% of worldwide smartphone sales, in other words they are in a duopoly where Google with Android holds 80% of sales but for low (<\$150) and mid (\$150-300) class, whereas Apple is mainly focused to sell the iPhone to high (\$600) class customer segment. Such sales focus of Apple puts the iPhone at the top position in the industry and makes around 50 percent of company revenues. Leadership of both companies could be mainly felt in mature industries of Europe, United States and some parts of Asia. As the smartphone usage has been rapidly increasing, in last five years the competition moved from acquiring new users to methods of retaining existing ones.¹⁵³

Table 4. Global Smartphone Vendor Shipments and Market Share

Global Smartphone Vendor Shipments (millions of units)	Q4 '14	2014	Q4 '15	2015
Samsung	74.5	317.2	81.3	319.7
Apple	74.5	192.7	74.8	231.5
Huawei	24.1	74.1	32.6	107.1
Lenovo-Motorola	24.7	92.7	20.2	73.9
Xiaomi	17.0	61.1	19.5	72.0
Others	165.3	545.7	176.1	637.5
Total	380.1	1283.5	404.5	1441.7

Global Smartphone Vendor Market share (%)	Q4 '14	2014	Q4 '15	2015
Samsung	19.6	24.7	20.1	22.2
Apple	19.6	15.0	18.5	16.1
Huawei	6.3	5.8	8.1	7.4
Lenovo-Motorola	6.5	7.2	5.0	5.1
Xiaomi	4.5	4.8	4.8	5.0
Others	43.5	42.5	43.5	44.2
Total	100	100	100	100

Total Growth Year-over-Year	31.0%	29.6%	6.4%	12.3%
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Source: <http://www.gartner.com/newsroom/id/2996817> (access: 10. 02. 2016.)

Smartphone sale however, is considered as one of the fastest growing segments of the telecommunication industry. As it could be seen in table 4., shipments in 2015 were over 1.4 billion units while in 2014 the sale was 1.2 billion units, which represents a growth of 12.3 percent and compared to 2013 the growth was 29.6 percent having over 969 million units.¹⁵⁴ It indicates that this industry is entering a maturity stage and process of market saturation

¹⁵² <http://mashable.com/2012/10/15/cellphones-smartphones/#hsIZIGVe0Pqf> (access: 10. 02. 2016.)

¹⁵³ GSMA Analysis Mobile Platform Wars (2014) GSMA Intelligence, Mobile for Development Impact, 1-26.

¹⁵⁴ <http://www.gartner.com/newsroom/id/2996817> (access: 10. 02. 2016.)

where the space for further two digit percentage growth will likely disappear in a short period and products have the tendency of achieving the dominant design in these stages which will be shown in the empirical research.

5.1.2. Analysis of the smartphone industry

Entry barriers are relatively high where for the start, many hardware and software parts are patented by industry leaders and therefore protected by law. In other words any potential company that wants to enter the industry has to be significantly financially supported because potential lawsuits can happen and there could be other reputation damages if any violations are found. If there is a suspicion that one of large companies did something, the litigation between these large smartphone manufacturers mostly ends in a licensing agreement for each other's patents but these rules are not possible for new companies in the industry because they have limited knowledge and therefore limited intellectual property that is useless to the counterpart.¹⁵⁵ Moreover, customer loyalty is one of the greatest barriers for a new company as market leaders are Apple and Samsung. In order to have a successful business, companies have to focus on customer loyalty, which has been strongly potentiated by Apple that understood the importance of not just providing customers with a fair price but also offer a decent service and product.

Today companies are aware of the importance of having loyal customers and therefore they are introducing customer loyalty programs and besides everything, they put great effort just to keep customers loyal. The focus on customer loyalty provides insight on strategy and tactics that are key ingredients of building strong brands.¹⁵⁶ Having such strong brand in consumers mind is a great advantage because a highly loyal customer base generates higher sales and profits, where on the other side if the company has none is vulnerable and it has to create loyal customers. But creating new customers might be costly whereas keeping the ones you have is more profitable and easier.¹⁵⁷ Further there are huge capital requirements coming mainly from enormous sunk costs, which means that these costs are been incurred and cannot be recovered. In other words having such high sunk costs, it is difficult for competitors to enter the market because they have to give money without any guarantee of having returns from such investment. Therefore, for existing companies in the smartphone industry, this positively affects them through huge risk reduction. Further, large capital investments for buying manufacturing plants and machinery just to start the business is also a great obstacle but it is supposed to be productive and profitable over many years. However, there are many ways of acquiring capital such as financial institutions, venture capital, angel investors, banks and investors willing to risk that on the other hand ease the business process and make the market situation fairer.

The industry attractiveness is high considering buyers if their number is relatively high compared to the number of sellers. Thus, companies have a very low dependence level on one buyer and it actually almost does not exist. Worth to mention is that companies are playing on the safe side because they are protected due to the fact that network effects and switching costs falling on customers are relatively high. This means that there is a low probability that customers will switch from one product to another and also a good factor is that they are generally price insensitive but quality oriented, which creates much space for companies to

¹⁵⁵Aviram, A. (2010), Smartphones in the U.S.: Market Analysis Urbana-Champaign: Scott Cromar

¹⁵⁶Duffy, D. L. (1998). Customer Loyalty Strategies. *Journal of Consumer Marketing* 15(5), 435-448.

¹⁵⁷Reichheld, F. and Sasser, W. (1990), Zero defection: quality comes to services, <https://hbr.org/1990/09/zero-defections-quality-comes-to-services/ar/1>, *Harvard Business Review*, Sept-Oct, 1990, 105-111.

have large margins such as it is the case with the iPhone. Smartphones today have the capability of offering highly developed functionality starting from hardware and software, touch screen, web browsing and email that is unimaginable not to have. Further, superb connectivity is provided over Bluetooth, 3G, GPS or Wi-Fi. Interesting is that the power of their suppliers is moderately high as for hardware the market is scattered and undifferentiated for low technological parts. However, the high-tech segment such as chips have usually only a single supplier that owns 85 percent of market share and even Microsoft has its license. The mentioned supplier for chips is called ARM Holdings or ARMH. Software on the other side is created by their own programmers, which means that it is in-house developed.¹⁵⁸ Such creation of the whole smartphone architecture and operating system is very profitable for these manufacturers. The whole smartphone industry seems to be in a halt but on the other side, the component suppliers are in a much better position. That is why many manufacturers started to diversify their business, where for instance Sony acquired Toshiba for image sensors that provide continuous revenues in this division and for Samsung the semiconductor production is making the greatest profit share and not the smartphone business that has been the cash cow earlier.¹⁵⁹

Substitutes also represent a great entry barrier for newcomers and at the same time they are threat to existing companies in the market. Meaning of a substitute is that it can satisfy similar customer utility and in economics it is a situation where there is a positive cross elasticity demand, which means that by increasing the price of one good the demand of the other will increase.¹⁶⁰ Smartphones have a moderate threat level regarding substitutes and in this example three of them will be mentioned: personal digital assistant (PDA), iPad and notebook / laptop. All mentioned products provide similar functions and can satisfy similar customer needs, but the market situation shows that currently everything is on the smartphone side where its sales skyrocketed and started to take the scene from PC sale having in 2009 growth that seemed to be unstoppable. In the last five years the sales proportion between smartphones and PC's has been 2:1 globally, which is mainly explained by longer technological and replacement cycles of PCs.¹⁶¹

Considering the competitive structure in this industry it can be considered to be relatively loose because it has a relatively small number of competitors. From above it was concluded that the expected demand growth is still high but with a tendency of falling. This situation is due to increasing customer wishes for multi-functionality, where time management efficiency is required. In the end the greatest difficulty for a company that customers do not think about is the exit barrier. Similar to entry barriers, companies experience specific barriers in order to leave the industry if they feel the fall in performance. In the smartphone industry the difficulty would be in transfer of capital and application of the technology into something else, which is usually a segment that can absorb and apply these attributes. Further, for every company it would be relatively easy to change to a regular telecommunication industry or just offer specific terms under which it is ready to be acquired from some other company. It could be said that such risk and exit barrier is relatively-moderately low as these companies have many options and it is up to them to decide what path to take.

¹⁵⁸<http://www.bloomberg.com/bw/articles/2014-02-24/the-unlikely-tale-of-how-arm-came-to-rule-the-world> (access: 17. 02. 2016.)

¹⁵⁹<http://techpp.com/2016/01/04/smartphones-trends-2016/> (access: 18. 02. 2016.)

¹⁶⁰ <http://www.investopedia.com/terms/s/substitute.asp> (access: 17. 02. 2016.)

¹⁶¹ GSMA Analysis Mobile Platform Wars (2014), GSMA Intelligence, Mobile for Development Impact, 1-26.

5.1.3. Smartphone industry threats and opportunities

The smartphone industry is entering a slowdown period and being able to survive becomes harder each quarter. It can be observed that these manufacturers go through a crisis such as HTC that lost almost its share price value, BlackBerry announcing exit out of the industry, Sony reducing the number of smartphones and many others having trouble where they had to fire employees, except Apple. Below there are approximate numbers of lost jobs in the smartphone industry by following companies (2015):

- HTC ~2,000
- Lenovo ~ 3,200
- Microsoft ~ 7,800
- BlackBerry ~ 500
- Samsung ~ 10,000.¹⁶²

Obviously these companies entered in a bad financial situation that might influence the amount of R&D investment. Therefore, in the near future radical innovations in this industry should not be expected but some researchers suggest that innovation is not necessarily affected by the financial situation of the company. Even Samsung, one of the most successful players is losing money but on the other side Apple is doing well. The only difference Apple did was the focus on brand value, putting extremely high margins for their products, and scale of sold devices as well. Probably with the focus on very few models annually (usually it is just one), Apple did not spread its energy on the scope and used the learning curve effect making it the top earner by having total of about 94 percent profit in this industry and having only 14 percent of unit sales in Q3 2015, where in the year before at the same period it owned 85 percent which represents a huge jump in just one year. Samsung on the other side as the innovator takes only 11 percent of the industry profit and by summing up, the result is 105 percent which should not be correct, but the reason for this is that other companies failed to make profit or just lost it.¹⁶³

It can be seen that most of players have their own strategy but there is some similarity. Due to the slowing growth in the industry, which is expected to be a single digit number this year, companies are facing different problems. This drop in the growth is mainly because of saturated and mature markets from developed countries that happen to be the greatest markets. Top players managed to use the potential in these developed countries, whose population has greater willingness to pay and companies could just put high margins to their products. However, the potential comes from developing countries and the ones in transition especially India, Middle East or African territory but with a much lower living standard that pushes down margins.¹⁶⁴ That drop is not only due to adaptation to living standards and lowering the average selling price (ASL), but also because of the fierce competition that observed the same strategy and entered that market. Therefore, future situation and movements might be that companies enter emerging countries and have great increase in sale but gain less profit.

¹⁶² <http://techpp.com/2016/01/04/smartphones-trends-2016/> (access: 13. 02. 2016.)

¹⁶³ <http://www.businessinsider.de/apple-94-percent-smartphone-industry-profits-canaccord-genuity-2015-11?r=UK&IR=T> (access: 14. 02. 2016.)

¹⁶⁴ Internet Society Global Internet Report 2015: Mobile evolution and development of the internet: 1-139 (http://www.internetsociety.org/globalinternetreport/assets/download/IS_web.pdf) (access: 14. 02. 2016.)

5.2. Empirical research of co-evolutionary Red Queen effects in the smartphone industry

Regarding the above chapter of the Red Queen theory, in the following section quantitative models will be used in order to prove several statements because the theoretical part is not always connected to real world issues. From the implementation period of smartphones, where they were considered as only available for business people and status symbol, but after few years they became available to everybody and still some represent status in the society. Therefore, it is interesting to see whether products considered as high status have better technological performance than the ones meant for everybody. So, evolutionary patterns in one group or niche of seven widely known and biggest smartphone producers will be observed, which simultaneously should approve or reject our hypothesis.

5.2.1. The research main source

With the goal to see whether the Red Queen effect exists in the Smartphone industry secondary data source will be used concerning seven most influential and known smartphone manufacturers in recent years. For every company, maximum of three models were taken for each year from the web site Specout.com that has *The Smart Rating* designed to help potential customers find the most suitable smartphone for personal usage.

The Smart Rating is based on following attributes:

- 43.7% tech specs - based on phone depth, weight, maximum video resolution, camera option, interfaces and 9 more attributes
- 33.8% Expert rating - data from CNET Rating, LAPTOP Mag Rating, PC Magazine Rating, PC World Rating and WIRED Rating.
- 14.2% performance benchmarks - based on camspeed score, basemark OS II score, rightware browsermark score, gfx bench score and dxomark mobile score
- 8.3% overview and features - is just based on features and the release date.¹⁶⁵

Below it will be explained in what manner the data was applied. Further, checking at other available sources was important in order to increase the correctness and validity of data as well as some for older models was missing.

5.2.2. Analysis of the co-evolutionary Red Queen effect based on chosen smartphone characteristics

The data is taken from the period of 2007 which is the year of the "official" smartphone era when Apple introduced the iPhone with all its features until the latest data of 2015. It has been both, a technical and quantitative issue of retrieving data from these manufacturers and hundreds of models they produce. The method of getting relevant data was to take up to three best rated models of each year from every manufacturer. However, the differentiation and segmentation of each model by their class, category and price was avoided because its relevance was not very high due to the fact that every phone is available to every status in the society and its class. Also, data from this website was checked every time with other relevant websites such as GSMArena.com, ubergizmo.com, phone-debate.com and 91mobiles.com in order to get as precise information as possible. It was concluded that all data was identical and the industrial norms of consistency, full availability and zero mistakes have been applied. Even for manufacturers it is important to have full and correct data available from the global

¹⁶⁵<http://smartphones.specout.com/> (access: 15. 02. 2016.)

market in order to help customers in their buying decisions, have increased customer satisfaction and loyalty. The technical part was difficult for older models, where combination of internet research and asking official distributors for specific data was necessary. As it has been mentioned above, the combination of different technical magazine ratings, user ratings and checking whether the information is right, should be an indicator that there might not be a plausible reason to doubt the correctness of data. In order to represent evolutionary development and the Red Queen effect over years in the smartphone industry, the best performance of each category and year for the period of 2007 - 2015 has been monitored and analyzed in the MS Office Excel and SPSS.

Concerning the smartphone industry, co-evolutionary Red Queen effects can be observed in technological manner because companies understand their scarce resources known as the demand. Further, in order to prove this thesis, observation of technological development over time has to be done, which proves the growth of absolute values and having relative values between different companies at constant rates, which explains the Red Queen effect. To show these technological developments, 19 parameters (seen in appendix 1.) have been used to prove hypothesis from this thesis.

As the theory of co-evolutionary dynamics suggests that all players are involved in this process, the correlation between them will be used as the main statistical method. This mentioned statistical method shows how changes are connected with each other, if the used Pearson correlation coefficient is one than the changes are happening parallel (negative - going down, positive - going up). However, if the coefficient of correlation is zero it means that changes are happening individually with no connection between industry players. All of this will be graphically presented, which should easily explain the co-evolutionary Red Queen effect in the smartphone industry. Further, calculation to see whether the industry is entering its maturity stage and experiences saturation effects, the coefficient of variation will be calculated. This calculation will indicate whether or not a dominant design for smartphones is emerging and this state can also show the Red Queen process through innovative and imitative activities in the industry.

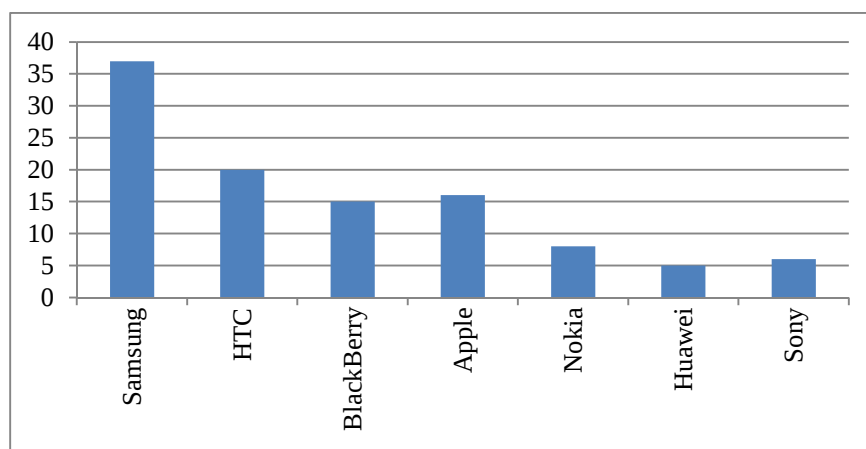
Price and market share have not been integrated in the data, which is understandable because the market share does not influence technical competence of a smartphone, for instance the iPhone that has one of the worst performances compared to taken models but owns about 95 percent industry profit. Therefore, these variables do not represent much and regression as a statistical method is rejected. For each company and each year, best characteristics are taken, which helps us to see co-evolutionary processes in the smartphone industry and eventually the Red Queen effect. Further, these characteristics were compared by the previous year. Each characteristic has been observed individually for the first mover, and it is the one that has the greatest value in the following year that at the same time is greater from all values of previous years. Then the number of times a company has been the first mover is counted and summed up (table 5.) by which it is seen that Samsung has been most frequently the first mover (37 times) and it is taken as a benchmark.

Table 5. Number of situations when Smartphone manufacturers were first movers

Company name	Number of times being first mover	%
Samsung	37	36.27
HTC	20	19.61
Apple	16	15.69
BlackBerry	15	14.71
Nokia	8	7.84
Sony	6	5.88
Huawei	5	4.90

It is interesting to observe that the origin of a company has no effect on innovative or imitative activities. Asian, especially Chinese manufacturers have the tendency to copy, which might be concluded from table 5 as well, having Huawei only innovating 4.9 percent of the time, but on the other side Sony as a Japanese company that is considered as an innovative and creative country is in the lower end being only 5.88 percent innovative first mover. However, South Korean Samsung (36.27%) and Taiwanese HTC (19.61%) are the two most innovative companies from this sample followed on the third place by Apple (15.69%), with an obvious misconception from regular customers to be the most innovative IT company worldwide.

Figure 7. Number of times being first mover



Apple on the other hand is known as the innovator and trend setter in the technology world, however in this table they just take the third place having only 15.69 percent of all innovation. An appropriate conclusion is that they were recognized in the early stages when they entered the market and introduced the first iPhone in 2007, which was very new. However, today they have a small crisis after its founder Steve Jobs died in 2011 and they still live from the old fame that is fading away slowly. In next sections it will be covered in detail why some companies have engaged as first mover but others remained still or just followed.

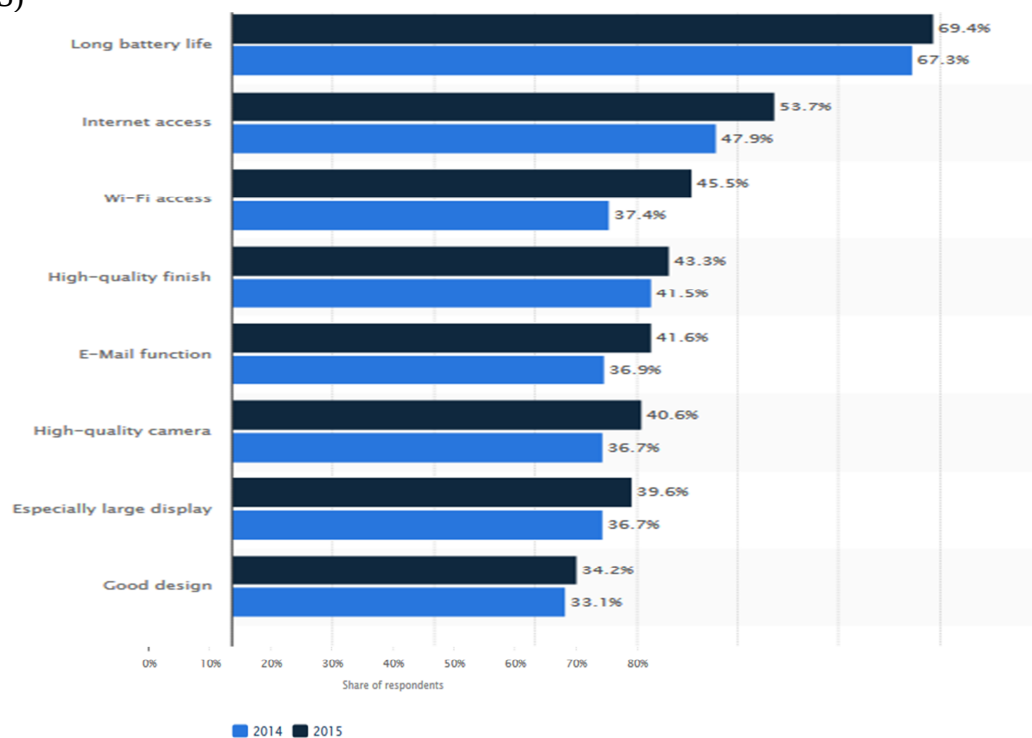
The co-evolutionary processes can be easily seen in different characteristics. As it is mentioned, the Red Queen effect means that in relative terms the difference between companies remains the same but absolute values increase over time. It is very hard and costly for a company to be involved in continuous innovation and performance improvement, where

in characteristics such as weight and memory there are no significant Red Queen effects or actually there was no necessity in their improvement.

5.3. Overview and analysis of smartphone characteristics for the Red Queen

The trend of producing modern parts and providing the best product for customers is greatly applied in this IT sector. Companies in order to stay viable in the industry have to improve their parts and influence the development of smartphones. To understand the competitive dynamics in this environment, it is important to continuously observe processes, and reason for so often changes are not only competitors or certain industry rules, it is also because of threats that arise over time from outside. In order to avoid these threats, companies are observing customers buying habits where major criteria for choosing specific smartphone are seen below.

Figure 8. Most important characteristics for buying a smartphone in Germany (2014 - 2015)¹⁶⁶



Source: <http://www.statista.com/statistics/463196/mobile-and-smartphones-purchase-criteria-germany/> (access: 15. 02. 2016.)

In figure 8. most important and attractive characteristics of a smartphone that customers are looking for when deciding to purchase a new device is represented. It can be said that most of characteristics taken for research purposes in this thesis are overlapping with this questionnaire. The top 10 characteristics are mainly weighting toward entertainment possibilities, brand and design whereas several last places are characteristics such as fingerprint sensor, tap-proof, MP3 player, etc. and these attributes are available in substitutes or not yet understood by customers. In the section below, most important smartphone characteristics and their evolutionary development will be observed, which should show the race between pray and predator.

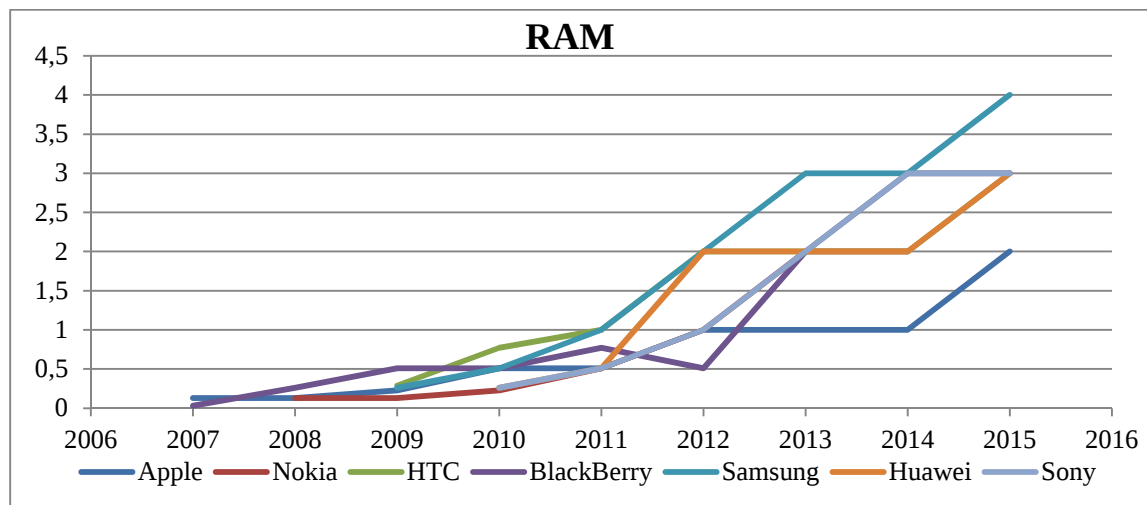
¹⁶⁶ The figure is cropped due to a great number of characteristic from original source and the necessity of providing the most important information to readers.

5.3.1. Random Access Memory

This category is a crucial part of each smartphone without which the same would be unable or it would be very slow to perform normal tasks such as accessing files. Their architecture makes a connection between Random Access Memory (RAM), internal storage (ROM) and the processing cores to retrieve data as fast as possible. Also, information that is required by the processor, such as operating systems, applications and game graphics are located in RAM, waiting to be activated and further applied. The great balance between RAM and the storage capacity can be seen in using an operating system that is about 2GB "heavy" and the storage allows efficient and dynamic ways of its application.

In our case Samsung will be considered as the predator whereas other companies will be the prey that have to survive. Starting with the first characteristic RAM it is seen that until the moment Samsung started to get involved in the industry, there has been an arms race between Apple and BlackBerry (figure 9.). In 2009 HTC quickly started to innovate, with the goal to be known as the trend setter which can be seen in the rapid development of the performance, but great marketing spending of Apple made it recognized as the trend setter. As mentioned above Samsung will be taken as the benchmark and from figure 9. is seen that it started to play a significant role from 2011. Even though HTC and later Huawei as the new entrant have been following with exact same performance level, the domination later occurred.

Figure 9. Trend lines for RAM (period 2007-2015)



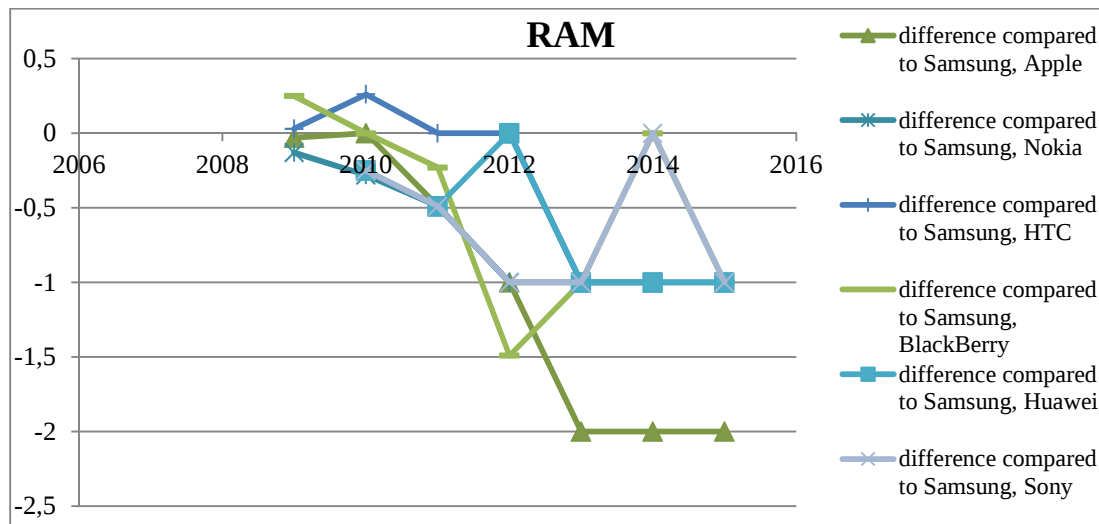
The Red Queen hypothesis can be proven just by observing the co-evolutionary trends over years. However, the following calculation has been done in order to show exactly how the Red Queen effect is happening. In the table 6. the correlation matrix is presented in order to show the co-evolutionary process in the industry over years. Despite of having a very small number of data, all coefficients of correlation are high and positive, which indicates a relatively good overlap of moves in observed companies. It is fascinating to observe how fast RAM performance increased due to the necessity for faster access to data, applications or different programs.

Table 6. Correlation matrix for Smartphone manufacturers - RAM

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.884	1.000					
HTC	0.961	0.888	1.000				
BlackBerry	0.826	0.903	0.773	1.000			
Samsung	0.918	0.989	0.966	0.890	1.000		
Huawei	0.915	0.868	0.993	0.740	0.960	1.000	
Sony	0.782	0.946	0.848	0.975	0.944	0.855	1.000

The Red Queen hypothesis is proved by calculating differences between companies compared to Samsung as the first mover and therefore predator where an arms race is observed. In figure 10. it is seen that all companies fight to be better than in the previous period, but the trend is not followed by Apple, which is falling each year. To be more precise, Apple is also improving over time, there is no fall in performance but they are developing in a much slower rate compared to Samsung and other companies. Each company at the beginning had similar performance to Samsung however, over time the gap between the leader and followers was increasing. There is a pattern of imitation in both figures, where companies behave accordingly in a specified period with approximately one year time lag behind the first mover. However, having more than one year time lag for imitating a specific performance can affect company performance, reduce its brand value, customer loyalty and in the end lose their relative market position.

Figure 10. Comparison with Samsung - RAM



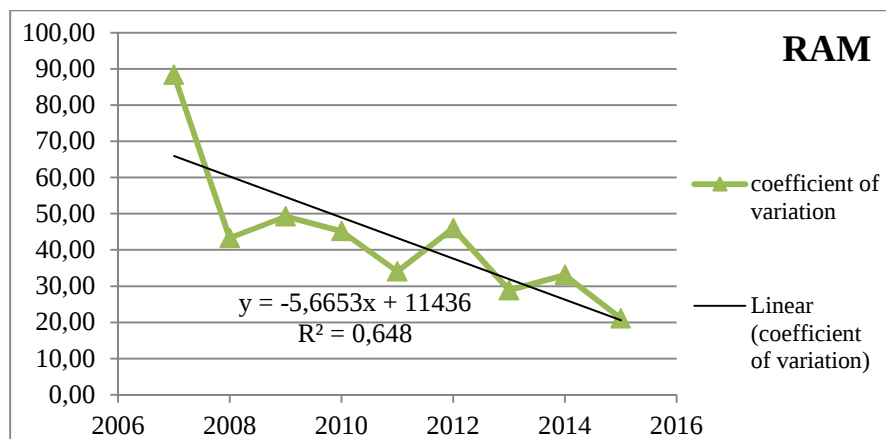
In table 7. it is seen that all coefficients of correlation between Samsung in year $(t-1)$ and other companies in year t are positive and high. This means that these other companies in year t have been following and imitating actions of the first mover, indicating the Red Queen effect as no company wants to be left behind and the fastest solution is to imitate. Considering this characteristic Sony is the greatest imitator with the result 1.000 indicating that it has been exactly mimicking Samsung's activities from the previous year. Apple on the other hand is imitating the least or it can be said that it is the slowest imitator (0.782).

Table 7. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t - RAM

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.782	0.946	0.848	0.975	0.855	1.000

It is also interesting to see at what life cycle stage smartphones are and whether technological saturation is approaching. This process is seen in the figure 11. that should represent the process of dominant design development for products and regarding RAM there is a falling tendency of the coefficient of variation (if we ignore small cyclical oscillations). Therefore, it is concluded that there is a tendency to achieve the dominant design regarding this characteristic, which concludes that demand for greater RAM performance is falling but there is still space for improvement. To continue, it is important to define what dominant design is because it will be calculated by using the coefficient of variation for each smartphone characteristic. Thus, it is a common design architecture that dominates in the industry, which usually is in the shape of a new product that has merged all individual technological innovations and that is most popular for consumers. This segment is very important as dominant design does not represent a hybrid or a combination of best technologies but a combination of all attributes that are most suitable and attractive to customers.¹⁶⁷

Figure 11. Trend for variability - RAM



This slow down might be logical because RAM only provides multitasking. If its capacity is greater, the greater number of processes, programs and applications can be used. If the smartphone has more RAM it does not mean that it will work faster but it will affect the performance such as multitasking. Therefore, if the capacity is filled up, it is indicated through slow application work and many LAGs. Because of the rapid growth of application usage and implementation of many new different functions in the device, it can be expected to still have growth but in a slower pace. Samsung as the first mover is announcing the next generation of smartphones that should have double the amount of RAM, which means that they are developing models with 6GB of RAM, increasing the gap between other company models. It is mentioned to be 20 percent more energy efficient and it will provide customers the opportunity of doing tasks with maximum performance. This evolution is happening soon, even though today's RAM generation by having 3GB represents the top of today capacity and

¹⁶⁷ Cecere, G., et al. (2014) Innovation and competition in the smartphone industry: Is there a dominant design? *Telecommunications Policy*: 1-15.

still many companies are using 2GB or even 1GB of RAM.¹⁶⁸ However, there is a little paradox where these manufacturers are increasing efficiency but at the same moment reduce battery life, that automatically downgrades the whole improvement to the same level.

Greater the RAM the better it is, because there is more information storage capacity and its availability when access is required. However, it is important to consider that by having more storage, the battery is used more and misbalance occurs in the system, but this is not even close to how much the display and processors are spending. Therefore, engineers managed to increase its efficiency just by having better operating systems, because these OS limit during multitasking processes of an application currently not in use. Even though these efficiency enhancing operating systems can provide better performance for less RAM, it is not enough for 3D models, games and sound that require high RAM storage. Thus, having more seems to be always a good solution in order to avoid LAG's and annoying loading screens.

Customers in the process of purchasing a device are also looking at RAM, but having only high performance in this characteristic is useless if the processing speed is slow, so the clock speed should also be taken into consideration. The whole link between these parts is confusing but briefly, the clock speed or processor provides greater potential for RAM. However, in the story comes battery life and because of that the processor does not go very high (usually 300 - 500 MHz), which is good for smartphones. Also the other way around, the RAM type affects the effectiveness of the processor and its consumption in MHz.

5.3.2. Central Processing Unit

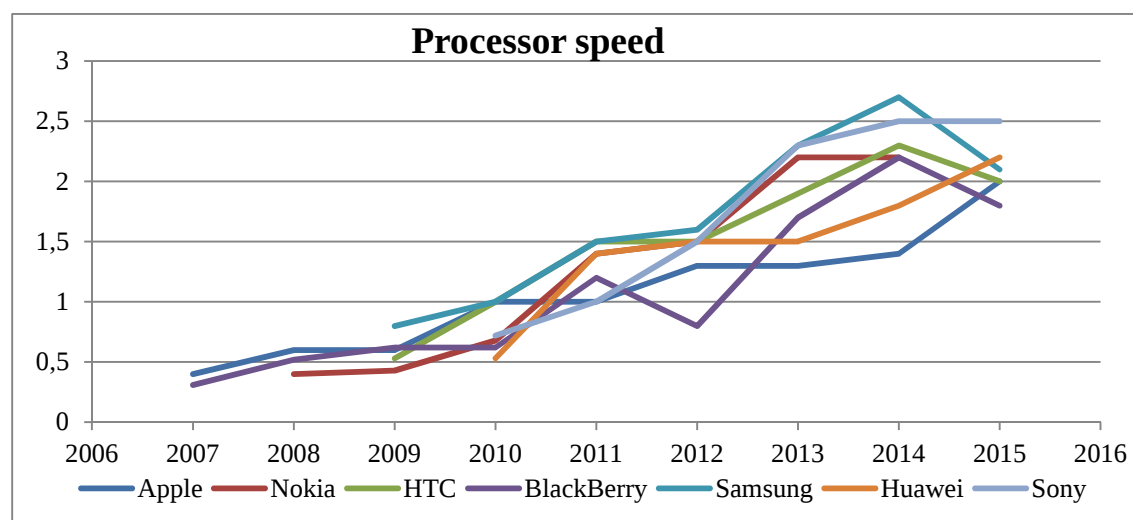
Processor is probably the most important smartphone component because it controls several actions and it is said that a processor or CPU is actually just a fast calculator whose task is taking information from the memory over which it is doing arithmetic and logical operations. Therefore, more complex the processor the greater number of tasks can be done in a time frame. Processor alone is not working but in the whole architecture there are precise tasks where besides the CPU there are various other chips obliged for different tasks.

First very good processors for modern smartphones were ARM, precisely ARMv6 and later ARMv7. Earlier companies have used ARM Cortex-A5 for flagships but today they were changed with quad core solutions that should improve lack of speed even though they are mainly 1.2 GHz. From the beginning many companies just used this model because of the cheap licenses for versions that spend less energy. The next step in the industry from ARM has been Cortex-A8 and later Cortex-A9 that were not much faster than Qualcomm Scorpion. With these processors smartphones started to become more serious, especially later with the combination of 1GB of RAM that were used in the iPhone 4s, Samsung Galaxy S2 or HTC that are still attractive to many customers. The next revolution occurred in 2012 in two ways, the first one was with models using ARM Cortex-A9 processors (quad core) together with 1GB of RAM with the screen size as big as possible, i.e. Samsung Galaxy S3 or HTC One S. The Google Nexus 4 that is the first model with quad core Krait processor and Adreno 320 GPU with 2GB RAM came later, but the point with quad core is to have better internal connection or relationship and the official maximum is to have 4 cores working simultaneously. However, through different designer actions it has been managed from two quad core chips to make an octa chip whose all cores are working simultaneously. The combinations of these cores is important also regarding battery usage, where different cores

¹⁶⁸ <http://www.androidcentral.com/samsungs-new-dram-module-will-lead-smartphones-6gb-ram> (access: 15. 02. 2016.)

have been made as the slow ones (savers) and fast that are spending the battery quick. The latest technology is Cortex A15 that is implemented in the newest models such as Nexus 10. Further, the question is whether the development of CPU technology for smartphones achieved its peak because the 2015 generation of flagships is not able to hold such power in small metal housings. There have been reports of overheating and shutting down of applications that have been solved with "under clocking" putting it back to the level of 2014, which is beautifully seen in the figure below. Therefore, the question is whether it is logical for customers to buy these new models with potential overheating despite its beauty and slim shape.¹⁶⁹

Figure 12. Trend lines for Central Processing Unit (period 2007-2015)



There are four major players in this segment: Qualcomm, NVIDIA, Samsung and Intel. Observing the Red Queen effect and co-evolutionary processes it is important to look at figure 12. Co-evolutionary effects are also involved in CPU, which is proven in both, the correlation matrix from table 8. and figure 12. According to data from the beginning Samsung has been the major leader and first mover in every year regarding the processor speed. Further, Sony and HTC have been the fastest followers that could achieve great performance with lower risk, and Samsung will be overtaken by Sony not because of the performance improvement but because of the lower need of customers for such great processing power.

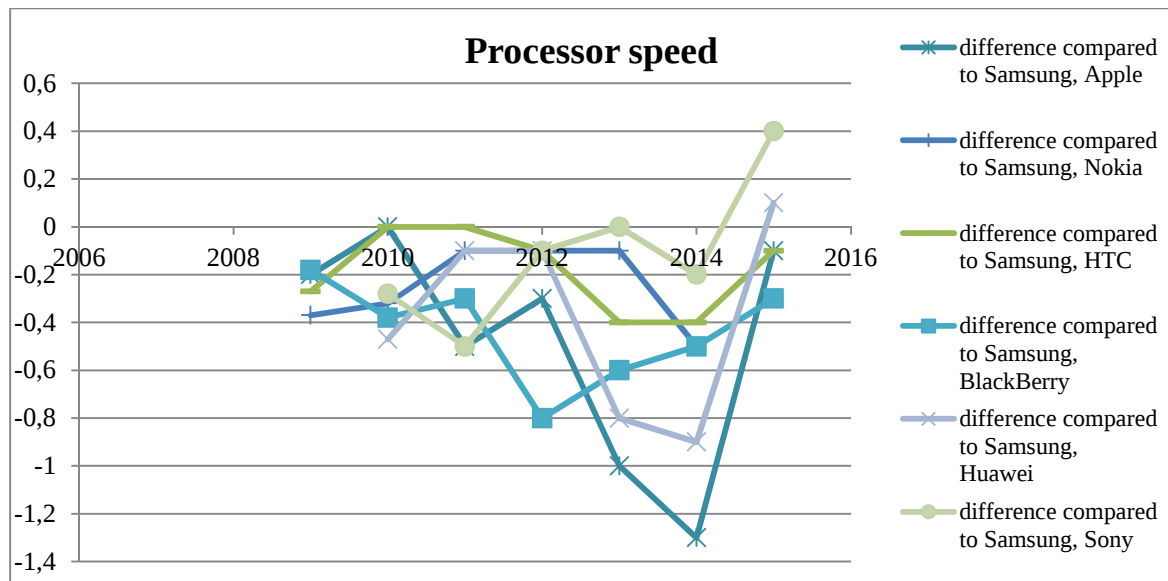
Table 8. Correlation matrix for Smartphone manufacturers - Central Processing Unit

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.915	1.000					
HTC	0.801	0.970	1.000				
BlackBerry	0.803	0.910	0.922	1.000			
Samsung	0.714	0.973	0.972	0.953	1.000		
Huawei	0.831	0.892	0.855	0.760	0.758	1.000	
Sony	0.783	0.956	0.939	0.892	0.936	0.836	1.000

¹⁶⁹ <http://in.pcmag.com/opinion/65083/2014-mobile-application-processors-arm-based-vendo> (access: 16. 02. 2016.)

As mentioned above, the reasonability of producing such powerful devices was questioned because devices started to overheat in these small metal boxes with the tendency for lowering thickness and the popularity of reducing weight. It is also interesting to observe slow growth of Apple processor speed that catches up in later periods, most likely because they started to use Samsung technology. Even though there is a small coefficient of correlation between Samsung and Apple, the forecast is that over time it will increase as they engage in several partnerships or share certain technology, even though patent charges have often be made.

Figure 13. Comparison with Samsung - Central Processing Unit



The Red Queen effect is clearly seen in the figure 13. together with the arms race between several companies. Most companies had a great decline in performance compared to Samsung from 2011, especially Apple, and it just reacted in 2014 where it managed to increase CPU speed. From this it can be seen that Sony is the fastest imitator, but if we take a look at table 9. it is seen that the coefficient of correlation is greatest for Apple (0.928), meaning that it is the greatest imitator, however Sony is in the end the best performer for sure.

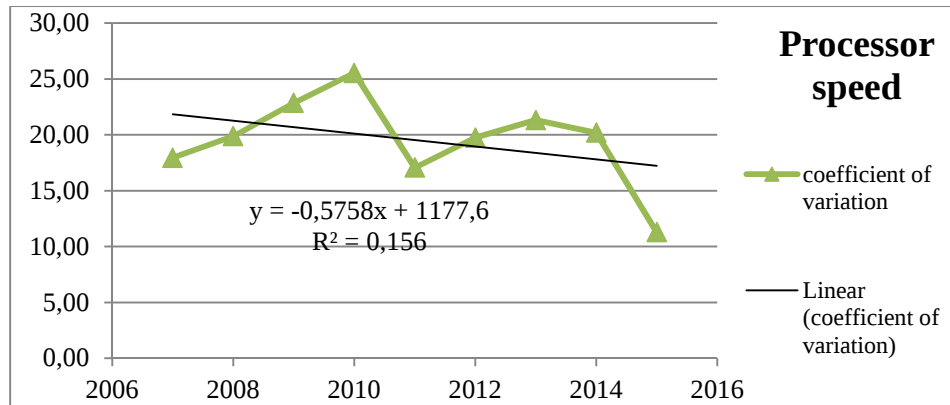
Table 9. Correlation matrix for Samsung in year ($t-1$) and other companies in year t - Central Processing Unit

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.928	0.861	0.858	0.800	0.896	0.914

Sony's quick reaction to the changes is very impressive that might be explained through the convergence of industries because Sony has been specializing in other technology devices (Play Station) that require great processor speed. However, as it was mentioned above, neither Sony nor Huawei have better performance than Samsung but the positive result is due to the decline of Samsung performance from the previous year that might be explained by the difficulty of cooling down devices and the actual need for such strong, eventually more expensive phone for customers. This decline in performance is not only seen in Samsung but in BlackBerry and HTC that can be considered as the weakest imitators (lowest coefficient of correlation, 0.800 and 0.858 respectively), but in the end performance of others remained equal. All other industry players are giving their best to stay alive or in other words

competitive compared to Samsung where mostly they need just one year to imitate Samsung but to have the same results companies need few years. This relatively slow reaction speed indicates the difficult environment and the dynamics in that industry.

Figure 14. Trend for variability - Central Processing Unit



According to figure 14., the observation shows no increasing or decreasing tendency because the cyclical oscillations are very high. This tells us that the dominant design regarding Central Processing Unit is far away and it is logical as the lack of technological development relative to the first mover is high. Also, further technological development of the first mover are uncertain because other attributes such as the cooling system or the actual need for stronger processors has to appear that might trigger further predatory actions due to the trend of producing slim shaped models.

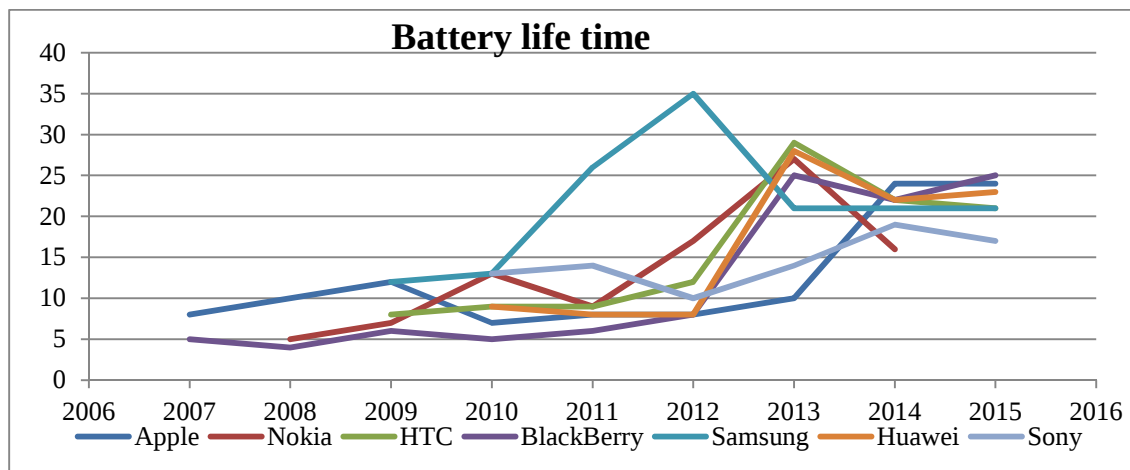
Additional explanation of not approaching to a common processor speed or achieving the dominant design may come from the Moore's law stating that the number of transistors is going to double every two years, whose progress is expected to slow down as he stated in an interview in 2005: "It can't continue forever...". Moore's law is expected to stop around 2025 but some forecast that it will last for few more centuries suggesting that in the end "everything gets better and better."¹⁷⁰ However, smartphones and current functions they provide, having additional transistors and greater processor speed will possibly reach its optimal maximum in couple of decades. Thus, dominant design can be expected from the moment this break-even point is achieved, where having even better performance is harmful for the whole device.

5.3.3. Battery life

This category is one of the most important concerning the smartphone. Some users love big screens, strong camera, processor, memory or even design but for everybody the battery life is important. The point is to have a long lasting usable device but these strong corporations focus mainly on different software that should increase efficiency instead of just inserting a stronger battery.

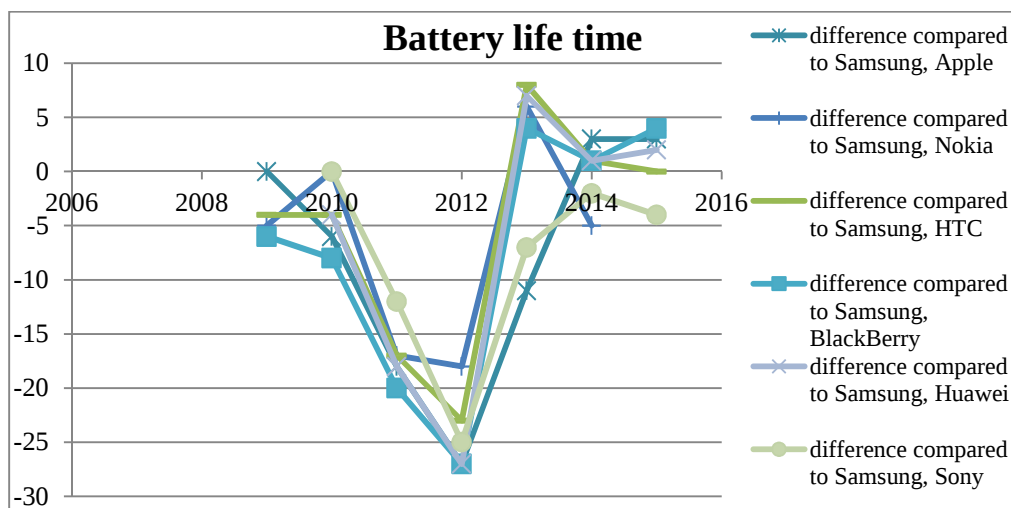
¹⁷⁰ <http://www.economist.com/node/3798505> (access: 16. 02. 2016.)

Figure 15. Trend lines for battery life time (period 2007-2015)



In figure 15. it is easy to see that Samsung has been very dominant concerning battery life, which increased from 2010 the following three years rapidly and dropped at almost the last place in 2013. It is interesting to see that other market players needed these three years just to improve battery life and they did not manage to come to the point where Samsung was in 2012 when it started to fall. However, sudden increase happened with Nokia, HTC, and BlackBerry up to Huawei where in some cases there was a growth of over 250%. Next year Samsung reduced their performance rapidly and in the following period others did the same move. Unfortunately, continuous growth stopped and absolute values experienced a halt, which explains very low coefficient of correlation seen in the appendix 2. at tables 21. and 22.

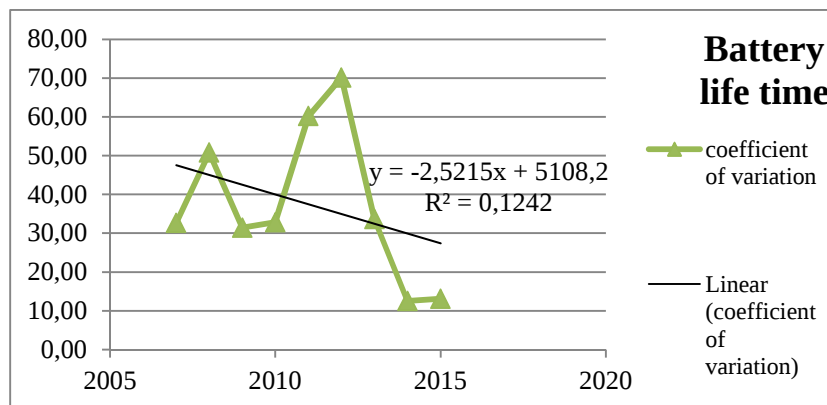
Figure 16. Comparison with Samsung – Battery life time



The process of the Red Queen is nicely presented in figure 16, together with the explanation of co-evolutionary processes in the nature. When the predator is too strong it has no need in spending too much energy for hunting and the same happens with the pray after it increased performance, realizing in the following periods that there is no need to spend additional energy if not in danger. Obviously Samsung is here the predator and the first mover whose action is imitated very quick and adapted to customer needs after understanding the best way to increase profits. From the fall in 2013 most companies remained in a relatively equal performance level where some experienced additional fall next year, but it all stabilized in

2015. Nowadays the trend is in fast charging batteries that can be ready in few minutes and the focus is also in wireless charging. It is interesting to observe how companies are fighting and moving boundaries in order to hold their position but not well known companies offer models with twice as strong as the ones having great brand value and do not experience sudden popularity. This tells that still brand value, customers' irrationality and the social need of being recognized in a certain group by the same society are still a huge factor for general company success and effort. Further question is why not companies that have a strong brand, do not increase the battery life and attract new customers if it is one of the crucial features required from customers.

Figure 17. Trend for variability – battery life time



Also the tendency of having mutual battery strength is not good because the cyclical oscillations are strongly expressed (figure 17.), which means that the potential of having better batteries is very high but there is a slight slowdown in the recent year that can be interpreted of approaching the dominant design, which is less likely to happen soon. Possible reason is that companies are enjoying this segment of having power where they made an unofficial agreement of gradually providing better capacities just to satisfy current customer needs, while the truth and real potential is covered behind.

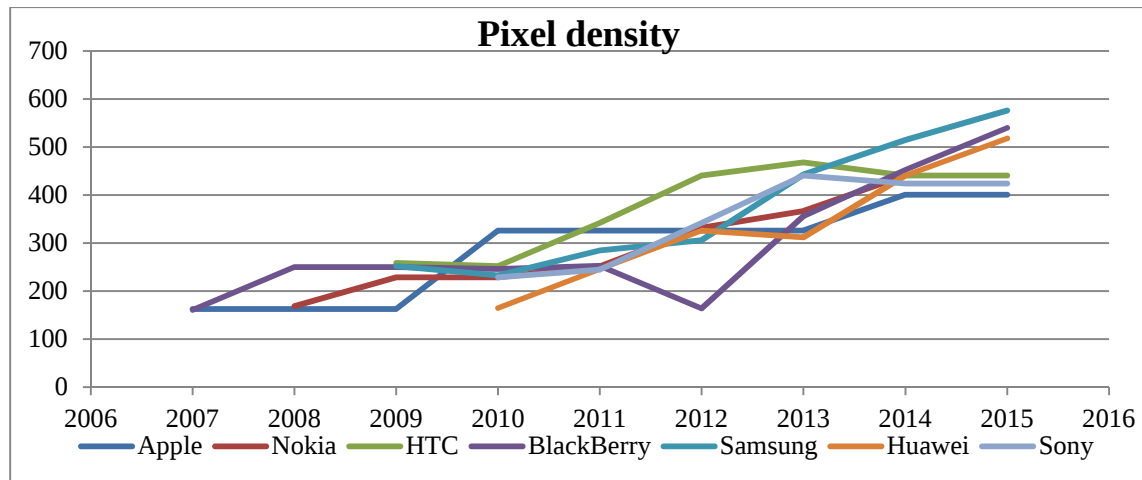
5.3.4. Pixel density

Today smartphones are also focusing on the PPI (pixel per inch) ratio that represents the number of pixels located in one square inch surface. Through this method customers and also companies can measure the sharpness and how clear the display seems to the eye. By mentioning the human eye, there has been a huge debate regarding the pixel per inch ratio. As it is observed from the data Apple did not improve this category for about four years and it remained 326 PPI from 2010 until 2013. The argument for the non-development was that the human eye has no ability to differentiate single pixels from the moment it goes above 300 and Steve Jobs set this optimal number of pixel density, as customers will not feel much difference. To prove this statement, several tests have been done where customers could not distinguish the improvement from 432 PPI to 577 PPI, especially if it is considered that normal reading distance is about 30 centimeters. Therefore, the question is made whether it is important to have high pixel density because of natural limitations of our eyes and at the same moment the battery life is largely affected.

Higher pixel density does not only affect battery endurance but also they require better chipsets, especially if the customer is used to play games with high graphics. The only benefit

with greater pixel density is that pictures and graphics will be much clearer. Negative effects are as mentioned above battery draining and increased price with no actual difference due to the limitations of the human eye. Great balance is seen with Apples iPhone where they have the Retina display models that are making the balance between the PPI and battery life. However, Samsung has greater pixel per inch density but also more energy efficient screens than the iPhone, which compensates the battery drain. So, the goal of every smartphone is to have the battery going for at least 24 hours with moderate or high level usage especially if it requires eliminating features that will make no major difference.

Figure 18. Trend lines for pixel density (period 2007-2015)



The comparison between Samsung Galaxy (576 PPI) and iPhone (401 PPI) is that there is a 30% difference in the resolution which is very high. However, despite the fact that there is no need to improve much above 300 PPI, companies are fighting for the domination in this segment because customers only understand that by having more it means better. Samsung now is the leader but HTC has been most of the time dominating in this category. The co-evolutionary effect is seen from figure 18. and as well table 10. that shows a high correlation coefficient to most of the companies and Apple with the lowest one.

Table 10. Correlation matrix for Smartphone manufacturers – pixel density

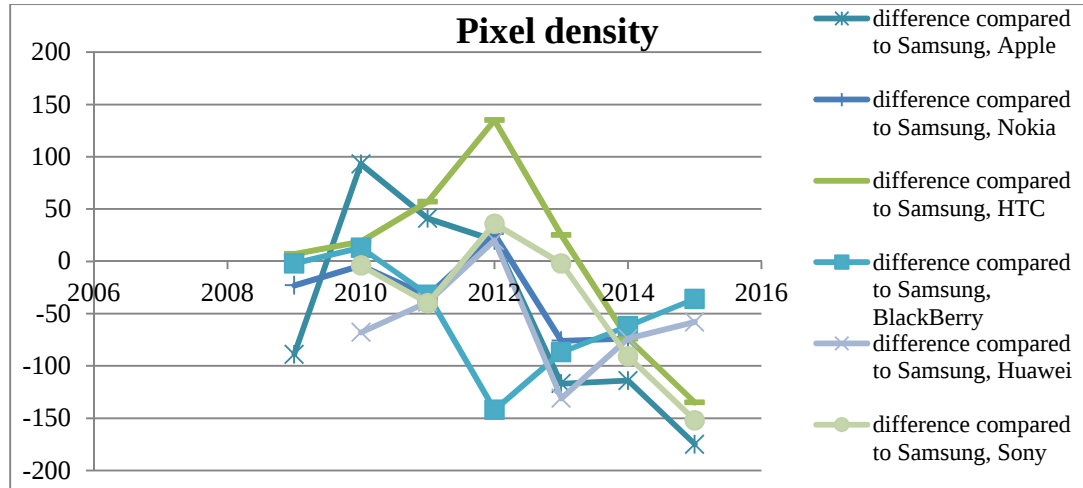
	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.783	1.000					
HTC	0.655	0.876	1.000				
BlackBerry	0.664	0.668	0.483	1.000			
Samsung	0.698	0.957	0.776	0.924	1.000		
Huawei	0.875	0.961	0.751	0.810	0.935	1.000	
Sony	0.598	0.932	0.907	0.693	0.892	0.811	1.000

BlackBerry has been mostly at the lowest position over years because their customer focus was on business people. The only thing they required is to send emails, SMS, follow other types of connections and they did not see any need to provide better resolution.¹⁷¹ However, as other companies started to provide the same functionality and became more interesting also

¹⁷¹<http://www.pcmag.com/encyclopedia/term/64138/google-play> (access: 17. 02. 2016.)

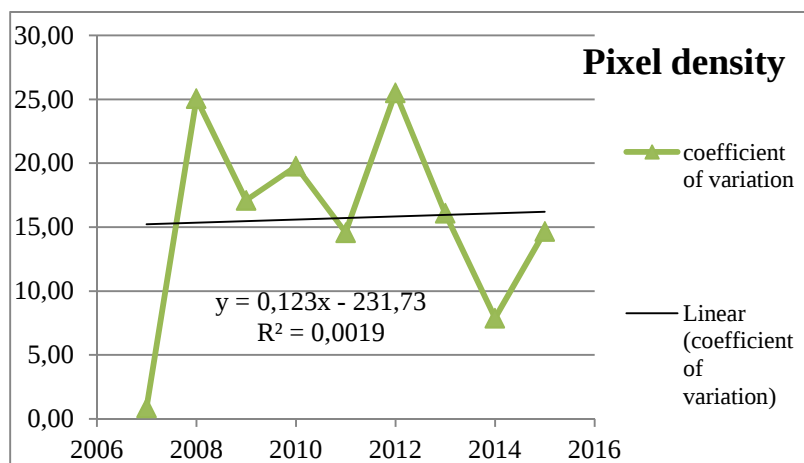
for business people, i.e. iPhone that with its applications was refreshment to the whole industry, in order to survive BlackBerry started to focus more on interactive functionalities with better graphics.

Figure 19. Comparison with Samsung – pixel density



Relative to Samsung companies are fighting against each other where compared it is seen that these companies have similar movements that indicates the Red Queen effect, but in this situation BlackBerry has its own strategy (figure 19.). Apple started to put pressure in 2010 but next year it was followed and overtaken by HTC. Clearly seen from 2012 BlackBerry started to lose their customer base as they were attracted to other models that offered identical functionality they needed. Obviously BlackBerry had to react very quickly and this reaction is seen by overtaking all other companies in the next three years, becoming the best performer. Companies had radical improvements regarding this category and in 2015 there are three companies (BlackBerry, Huawei and Samsung) with over 500 PPI with Samsung at the top.

Figure 20. Trend for variability – pixel density



Also in figure 20. we cannot talk about an increasing or falling tendency because cyclical oscillations are significant here as well. This indicates that companies are still innovating and looking for better ways of providing more pixel density even though it is not necessary after a certain amount. This may be only a marketing trick such as Apples Retina display and if

devices have unnecessarily greater number of PPI it puts greater stress on the battery and CPU / GPU.

Table 11. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t - pixel density

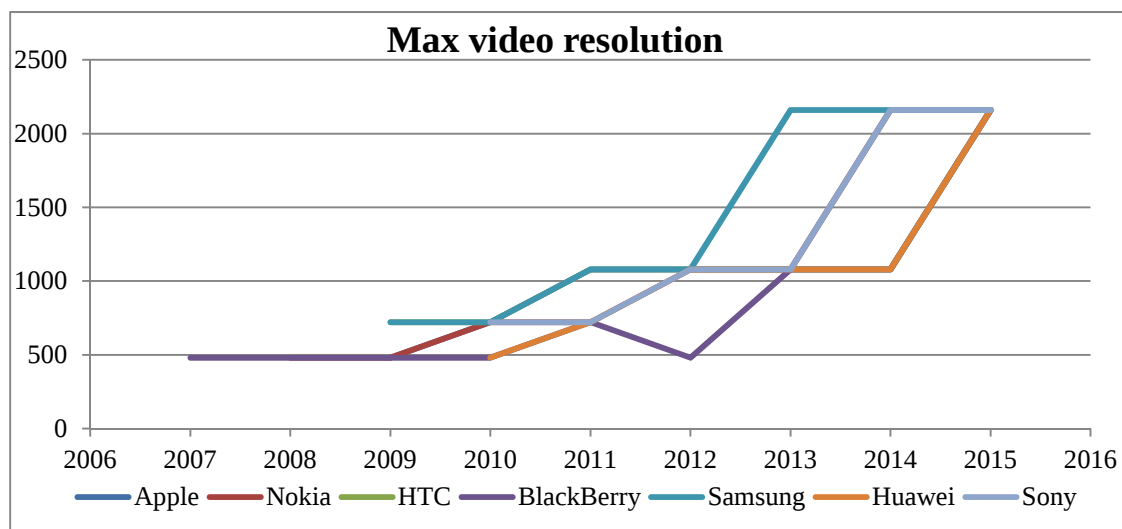
	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.954	0.918	0.549	0.911	0.943	0.739

Observing the imitation rate it is seen that all coefficients of correlation between Samsung in year $(t-1)$ and other companies at year t are positive and relatively high (table 11.). This means that other companies at year t have followed the moves of Samsung, where it is seen that the highest result has Apple as the greatest imitator whereas HTC as a new player and with different strategies is imitating the least.

5.3.5. Max video resolution

The story with video resolution is identical to the one with pixel density where customers have the feeling that by having higher screen resolution means to have a better model. However, users can be just satisfied with 720p and not 1080p, which would not only reduce the price of that particular model but also reduce pressure on other smartphone features, especially graphics. Further, by making an experiment on two almost identical phones where one had 720p and the other 1080p, the performance of the first was much better during gaming as the GPU had to deal with only 720p. Also, having higher resolution affects the battery life.¹⁷²

Figure 21. Trend lines for max video resolution (period 2007-2015)



This positive and relatively high coefficient of correlation (table 12.) indicates that there are great co-evolutionary effects and it can also be nicely seen from the figure 21. However, as there is no need for further improvement of the video resolution due to the limitations of

¹⁷² <http://www.techradar.com/news/phone-and-communications/mobile-phones/phone-resolution-doesn-t-matter-here-s-why-1288858>
<http://www.techradar.com/news/phone-and-communications/mobile-phones/phone-resolution-doesn-t-matter-here-s-why-1288858> (access: 18. 02. 2016.)

human eyes and it is expected that companies will slow down the development. This forecast is observed in figure 22. where companies have improved this category until 2014 and in the last observable year they achieved the perfect dominant design created from the sample of observed companies.

Table 12. Correlation matrix for Smartphone manufacturers - max video resolution

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.584	1.000					
HTC	0.987	0.572	1.000				
BlackBerry	0.921	0.740	0.938	1.000			
Samsung	0.676	0.786	0.647	0.792	1.000		
Huawei	0.967	0.634	0.967	0.921	0.687	1.000	
Sony	0.681	1.000	0.681	0.772	0.788	0.770	1.000

However, when we follow the coefficient of correlation of companies at time (t) and Samsung as first mover ($t-1$), meaning if higher the number, it represents a greater yearly imitation speed of the first mover. As it can be seen from table 13., all coefficients of correlation between Samsung in time ($t-1$) and other companies at time t are positive and high. This means that other companies at time t have followed or imitated activities and movements of Samsung from year ($t-1$). Thus, the table tells that HTC imitated the least whereas Nokia and Sony have been following step by step each year movements of this South Korean company. So, by having the coefficient of correlation 1.000 or in other words 100% means that Nokia and Sony achieved at t what Samsung did the year before.

Table 13. Correlation matrix for Samsung in year ($t-1$) and other companies in year t - max video resolution

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.681	1.000	0.681	0.772	0.770	1.000

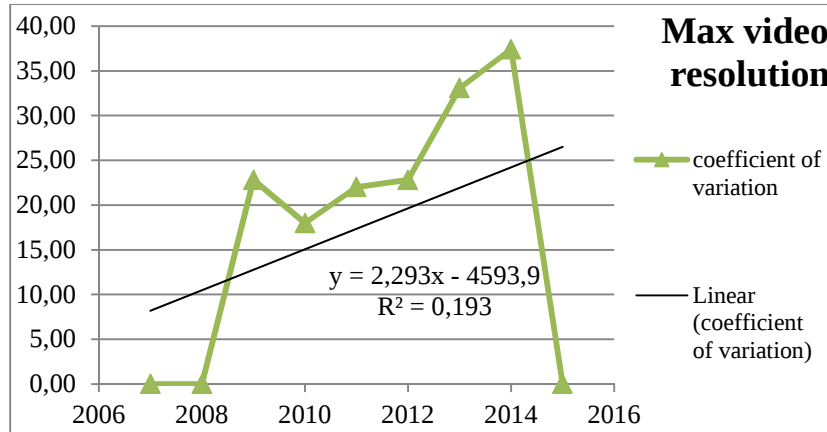
Models offering 1080p are the ones that have a huge amount of pixels, and also the screen size affects the before mentioned pixel per inch (PPI). For instance a phone that has 1920x1080 with five inches screen size will have 440 ppi, but if the screen size is reduced suddenly the number of ppi increases to 468. Therefore, in the smartphone industry there is a trend of increased screen size as well as the resolution, but numbers mentioned are about 50 percent higher than the natural capacity of human eyes in distinguishing differences in a normal usage distance.

According to an independent game developer each additional pixel that has to be processed puts stress on the CPU / GPU components and battery as well, and due to the fact that the human eye does not recall any difference by having more than 300 ppi, this means that having more pixels or in this case greater video resolution surplus is wasted. It goes so far that graphics in high resolution screens provide worse video quality and graphics because of the spent energy and time of every pixel.¹⁷³ However, the tendency of increasing video resolution does not stop at 1080p it goes further with the implementation of 4K (2160p). This means that people have free choice to decide what type of performance they prefer, even though they are

¹⁷³ <http://lifehacker.com/do-i-need-a-1080p-display-in-my-smartphone-1450793273> (access: 19. 02. 2016.)

not able to see the difference between 720p and 1080p on a 5 inch smartphone but if the screen size would get bigger the difference would be greater, which leads to a new measurement as pixel per inch.

Figure 22. Trend for variability - max video resolution



From figure 22. it is very hard to say whether it is a growing or falling tendency because cyclical oscillations are very high but considering the fact that in 2015 there was a sudden coefficient of variation reduction to zero, meaning that in that year all companies had the same performance level for this characteristic. However, as technologies are connected to each other and if some performance is higher it can reduce other performances, which can make a conclusion that for a relatively longer period the smartphone industry should not expect any more performance development in the video resolution. Further, as a reader you might get confused with the fact that a logical situation following this sudden saturation in the video resolution should happen with the pixel density, as they are two sides of the same coin. However, it is not happening as the pixel density despite the screen resolution changes as the screen size varies.

5.3.6. Camera

This part is continuing to the similar story as for PPI and video resolution, however in the process of buying a smartphone a great influence on customers has camera. According to DxOMark, which is a respected laboratory for camera and lens testing, Android cameras show better results than Apple iPhones where its 12MP camera is not as good as their marketing.¹⁷⁴ Again there is a misconception between users that a smartphone with greater megapixel (MP) number is a better phone. This is true to a certain extend and it is logical that having more megapixels it is easier to zoom in and crop some parts of a photo, but even more important are camera sensors on to which the light is falling down.

Firstly, it is important to explain the system of valuing the camera with megapixel, which means to have one million pixels. Further, pixel is the smallest segment of which a picture is made of and it is square shaped. In order to explain more in detail we can use mathematics, where in one picture considering both, x and y axis have 1000 pixels and therefore the picture has 1000x1000 pixels or one megapixel. Considering the screen resolution to explain it furthermore, if there is a greater number of these segments or pixels in a smaller area

¹⁷⁴http://www.phonearena.com/news/DxOMark-says-the-iPhone-6s-camera-isnt-as-good-as-what-certain-Android-handsets-are-offering_id74690 (access: 19. 02. 2016.)

compressed, the photo is clearer and therefore it is said that the screen or in this case the photo is in high resolution.¹⁷⁵ As mentioned earlier, not only the number of megapixels is important but the camera sensors as well. Thus, there might be a situation where a 4MP camera has better results from a 12MP camera, which was the situation with HTC in year 2013. The reason for this is that the sensors might be more sensitive and that having larger sensors the efficiency of converting light to digital signals is greater, without losing any quality.

As it could be seen from previous examples about the connectivity between characteristics in the smartphone architecture, again in this case there is a situation that if the smartphone has greater number of pixels (MP), having it in high resolution, makes the files *heavier* which puts greater stress on the storage. Therefore, a good solution for this is to have a high capacity microSD so that the data from the internal memory is transferred and the internal storage is not much under pressure.¹⁷⁶ Further, there must be a distinction between the front and rear camera where interestingly the front camera is much weaker. In the graph and table in the appendix 2 (figure 37, table 31) absolute developments of the front camera performance are seen, the but from the table there are some values that do not show any consistency. Especially difficult is to get better results because BlackBerry in this case did not implement the front camera until 2013.

The Red Queen effect is not strong in this smartphone characteristic and Huawei in this case is the leader. One good explanation for this great performance of the Chinese manufacturer is that as a newcomer in that closed industry they had to provide additional value to customers. As today's generation and trend is focused with taking *selfies*, Huawei considered this fact by trying to offer higher quality *selfies*.¹⁷⁷ This trend is seen mainly in Asian countries and parameters show that the demand for such models is increasingly at Asian smartphone manufacturers such as HTC, Sony and Samsung in smaller manner. Further, about the rear camera it is important to say that Nokia and Sony are dominating in the camera segment providing high resolution technology with great megapixel number. Therefore, in order to show the Red Queen effect, may not be relevant in this case as Samsung is no longer the predator but the pray that has to survive. However, if the philosophy of nature is followed than every pray is a predator at the same time, which is represented in the table 14. To show that Samsung is imitated, table 14. indicates that the coefficient of correlation between Samsung in year $(t-1)$ and others in year t are positive and high except for Nokia. This means that all companies besides Nokia at t have been following or imitating Samsung moves from year $(t-1)$. It is seen that Huawei and BlackBerry (0.942 and 0.930 respectively) are the strongest followers whereas Apple imitates the least with the score 0.804.

Table 14. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t – rear camera

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung $(t-1)$	0.804	0.312	0.850	0.930	0.942	0.868

The co-evolutionary effect is seen as well with absolute values of technological progress increasing each year. But looking relatively, there is not a strong Red Queen effect in this

¹⁷⁵ <http://www.phoneppi.com/mobile-cell-phone-camera-quality.html> (access: 20. 02. 2016.)

¹⁷⁶ Ibid.

¹⁷⁷ a photograph that one has taken of oneself, typically one taken with a smartphone or webcam and shared via social media -<http://www.oxforddictionaries.com/definition/english/selfie> (access: 20. 02. 2016.)

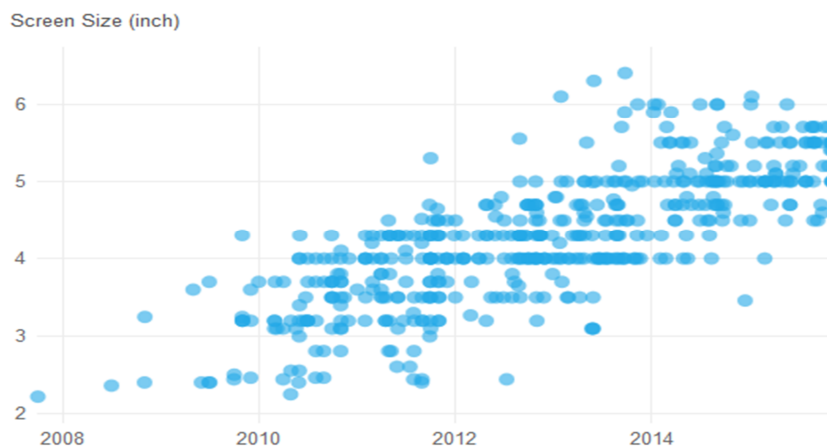
characteristic, but the strongest indication is that the trend for achieving a dominant design is negative. From the numbers as well, it looks like all companies are following their own decisions where Nokia is having a focus on a specific customer target. (appendix 2, rear camera).

5.3.7. Screen size

In early days customers had only small screen size phones whereas now they have huge screens. First generation of phones had great dimensions but not screens and they were collectively called "*bricks*", where after 2007 there was a trend of reducing these dimensions and implementing touch screen technology that changed the whole functionality. Few years ago the most popular dimension between customers was from 4 - 4.5 inch screen size such as iPhone 5S. The popularity of these dimensions is proven by the fact that next year the iPhone introduced again a 4 inch device and by implementing this screen Apple became recognized using the demand push strategy.

Soon, the industry had introduced tablets (potential substitutes) and smartphones have similarly great dimensions almost as tablets going to 5.7 inches and more, such as Samsung Galaxy S6 Edge+. However, today questionnaires get results that devices from 5 to 5.5 inches are preferred by customers and this is just a personal opinion and a matter of taste. Because it is only a matter of taste which is individually different, the trend will probably be to introduce all popular models in different dimensions in order to maximize performance and cover a greater spectrum of potential customers.

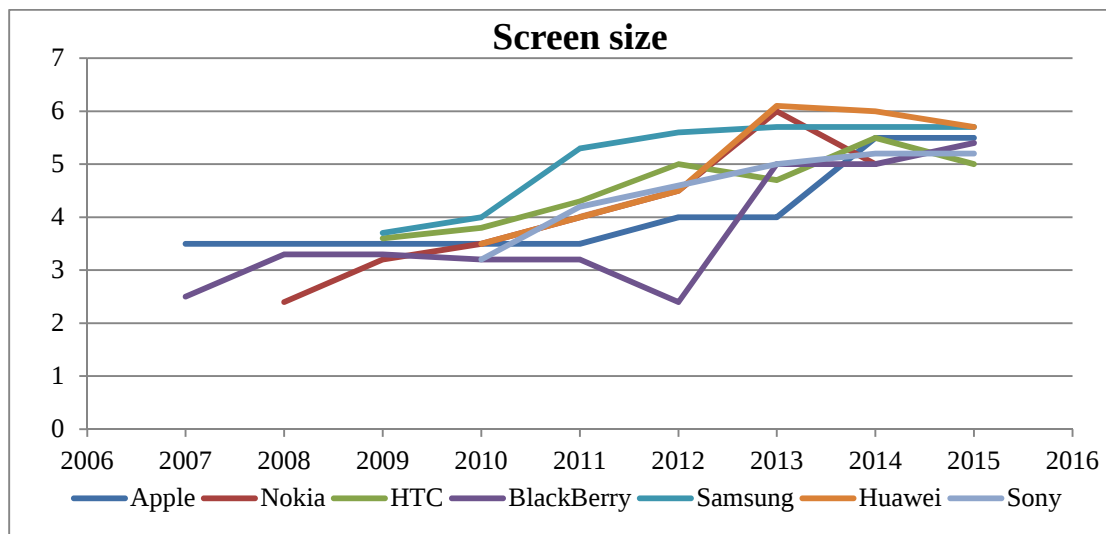
Figure 23. Evolution of screen size



Source: <http://www.pcworld.com/article/2455169/why-smartphone-screens-are-getting-bigger-specs-reveal-a-surprising-story.html> (access: 21. 02. 2016.)

According to figure 23., until 2011 almost every model had the screen size ranging from 2.5 and 4 inches where from 2013 the tendency of getting bigger every year with every model improved in such way that there was no model offering less than 4 inches. Screen size is very important for sale because even if software features are not in the top, the visible attributes such as the size of the screen will influence customer decision. It seems that the bigger the screen the more units have been sold.

Figure 24. Trend lines for screen size (period 2007-2015)



The co-evolutionary processes can be seen in the figure 24., which is also confirmed with high and positive coefficients of correlation that show a relatively good decision overlap at the analyzed companies despite a small set of data (table 15.). Smartphone manufacturers wanted from the beginning to produce phones with large screen size but the latest technology did not allow it, as the whole phone architecture is connected. Therefore, due to the improvement in battery capacity and reasonable pixel density, it allows today's models to have 6 inches and more.

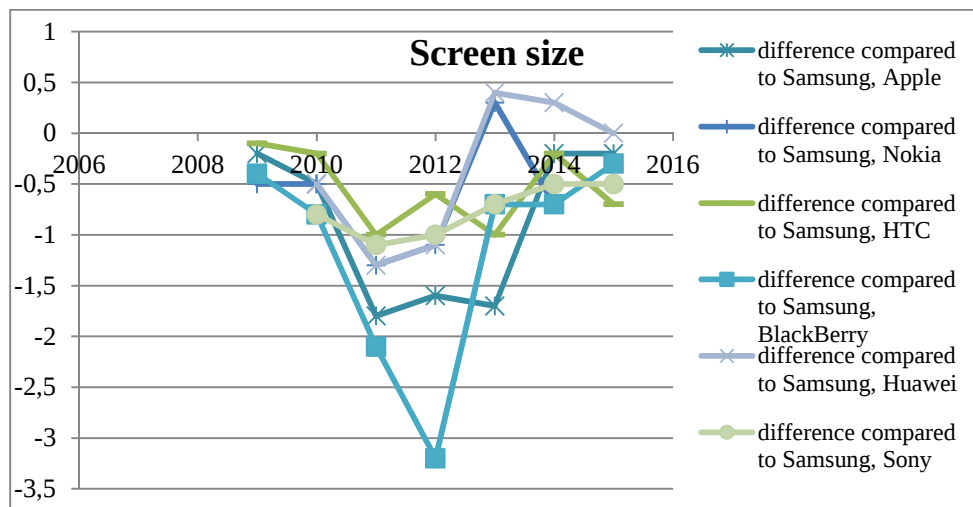
Table 15. Correlation matrix for Smartphone manufacturers - screen size

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.568	1.000					
HTC	0.817	0.736	1.000				
BlackBerry	0.785	0.633	0.510	1.000			
Samsung	0.624	0.841	0.905	0.480	1.000		
Huawei	0.746	0.936	0.785	0.847	0.783	1.000	
Sony	0.768	0.846	0.900	0.680	0.950	0.918	1.000

In 2007 customers and also companies could not imagine that in just several years these devices would have the capacity to substitute PC's. These companies started to search for potential increase in demand in developing countries because markets in developed countries are getting saturated and sale is slowing down. This smartphone characteristic is very important for users in developing countries because it is much cheaper than owning a PC and it offers same functionalities. These new customers seek for greater screen size because their interest is video conversation and watching music videos or movies on their smartphone.¹⁷⁸

¹⁷⁸<http://www.pcworld.com/article/2455169/why-smartphone-screens-are-getting-bigger-specs-reveal-a-surprising-story.html> (access: 21. 02. 2016.)

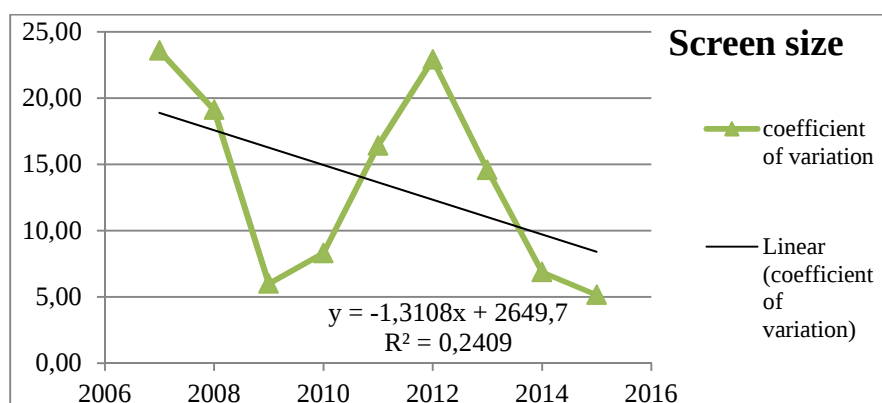
Figure 25. Comparison with Samsung – screen size



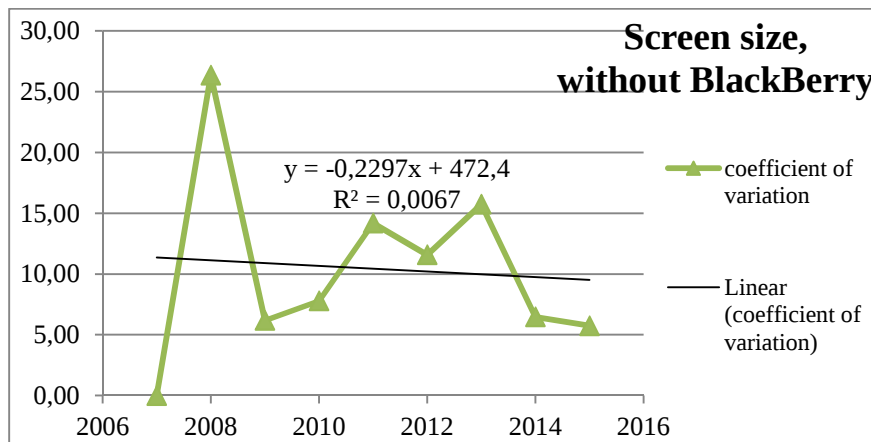
Above on figure 24. it is seen that all companies started from a relatively same position ranging dominantly from 3 - 3.5 inches. An arms race is nicely represented where companies gradually increased their screen size and in 2012 each crossed the 4 inch barrier except BlackBerry that fell on 2.4 inches. The reason why they remained on such small screen was mentioned above as well, they thought that their customer focus (businessman) is not looking for that style but some serious looking design. Fortunately, they realized their mistake and radically changed their model by increasing its screen size to five inches next year. Worth to mention is that the screen size is reaching its limit, because consumer taste is willing to purchase up to six inches models and anything higher is unattractive, uncomfortable or just unnecessary. Therefore, the dominant design is soon achieved and the Red Queen effect can be confirmed as companies are producing closely related products with dominant mimetic activities. But figure 26. has no steady fall and it is hard to tell whether it has a falling or rising tendency due to cyclical oscillations. However, reason of such shape is that in 2012 BlackBerry had no improvement due to factors mentioned and the difference between manufacturers remained high, creating great standard deviation in the calculation process and thus increasing the coefficient of variation. This example is a great manifestation that researchers and readers as well should not only focus on the graphics but also on the story behind, to make plausible and valid research results and explanation.

Figure 26. Trend for variability – screen size

a. all Smartphone manufacturers



b. without BlackBerry



Two figures were created in order to have a better overview on the development of the dominant design considering the screen size. BlackBerry was the outlier and at figure 26. a.) it can be seen that in 2012 there has been a great gap between companies that is observed by having great coefficient of variation in that period. The biggest reason for such movement is that BlackBerry still had screen size ranging from 2.5-3 inches where others had way above 4 inches. Therefore, second figure has been made where BlackBerry is taken out in order to have better overview on the development. It is interesting to observe that in figure 26. a.) there is a steep fall toward a common design but in figure 26. b.) where it was expected to have better result was not the case. This fall and flat figures are due to the fact that in the first case there was a greater coefficient of variation where BlackBerry's sudden improvement and catching up to its competitors made a steep fall for following years, where in the second case the performance differences remained constant. Despite different shapes of these figures, both represent a slow but constant approach to a mutually accepted screen size, which will never be achieved as customers have different preferences and companies want to cover the greatest market share.

In the near future smartphones can provide even greater screens but it is not considered as an integrated part of the actual phone. Probably new models will offer additional parts such as projections on the wall or as it is the case with the new LG model introduced several days ago, whose screen is able to reshape and become larger if needed. It will be interesting to see what will be created in this dynamic and highly innovative industry, especially with internal crisis, market saturation and resources getting scarcer. There is a tendency of developing creative types of displays where the research and development department of innovator companies are looking for a model that does not take much space in customer pockets, but when it is used it should have a large surface. It will be interesting to observe how manufacturers create new innovative types in order to attract old or even new customers.

5.3.8. Weight

From the period where telephones were developed, continuing with mobile phones and in the end with smartphones too, weight has always been the major attribute. Less heavy phones are considered to be more attractive, but the results show that companies are coming close to the limits with current technology. There is the difficulty in producing a smartphone that has better performance and other new functions each year, but at the same time it should be

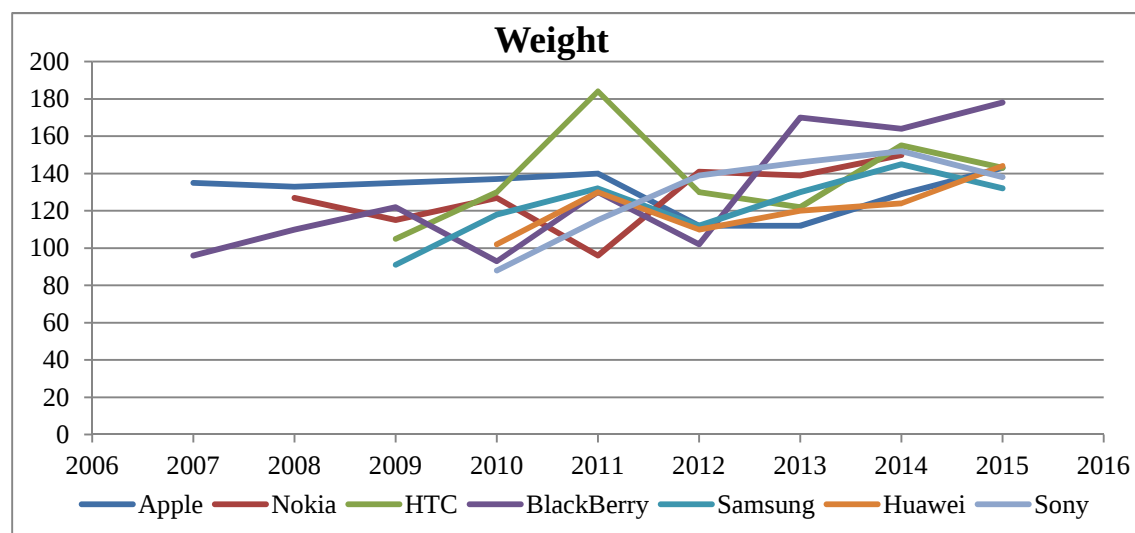
lighter. Interestingly from the data it is seen that the evolution in weight did not appear, it just remained relatively close to models from previous years or even became heavier.

Figure 27. Comparison with Samsung - weight



The lightest versions were at the beginning of the industry development and every company increased weight of their phones in 2015 compared to their first year. One possible explanation is that customers do not feel a lot the difference calculated in several grams and that their demand is actually focused on the overall phone performance. As customers carry their smartphones every day in their pockets, they do not realize the weight difference unless they visualize it. It means that the tendency of smartphones is to achieve greater performance, but to remain inside certain frames regarding weight and to look elegant. The elegance of the customer smartphone and its design has a greater impact on the purchase then the actual weight.

Figure 28. Trend lines for weight (period 2007-2015)



As well if this characteristic is compared to our first mover, the movements are very heterogeneous and there is no actual pattern of the movements. Therefore, it may be said that the actual Red Queen hypothesis is not precisely observed in the weight category. Several

companies seem to have followed each other regarding weight especially in the period from 2010 until 2013 and these mutual movements can be observed from the figure 27. but more precisely it is seen from table 16.

Table 16. Correlation matrix for Smartphone manufacturers - weight

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	-0.673	1.000					
HTC	0.366	-0.341	1.000				
BlackBerry	-0.050	0.303	0.181	1.000			
Samsung	0.045	0.295	0.706	0.616	1.000		
Huawei	0.461	-0.327	0.480	0.790	0.627	1.000	
Sony	-0.491	0.597	-0.094	0.706	0.468	0.450	1.000

Unfortunately these data are not sufficient in proving the Red Queen hypothesis regarding this category but some slight co-evolutionary effects can be seen between few companies. Looking at the creation of the dominant design regarding weight, it is interesting to see that even these manufacturers are focusing to stay in certain frameworks and not produce enormous models, but still the cyclical oscillations are high at the coefficient of variation. This means that companies actually do not focus that much on weight but on other more attractive performances that by their implementation the weight oscillates for several grams. Therefore, no pattern can be observed, leaving this characteristic ignored and companies seem to fight in different areas.

5.3.9. Memory and user removable storage

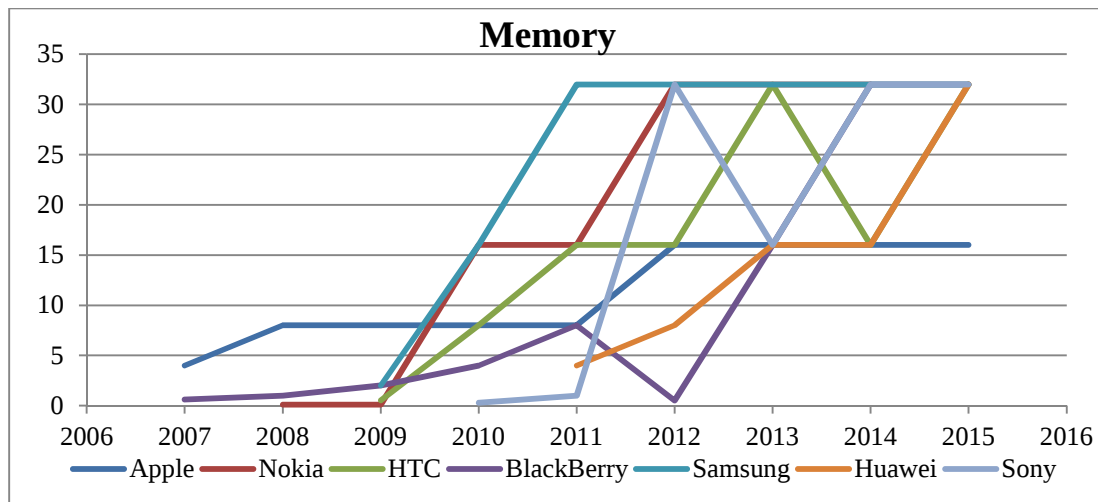
Going back in time people remember phones that were much different than today. Their memory was just several megabytes but the need for greater storage appeared from the moment smartphones came to the market. Today it is almost impossible to think about a smartphone having less than 8 GB of memory and most have also the possibility to expand it with the help of external memory cards. Such demand for memory and its expansion are characterized by the ever growing number of pictures, videos, games, applications, etc. Storage on regular phones ranges from 16/32/64 GB and sometimes it is also 124 GB, but after the operating system is installed the usual storage becomes much lower.

Companies increased the internal storage capacity several times, which might in turn increase the price but the memory card is also implemented in order not to pay more for additional storage. Some models however do not offer the option to use external memory such as the iPhone but it offers a range of same models with different internal memory. However, according to a questionnaire made on media-savvy, users are satisfied with storage that can hold approximately 1000 - 2000 photos from a 3.2 megapixel camera whose size is about 1GB or 2GB. Also videos and music was involved but users mainly browse internet and use YouTube on their phones in order to get entertained, which saves lot of memory. Therefore, if the characteristic of an average user is to save all their favorite pictures, music, apps and videos, they require not more than 8GB of storage. In the market there are many apps and videos about how to increase your storage as well as other methods such as the cloud which is a possibility to store on the internet.¹⁷⁹

¹⁷⁹ <http://www.geek.com/smartphone-buyers-guide/storage/> (access: 21. 02. 2016.)

User removable store, also referred as the external storage, means that it can be manipulated and removed by the user. The most common type of external storage is microSD cards. Android is the type that supports this kind of memory storage whereas iOS on the other side has no option for them. Because Apple does not provide any additional methods of memory expansion for customers, they provide iPhones with very high internal storage. Interestingly, these cards have different capacities ranging mostly from 2GB up to 2TB.¹⁸⁰

Figure 29. Trend lines for memory (period 2007-2015)



A theory why Apple does not implement external memory is that they can charge more for the iPhone that provides greater memory where it is only a little additional cost during the production process, which means that if they would integrate the memory slot people would buy the cheapest iPhone that is the one with smallest storage capacity. Also by implementing this, the additional Apple strategy (income source) such as iTunes and iCloud would be reduced extremely. Further, all companies have to consider a tradeoff whether they are willing to eliminate some part in order to gain on other attributes. Good example is with microSD where every company that does not implement it, gains space for a bigger and stronger battery without changing the volume because the external memory needs a large motherboard. Also, Apple does not want to be equalized in the minds of users with other manufacturers and there are quality issues, because fake cards were sold making a 30 percent of complaints for customer service. Therefore, due to these complaints for a part not relevant for the iPhone, Apple does not want to implement it. Also, the reason is greater revenue as customers always have the feeling that they are using more of everything than it is really the case, they will purchase the more expensive models providing 64 or 124 GB of internal storage. Also, design is as well a great reason for not implementing external storages, because the whole architecture for this part is making the smartphone more massive and thicker.¹⁸¹

¹⁸⁰ <http://www.neowin.net/news/guide-to-smartphone-hardware-37-memory-and-storage> (access: 22. 02. 2016.)

¹⁸¹ <https://www.quora.com/Why-dont-iPhones-have-a-memory-card-slot> (access: 22. 02. 2016.)

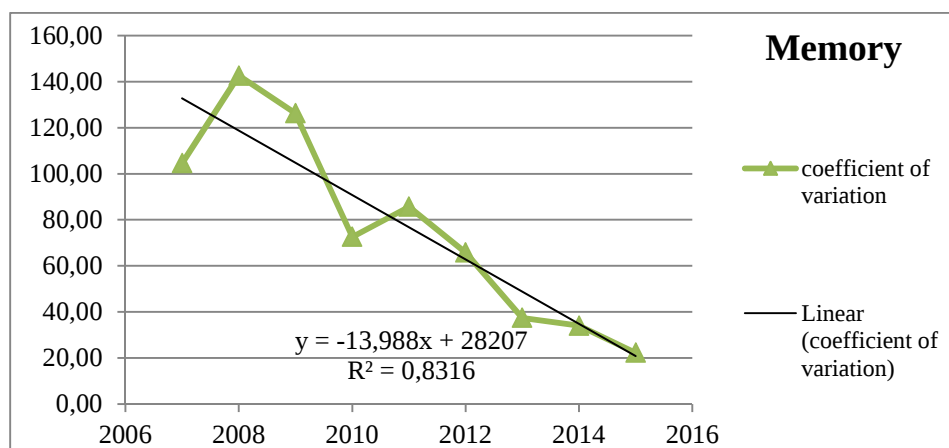
Table 17. Correlation matrix for Smartphone manufacturers - memory

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.892	1.000					
HTC	0.730	0.793	1.000				
BlackBerry	0.682	0.589	0.623	1.000			
Samsung	0.687	0.876	0.782	0.510	1.000		
Huawei	0.583	0.778	0.748	0.794	/	1.000	
Sony	0.916	0.909	0.413	0.546	0.590	0.560	1.000

Despite the small set of data all coefficients of correlation are high and positive, which indicates on a relative good match of movements and decisions between analyzed companies (table 17.). However, results are not very high and observing them from a different angle it can be said that the co-evolutionary effects considering weight are not strong.

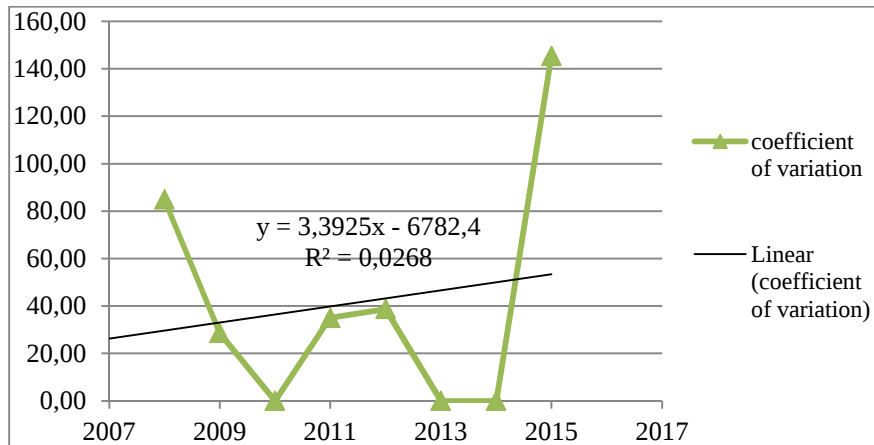
The Red Queen effect can be seen in the whole observation period, especially from 2009 until 2012. Since 2012 there has been only development of BlackBerry and performance decrease in few other companies. However, this information is not fully relevant because the data taken here focuses only on basic models that can be explained with the iPhone, whose basic model has the lowest storage but they offer an identical model that has more internal storage (appendix 2., figure 30.). Decisions made by these smartphone companies are different, where Apple does not offer the possibility of using external storage whereas the others do not focus that much on their internal storage because the first one exists. Due to this situation it can be observed that according to the falling tendency of coefficient of variation (ignoring cyclical oscillations) the achievement of the dominant design increases rapidly over time, which is seen in the figure 31.

Figure 31. Trend for variability - memory



As mentioned above, most companies focused mainly on their external memory that developed individually and not fully related to companies. Even though great co-evolutionary effects can be seen from high and positive coefficients of correlations, it means only that companies adapted their motherboard in that manner that can handle the specific power. This technology is developed rapidly, which can be seen from the opposite movement of dominant design creation (figure 32.).

Figure 32. Trend for variability



Despite the fact that the "b" coefficient is positive and the coefficient of variation is rising, which should indicate no Red Queen effects, looking at the numbers it can be seen that companies had been competing each year for the increasing performance. Such number is because in the year 2015 and especially HTC managed to integrate an over 2 TB of storage. Most likely other manufacturers could integrate such technology in their models as well but for the customer in order to fill up 2 Terabytes of data requires so much information that is almost impossible to fill up, especially for a smartphone. The forecast of further movements will be similar to Nokia camera case, where they just went back to the performance that was in previous years because the need and demand for greater one is very low, and further increases production costs.

6. Conclusion

Most economists ask themselves why some companies are more competitive and others are not. Different industries are characterized by fierce competition where the best answers for it are innovations and imitations in many cases. Therefore, different theoreticians have designed models where they try to create a framework and help the management to position their companies better in the market. In this thesis most popular models will be used in answering such question, where they made huge impact in the segment of management and company leadership: evolutionary theory, industrial organization theory, resource-based view and dynamic capability theory.

The evolutionary theory suggests that nothing is given by the creator but every process has to be gradually developed and improved, saying that companies are mutually aware and engage in co-evolutionary processes that push forward technological growth and innovation. The industrial organizational theory is opposed to the previous and it suggests that companies should find the most attractive industry, having its components in the most optimal way. However, the disadvantage of this theory is that it is only suitable for stable environments with little changes, which characterizes the period when it was developed. To fill this gap, economists considered the resource based view that focuses on company specific resources and capabilities. The disadvantage of it was that companies were too narrowly focused in internal factors, ignored external market situation and was not applicable in uncertain environments. Mentioned case led to creation of a new modified strategy that considers daily and potential future changes, having also the capability seen as a connection between internal (company) and external (industry) factors where it is called the dynamic capability theory. It uses company capabilities that help transfer and combine in most optimal ways company's resources according to external pressures and continuous changes or uncertainty from the environment.

Main reason of choosing this topic is that evolutionary processes are in every segment of our lives and it intrigued me what its function is in economics. Further, the Red Queen theory is still relatively young compared to others and its explanation that in economics just as it is in nature, the prey and predator relationship is also incorporated between companies. Due to scarce resources, companies have two options, which are to run even harder - representing that companies become more efficient and engage in price wars or differentiate and innovate. The first option will provide positive effects in the short-run as they may eliminate companies whose marginal costs are greater, but in the end it is also harmful for the focal company as they have great opportunity costs and less profit that it can be achieved through innovation, which in the long-run represents a better solution. Innovative activities can lead to creative destruction where other companies also engage in certain processes in order not to be left behind and in the end punish the focal firm for making a move. Thus, innovative processes also activate imitative processes, where companies use this strategy to save R&D costs and allocate these resources to other segments. In conclusion, the Red Queen effect in the case of this thesis, therefore the smartphone industry means that in absolute terms technological performance is increased where observed in relative terms everything remained constant compared to competition.

Bearing in mind all specificities of different industries and importance of core competences, it can be said that the Red Queen has its roots in all four theories with the major decision whether to engage in price wars or differentiate through continuous innovation. The goal of this paper was to find whether the Red Queen effect exists in fast growing and young

industries such as the smartphone industry and it could be concluded that modern theories are connected to this particular industry. It can be said that co-evolutionary processes among existing companies are very strong and they force innovative activities that may activate the *creative destruction*, meaning that the focal firm engaging in innovations will be punished by its competitors. As the competition never sleeps, companies are required to work twice as hard in order not to be left behind, where "*...it takes all the running you can do, to keep in the same place*". Therefore, in order to catch up other companies, there is a possibility to actively search for a problem solution. However, if there are innovators in an industry there must be imitators that will pressure others to make their innovative counter moves. Innovative activities are very important in dynamic and turbulent environments such it is the case in the smartphone industry. Companies in the mentioned industry have two options available in order to not fall behind its competitors: making upgrades and adaptations of existing products or creating a totally new product. Peter Drucker said that companies by not engaging in innovative activities are doomed to fail in today's markets with fierce competition where they have to "*innovate or die*".

Such competition will make it difficult for companies to create profits and increase market share, where further negative consequences can arise from the Red Queen effect. On the other side, companies known for imitative strategies have bad reputation but they can generate large profits from research and development savings. Companies decide for such unpopular strategy in situations where they just want to survive in the market and the first mover sends signals that others should follow the same path, creating high pressure for others. However, it required several decades of opinion changing to have imitation considered as one of most attractive strategies in uncertain environments requiring fast reaction speed. Importance of innovations and imitations in such fast growing and dynamic industries like the smartphone industry has great importance. In the observation focus of the top management from taken companies, are improvements considering existing products and creation of new ones according to customers' expectancy and wishes, whereas also disruptive innovations can take its part. Improvements (innovations) can be in the production process and service as well, not only on the final product. On the other side companies that are followers or imitators have to increase their capabilities and knowledge in order to have faster reaction speed for survival.

In the end strategies, innovation and imitation have great consequences and risks, but companies are willing to engage in either of them as they can provide great reward. In the mentioned industry it is recommended to get even more involved in faster imitation and / or innovation processes with a more proactive approach in creating markets of the future. It can be observed and forecasted that these strategies will be used even stronger in the smartphone industry as companies are moving closer to each other every time. Despite internal threats coming from existing companies and maybe external from new entrants, a major hardship for mentioned industries is due to macroeconomic imbalances happening in the modern world. Companies lost their resource (demand) in developed markets where they only have the option to takeover other companies or their market share. Such situation can create great opportunities for branch convergence, where existing industries can be merged together, or through the transfer of core competences enter other markets. This convergence is possible through related and unrelated diversification where for such achievement it is not only enough to have VRIN (valuable, rare, inimitable and non-substitutable) resources but also great transferability capabilities, which is a resource based approach. These survival methods are innovations as well, that are not only defined as creation of new products but also as creation of new industries where knowledge from the smartphone industry can be applied elsewhere thanks to its human capital.

Great example is coming from several companies such as Sony, where at the first place they incorporated knowledge from the gaming sector (Play station) into the smartphone industry. However, their cash cow started to lose power and now their major source of income comes from making image sensors. Further example is Samsung, which could be considered as one of strongest players in the smartphone industry, but their diversification is so great that they have business in construction, hospitality, medical and health care services, retail, shipbuilding, etc., where they apply the industry convergence option. Last example regarding is Apple and 50 percent of their income comes from smartphones. However, as they realize the crisis movement in this industry, they started to diversify as well with the Mac, iCars, iPads, iPod, etc. and there is expected to be a price decrease for the iPhone where they want to reach out to every customer. Smartphones will stop to be the major generator of money for these companies but they will transfer these capabilities and knowledge in other profit centers. As well there are other ways of solving the issue of market saturation in developed markets, which is observed through entering to developing markets. This area can be considered as their safety net but due to the lower living standard these companies will not be able to reach high margins, however they will be able to enjoy great sales. These markets have different taste than others where for instance Indian customers prefer screen sizes above 6 inches as they have better price availability from PCs and their main user preference is watching movies or listening to music videos. Therefore, these developments come from threats in the environment and the best way to behave is to find the middle ground as it could be concluded from this thesis that the only difference is whether a company will decide to be the pray or predator, translated in business terms be the innovator or imitator.

Companies in the smartphone industry experience as well co-evolutionary development of most characteristics but it starts to slow down even though technological development could handle it. The issue comes from limitations of the human body as it is the case with video resolution, camera and pixel density where the eye is only able to find difference up to a certain point. Also, creation of the dominant design is a good indicator of having the Red Queen as companies seek to equalize to other companies, which can be achieved through both, innovation and imitation. However, some parts probably will never experience the perfect dominant design as customer taste is an individual part and subjective, where some prefer one type of product while others different one.

The empirical research was focused on improvement and gradual innovative processes concerning smartphone characteristics. The first idea has been to involve company financial results annually in order to observe whether their performance level is changing but due to lack of information this idea was not further considered. Later, to easily prove the primary hypothesis it is important to at least know their brand value and ranking which could not be objectively observed as there was many other companies involved coming from different industries. The greatest issue that has been on both ideas, is that for all mentioned companies the smartphone industry is not their only business and retrieving data relevant for this paper was very hard to find. Therefore, slight modification was required where not the company performance is affected by chosen strategies but improvement of their product performance. From different categories it can be mainly observed that companies considered as first movers such as Samsung and HTC had best performance in most of them. However, imitators had also great performance development, which indicates that it is important for a company to decide what strategy to use because both have their advantages and disadvantages. The major conclusion is however that between innovator and imitator there should be low time gap where having more than two years difference, strongly affects the relative position of that

company. Meaning that if the company quickly reacts to any changes in the market or to actions of first movers (innovators) they will hold their relative market position but if not, then companies will experience stagnation and most likely drop in company performance. If companies would not engage in such competition, even today we would live in a world with expensive mobile phones only available to a certain social status and their performance would not be even close to today's mini super-computers.

The Red Queen effect can be observed as well in technological segment, which has been applied in this thesis and research is done by observing 19 parameters of smartphones in order to prove our hypothesis. Worth to mention is that price and market share has not been taken into account because they do not affect the technical competences of smartphones. Method of acquiring the database was using secondary data, where up to three best models of each year have been observed and in the end a hybrid model has been created that has best performances in every characteristic at that particular year. Samsung has been used as the benchmark because according to our research method he has been the first mover most of the time and therefore, it is also considered as the greatest innovator from the sample of chosen companies. In most cases between companies and products the arms race could be observed, thus the co-evolutionary development together with the Red Queen effect is experienced. The observed environment is very difficult with fierce competition, where it is reacted to slightest changes in performance and the same most likely will be punished. However, many smartphone characteristics have the tendency of achieving the dominant design that could indicate market saturation or even reaching technological limits.

Dominant design represents common attributes of a product that is implemented by different models; however it does not represent creation of a device with maximal performances but the one that is highly demanded by customers. In the end it can be concluded that the actual need in the market for such high-tech performance models is insignificant and it is also limited by putting stress to other components. For instance, coefficient of variation for batteries, which represents the dominant design, is very strong but far away of achieving it, as technologies are interconnected and their improvement puts stress on other components, also greater megapixels for camera puts stress on the storage. Same combinations of increasing performance of one component whereas it puts pressure on other components can be seen in the empirical research.

From the empirical research it can be seen that the strategic orientation, whether to be innovator (first mover) or imitator (follower) directly affects development of product performance. Most characteristics experienced their absolute growth and in relative terms companies remained equal, which is one of the representation of the Red Queen effect. Further, great influence on product performance over the period was concerning the time needed to follow or just copy, where the average lag between first mover and follower was one year. However, the moment a company waits longer than one year to catch up innovators performance from the year before, is observed as catastrophic change of relative company rating, as competitors are gradually improving but the focal company remains still. The Red Queen is not giving the whole effect to the smartphone industry as some characteristics are not fully developed and they raise barriers for themselves. Greatest reason for not developing models further is that certain technology did not catch up or that increase of one will put great pressure on the other. Also, one reason for not experiencing in full extent this effect is due to patent rights that limit other companies to imitate as it can be represented through the arms race and co-evolutionary developments. Further, companies are not able or just do not want to achieve the dominant design, which is also an indicator of the Red Queen effect calculated

using the coefficient of variation, as major goal of companies is to maximize profits and market share. Achieving the dominant design can slow down these maximization goals, where in cases it is not achieved it may represent further growth potential that currently experiences its limitations or they are focusing on different customer segments. Common architecture design is subjective and managers need to be cautious as they can make mistakes such as *"if I like it, everybody does"*.

Suggestions for future research would be implementation of other characteristics in the empirical research and create deeper results that should indicate at what rate fully new characteristics were created that customers many times do not even realize. As well the market share, as a variable, could be included in observation of the Red Queen effect in highly concentrated industries and vice versa. Starting idea for this research was to use brand value and its rating as a variable, and also by taking the best smartphone model of a particular month and observe quarterly data where it should more precisely show how market domination influences companies' performance. Great example is market leaders that have the tendency to eliminate their competitors, which can make them vulnerable as they relax and lose their capability to react. Further it would be interesting to observe how operating systems influence company and product performance as it was mentioned that they can increase the efficiency. In the end it can be concluded that this topic and industry have much potential for future research as the smartphone manufacturers are still surprising their customers and people in general with their creativity, innovativeness and many tricks they apply to surpass competitors. Thus, it is becoming more popular and is expected to stay like this for many years.

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Appendixes

Appendix 1. Time series for analyzed characteristics of smartphones

year	company	RAM	CPU	battery talk	weight	pixel	resolution	screen	memory	microSD	max video	front	rear
2015	Apple	2	2	24	143	401	1920x1080	5.5	16	no	2160	5	12
2014	Apple	1	1.4	24	129	401	1920x1080	5.5	16	no	1080	1.2	8
2013	Apple	1	1.3	10	112	326	1136x640	4	16	no	1080	1.2	8
2012	Apple	1	1.3	8	112	326	1136x640	4	16	no	1080	1.2	8
2011	Apple	0.51	1	8	140	326	960x640	3.5	8	no	1080	0.3	8
2010	Apple	0.51	1	7	137	326	960x640	3.5	8	no	720	no	5
2009	Apple	0.23	0.6	12	135	163	480x320	3.5	8	no	480	no	3
2008	Apple	0.13	0.6	10	133	163	480x320	3.5	8	no	no	no	2
2007	Apple	0.13	0.4	8	135	163	480x320	3.5	4	no	no	no	2
2014	Nokia	2	2.2	16	150	441	1920x1080	5	32	128	2160	1.2	20
2013	Nokia	2	2.2	27	139	367	1920x1080	6	32	64	1080	1.3	41
2012	Nokia	1	1.5	17	141	332	1280x768	4.5	32	64	1080	1.3	41
2011	Nokia	0.51	1.4	9	96	252	640x360	4	16	32	720	2.8	8
2010	Nokia	0.23	0.68	13	127	229	640x360	3.5	16	32	720	0.3	12
2009	Nokia	0.13	0.43	7	115	229	640x360	3.2	0.1	16	480	no	2
2008	Nokia	0.13	0.4	5	127	169	320x240	2.4	0.1	8	480	0.1	3.2
2015	HTC	3	2	21	143	441	1920x1080	5	32	2048	2160	5	20
2014	HTC	2	2.3	22	155	441	1920x1080	5.5	16	128	1080	8	13
2013	HTC	2	1.9	29	122	468	1920x1080	4.7	32	64	1080	2.1	4
2012	HTC	2	1.5	12	130	441	1920x1080	5	16	32	1080	2.1	8
2011	HTC	1	1.5	9	184	342	1280x720	4.3	16	32	1080	2	8
2010	HTC	0.77	1	9	130	252	800x480	3.8	8	32	720	no	8
2009	HTC	0.29	0.53	8	105	259	800x480	3.6	0.5	32	720	no	5
2015	BlackBerry	3	1.8	25	178	540	2560x1440	5.4	32	200	2160	2	18
2014	BlackBerry	3	2.2	22	164	453	1440x1440	5	32	128	1080	2	13

year	company	RAM	CPU	battery talk	weight	pixel	resolution	screen	memory	microSD	max video	front	rear
2013	BlackBerry	2	1.7	25	170	356	1280x720	5	16	64	1080	2	8
2012	BlackBerry	0.51	0.8	8	102	164	320x240	2.4	0.5	32	480	no	3.2
2011	BlackBerry	0.77	1.2	6	130	253	640x480	3.2	8	32	720	no	5
2010	BlackBerry	0.51	0.62	5	93	246	480x360	3.2	4	32	480	no	5
2009	BlackBerry	0.51	0.62	6	122	250	480x360	3.3	2	32	480	no	3.2
2008	BlackBerry	0.26	0.52	4	110	250	480x360	3.3	1	32	480	no	3.2
2007	BlackBerry	0.03	0.31	5	96	161	320x240	2.5	0.6	4	480	no	3.2
2015	Samsung	4	2.1	21	132	576	2560x1440	5.7	32	no	2160	5	16
2014	Samsung	3	2.7	21	145	515	2560x1440	5.7	32	128	2160	3.7	16
2013	Samsung	3	2.3	21	130	443	1920x1080	5.7	32	64	2160	2.1	13
2012	Samsung	2	1.6	35	112	306	1280x720	5.6	32	64	1080	1.9	8
2011	Samsung	1	1.5	26	132	285	1280x800	5.3	32	64	1080	2	8
2010	Samsung	0.51	1	13	118	233	800x480	4	16	32	720	1.3	5
2009	Samsung	0.26	0.8	12	91	252	800x480	3.7	2	32	720	0.3	5
2015	Huawei	3	2.2	23	144	518	2560x1440	5.7	32	128	2160	8	20
2014	Huawei	2	1.8	22	124	441	1920x1080	6	16	128	1080	8	13
2013	Huawei	2	1.5	28	120	312	1280x720	6.1	16	64	1080	5	8
2012	Huawei	2	1.5	8	110	326	1280x720	4.5	8	32	1080	1.3	8
2011	Huawei	0.51	1.4	8	130	246	854x480	4	4	32	720	0.3	8
2010	Huawei	0.26	0.53	9	102	165	480x320	3.5		32	480	no	3.2
2015	Sony	3	2.5	17	138	424	1920x1080	5.2	32	200	2160	8	23
2014	Sony	3	2.5	19	152	424	1920x1080	5.2	32	128	2160	2.2	20.7
2013	Sony	2	2.3	14	146	441	1920x1080	5	16	64	1080	2.2	20.7
2012	Sony	1	1.5	10	139	342	1280x720	4.6	32	32	1080	1.3	13
2011	Sony	0.51	1	14	115	245	854x480	4.2	1	32	720	0.3	8
2010	Sony	0.26	0.72	13	88	229	640x360	3.2	0.3	32	720	no	8

year	company	GPS	WiFi	LED Flash	Autofocus	digital zoom	face detection	smile detection	panorama	touch focus
2015	Apple	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	Apple	yes	yes	yes	yes	yes	yes	yes	yes	yes
2013	Apple	yes	yes	yes	yes	yes	yes	no	yes	yes
2012	Apple	yes	yes	yes	yes	yes	yes	no	yes	yes
2011	Apple	yes	yes	yes	yes	yes	yes	no	yes	yes
2010	Apple	yes	yes	yes	yes	yes	no	no	no	no
2009	Apple	yes	yes	no	no	no	no	no	no	no
2008	Apple	no	yes	no	no	no	no	no	no	no
2007	Apple	no	yes	no	no	no	no	no	no	no
2014	Nokia	yes	yes	yes	yes	yes	yes	no	yes	yes
2013	Nokia	yes	yes	yes	yes	yes	yes	no	yes	yes
2012	Nokia	yes	yes	yes	yes	yes	yes	yes	yes	yes
2011	Nokia	yes	yes	yes	yes	yes	no	no	yes	no
2010	Nokia	yes	yes	yes	yes	yes	no	no	no	no
2009	Nokia	yes	yes	no	no	yes	no	no	no	no
2008	Nokia	yes	yes	no	yes	yes	no	no	no	no
2015	HTC	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	HTC	yes	yes	yes	yes	yes	yes	yes	yes	yes
2013	HTC	yes	yes	yes	yes	yes	yes	yes	yes	no
2012	HTC	yes	yes	yes	yes	yes	yes	yes	yes	no
2011	HTC	yes	yes	yes	yes	yes	yes	yes	yes	yes
2010	HTC	yes	yes	yes	yes	yes	yes	no	no	no
2009	HTC	yes	yes	no	yes	no	no	no	no	no
2015	BlackBerry	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	BlackBerry	yes	yes	yes	yes	yes	yes	no	yes	yes
2013	BlackBerry	yes	yes	yes	yes	yes	yes	no	yes	yes
2012	BlackBerry	yes	yes	yes	yes	yes	no	no	no	no
2011	BlackBerry	yes	yes	yes	yes	yes	no	no	no	no

year	company	GPS	WiFi	LED Flash	Autofocus	digital zoom	face detection	smile detection	panorama	touch focus
2010	BlackBerry	yes	yes	yes	yes	yes	no	no	no	no
2009	BlackBerry	yes	yes	yes	yes	yes	no	no	no	no
2008	BlackBerry	yes	yes	yes	yes	yes	no	no	no	no
2007	BlackBerry	yes	yes	yes	yes	no	no	no	no	no
2015	Samsung	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	Samsung	yes	yes	yes	yes	yes	yes	yes	yes	yes
2013	Samsung	yes	yes	yes	yes	yes	yes	yes	yes	yes
2012	Samsung	yes	yes	yes	yes	yes	yes	yes	yes	yes
2011	Samsung	yes	yes	yes	yes	yes	yes	yes	no	yes
2010	Samsung	yes	yes	yes	yes	yes	no	no	yes	no
2009	Samsung	yes	yes	yes	yes	no	no	no	no	no
2015	Huawei	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	Huawei	yes	yes	yes	yes	yes	yes	yes	yes	yes
2013	Huawei	yes	yes	yes	yes	yes	yes	yes	no	no
2012	Huawei	yes	yes	yes	yes	yes	yes	no	yes	yes
2011	Huawei	yes	yes	yes	yes	no	no	no	no	no
2010	Huawei	yes	yes	no	yes	no	no	no	no	no
2015	Sony	yes	yes	yes	yes	yes	yes	yes	yes	yes
2014	Sony	yes	yes	yes	yes	yes	yes	no	yes	yes
2013	Sony	yes	yes	yes	yes	yes	yes	yes	yes	yes
2012	Sony	yes	yes	yes	yes	yes	yes	yes	yes	yes
2011	Sony	yes	yes	yes	yes	yes	yes	yes	yes	yes
2010	Sony	yes	yes	yes	yes	yes	no	no	no	no

Appendix 2. Some analysis for analyzed characteristics of smartphones

RAM

Table 18. Descriptive statistics for RAM

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	3.00	0.63	21.08	-2		-1	-1	-1	-1
2014	2.29	0.76	33.07	-2	-1	-1	0	-1	0
2013	2.00	0.58	28.87	-2	-1	-1	-1	-1	-1
2012	1.36	0.62	45.97	-1	-1	0	-1.49	0	-1
2011	0.69	0.23	34.03	-0.49	-0.49	0	-0.23	-0.49	-0.49
2010	0.44	0.20	45.17	0	-0.28	0.26	0	-0.25	-0.25
2009	0.28	0.14	49.27	-0.03	-0.13	0.03	0.25		
2008	0.17	0.08	43.30						
2007	0.08	0.07	88.39						

Processor speed

Table 19. Descriptive statistics for CPU

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	2.10	0.24	11.27	-0.1		-0.1	-0.3	0.1	0.4
2014	2.16	0.44	20.18	-1.3	-0.5	-0.4	-0.5	-0.9	-0.2
2013	1.89	0.40	21.31	-1	-0.1	-0.4	-0.6	-0.8	0
2012	1.39	0.27	19.73	-0.3	-0.1	-0.1	-0.8	-0.1	-0.1
2011	1.29	0.22	17.06	-0.5	-0.1	0	-0.3	-0.1	-0.5
2010	0.79	0.20	25.53	0	-0.32	0	-0.38	-0.47	-0.28
2009	0.60	0.14	22.84	-0.2	-0.37	-0.27	-0.18		
2008	0.51	0.10	19.87						
2007	0.36	0.06	17.93						

Battery life time

Table 20. Descriptive statistics for battery life time

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	21.83	2.86	13.09	3		0	4	2	-4
2014	20.86	2.61	12.51	3	-5	1	1	1	-2
2013	22.00	7.39	33.61	-11	6	8	4	7	-7
2012	14.00	9.81	70.11	-27	-18	-23	-27	-27	-25
2011	11.43	6.88	60.17	-18	-17	-17	-20	-18	-12
2010	9.86	3.24	32.84	-6	0	-4	-8	-4	0
2009	9.00	2.83	31.43	0	-5	-4	-6		
2008	6.33	3.21	50.76						
2007	6.50	2.12	32.64						

Table 21. Correlation matrix for Smartphone manufacturers – battery life time

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.100	1.000					
HTC	0.506	0.886	1.000				
BlackBerry	0.735	0.822	0.956	1.000			
Samsung	-0.110	0.284	0.097	0.045	1.000		
Huawei	0.618	0.808	0.978	0.975	-0.304	1.000	
Sony	0.873	-0.012	0.503	0.666	-0.467	0.628	1.000

Table 22. Correlation matrix for Samsung in year ($t-1$) and other companies in year t – battery life time

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.074	0.943	0.794	0.638	0.661	-0.089

Weight

Table 23. Descriptive statistics for weight

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	146.33	16.16	11.04	11		11	46	12	6
2014	145.57	14.32	9.83	-16	5	10	19	-21	7
2013	134.14	19.60	14.61	-18	9	-8	40	-10	16
2012	120.86	15.54	12.86	0	29	18	-10	-2	27
2011	132.43	26.96	20.36	8	-36	52	-2	-2	-17
2010	113.57	19.28	16.97	19	9	12	-25	-16	-30
2009	113.60	16.70	14.70	44	24	14	31		
2008	123.33	11.93	9.67						
2007	115.50	27.58	23.88						

Figure 30. Comparison with Samsung - memory

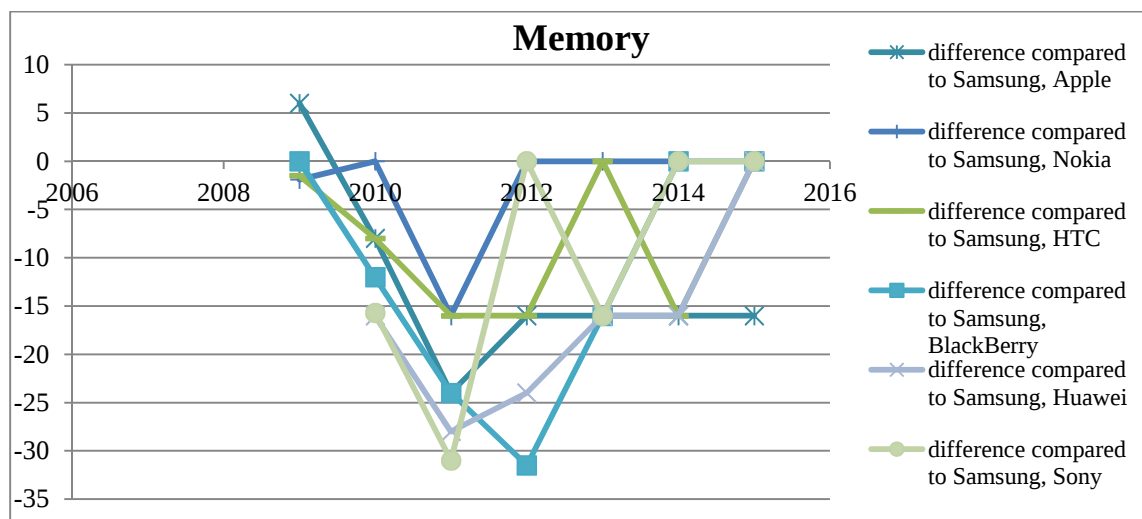


Figure 34. Trend for variability - weight

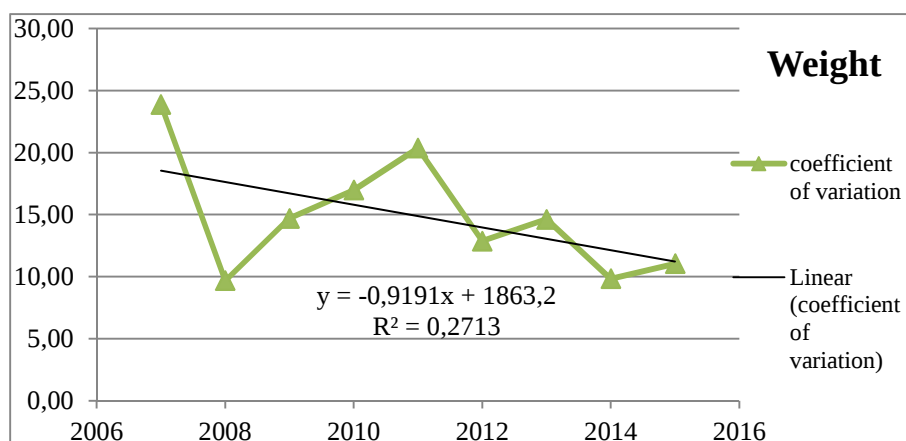


Table 24. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t – weight

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.023	0.306	0.196	0.548	0.724	0.732

Pixel density

Table 25. Descriptive statistics for pixel density

Year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	483.33	70.84	14.66	-175		-135	-36	-58	-152
2014	445.14	35.09	7.88	-114	-74	-74	-62	-74	-91
2013	387.57	62.34	16.08	-117	-76	25	-87	-131	-2
2012	319.57	81.52	25.51	20	26	135	-142	20	36
2011	278.43	40.54	14.56	41	-33	57	-32	-39	-40
2010	240.00	47.42	19.76	93	-4	19	13	-68	-4
2009	230.60	39.41	17.09	-89	-23	7	-2		
2008	194.00	48.59	25.05						
2007	162.00	1.41	0.87						

Screen size

Table 26. Descriptive statistics for screen size

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	5.42	0.28	5.14	-0.2		-0.7	-0.3	0	-0.5
2014	5.41	0.37	6.86	-0.2	-0.7	-0.2	-0.7	0.3	-0.5
2013	5.21	0.76	14.58	-1.7	0.3	-1	-0.7	0.4	-0.7
2012	4.37	1.00	22.90	-1.6	-1.1	-0.6	-3.2	-1.1	-1
2011	4.07	0.67	16.40	-1.8	-1.3	-1	-2.1	-1.3	-1.1
2010	3.53	0.29	8.30	-0.5	-0.5	-0.2	-0.8	-0.5	-0.8
2009	3.46	0.21	5.99	-0.2	-0.5	-0.1	-0.4		
2008	3.07	0.59	19.11						
2007	3.00	0.71	23.57						

Table 27. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t – screen size

	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung ($t-1$)	0.769	0.863	0.895	0.642	0.921	0.940

Memory

Table 28. Descriptive statistics for memory

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	29.33	6.53	22.27	-16		0	0	0	0
2014	25.14	8.55	34.02	-16	0	-16	0	-16	0
2013	22.86	8.55	37.42	-16	0	0	-16	-16	-16
2012	19.50	12.82	65.76	-16	0	-16	-31.5	-24	0
2011	12.14	10.40	85.64	-24	-16	-16	-24	-28	-31
2010	8.72	6.33	72.59	-8	0	-8	-12	-16	-15.7
2009	2.52	3.18	126.28	6	-1.9	-1.5	0		
2008	3.03	4.32	142.57						
2007	2.30	2.40	104.53						

Table 29. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t – memory

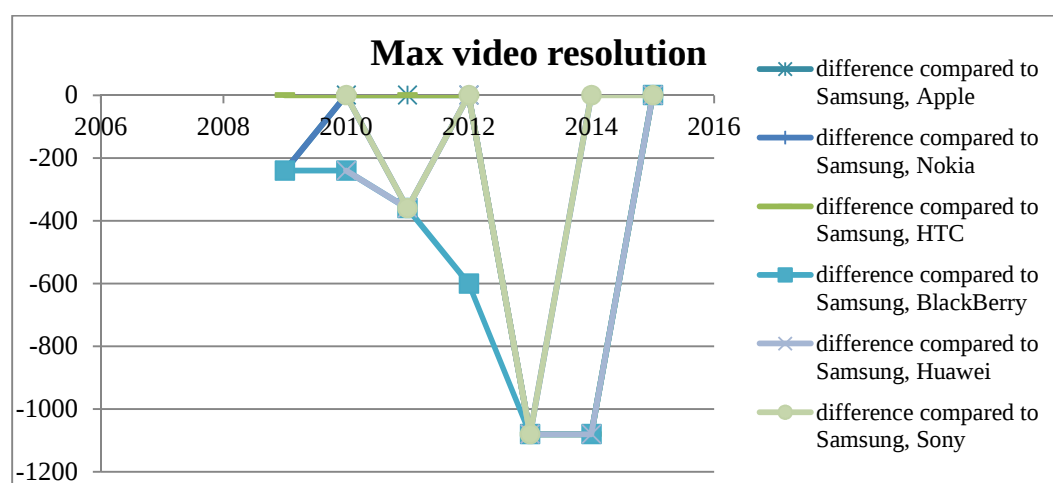
	<i>Apple (t)</i>	<i>Nokia (t)</i>	<i>HTC (t)</i>	<i>BlackBerry (t)</i>	<i>Huawei (t)</i>	<i>Sony (t)</i>
Samsung $(t-1)$	0.937	0.931	0.683	0.526	0.583	0.863

Max video resolution

Table 30. Descriptive statistics for max video resolution

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	2160.00	0.00	0.00	0		0	0	0	0
2014	1542.86	577.28	37.42	-1080	0	-1080	-1080	-1080	0
2013	1234.29	408.20	33.07	-1080	-1080	-1080	-1080	-1080	-1080
2012	994.29	226.78	22.81	0	0	0	-600	0	0
2011	874.29	192.43	22.01	0	-360	0	-360	-360	-360
2010	651.43	117.11	17.98	0	0	0	-240	-240	0
2009	576.00	131.45	22.82	-240	-240	0	-240		
2008	480.00								
2007	480.00								

Figure 35. Comparison with Samsung – max video resolution



Front camera

Figure 36. Trend lines for front camera (period 2006-2015)

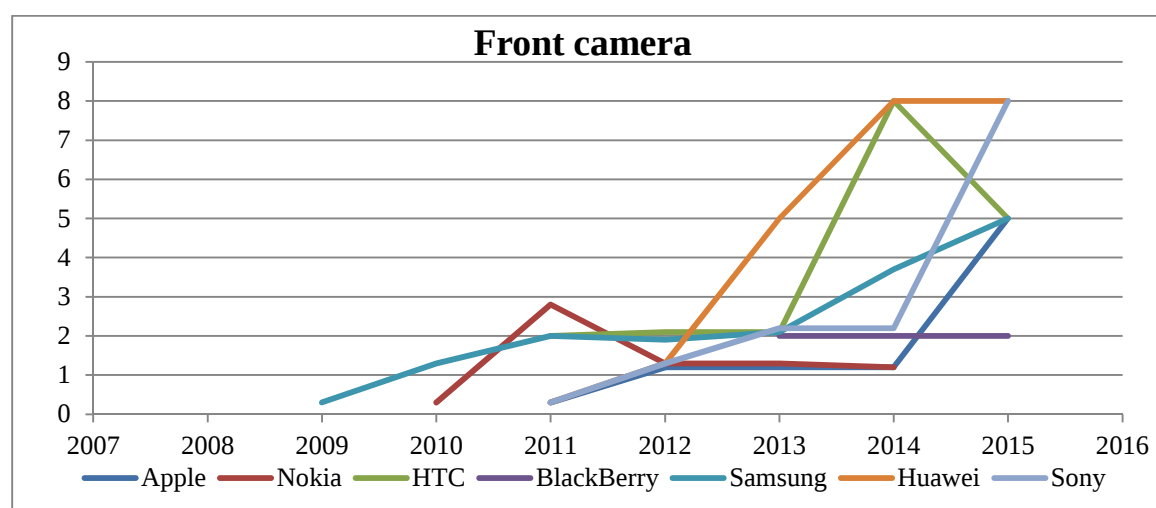


Table 31. Descriptive statistics for front camera

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	5.50	2.26	41.06	0		0	-3	3	3
2014	3.76	3.02	80.29	-2.5	-2.5	4.3	-1.7	4.3	-1.5
2013	2.27	1.27	55.90	-0.9	-0.8	0	-0.1	2.9	0.1
2012	1.52	0.38	25.16	-0.7	-0.6	0.2		-0.6	-0.6
2011	1.28	1.12	86.97	-1.7	0.8	0		-1.7	-1.7
2010	0.80	0.71	88.39		-1				
2009	0.30								
2008	0.10								
2007									

Figure 37. Comparison with Samsung – front camera

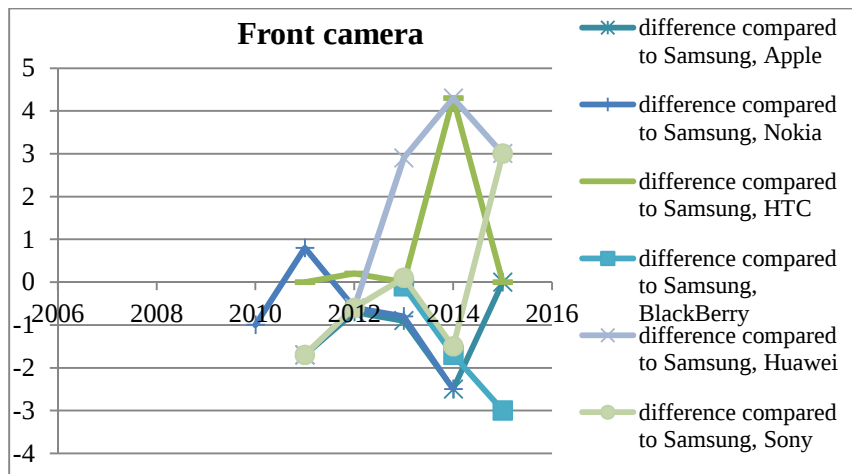


Table 32. Correlation matrix for Smartphone manufacturers – front camera

	Apple	Nokia	HTC	BlackBerry	Samsung	Huawei	Sony
Apple	1.000						
Nokia	-0.998	1.000					
HTC	0.311	-0.405	1.000				
BlackBerry	/	/	/	/			
Samsung	0.860	0.140	0.727	/	1.000		
Huawei	0.637	-0.670	0.807	/	0.842	1.000	
Sony	0.992	-0.896	0.369	/	0.890	0.712	1.000

Figure 38. Trend for variability – front camera

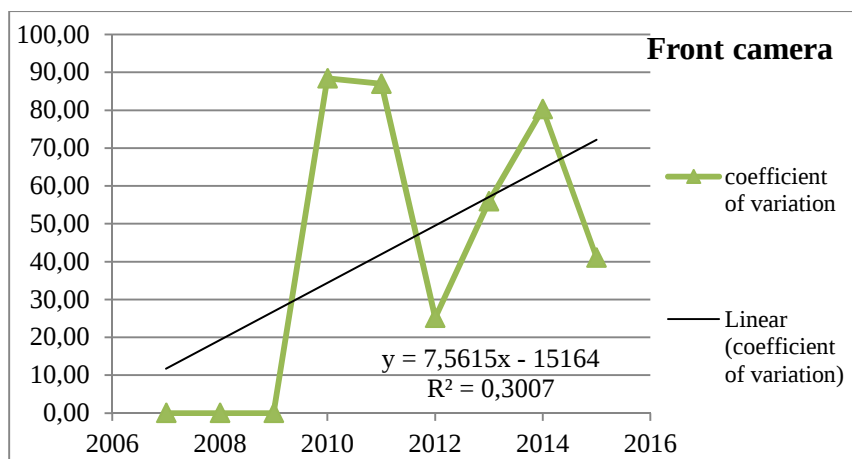


Table 33. Correlation matrix for Samsung in year $(t-1)$ and other companies in year t – front camera

	Apple (t)	Nokia (t)	HTC (t)	BlackBerry (t)	Huawei (t)	Sony (t)
Samsung (t-1)	0.988	0.309	0.406	/	0.707	0.983

Rear camera

Figure 39. Trend lines for rear camera (period 2006-2015)

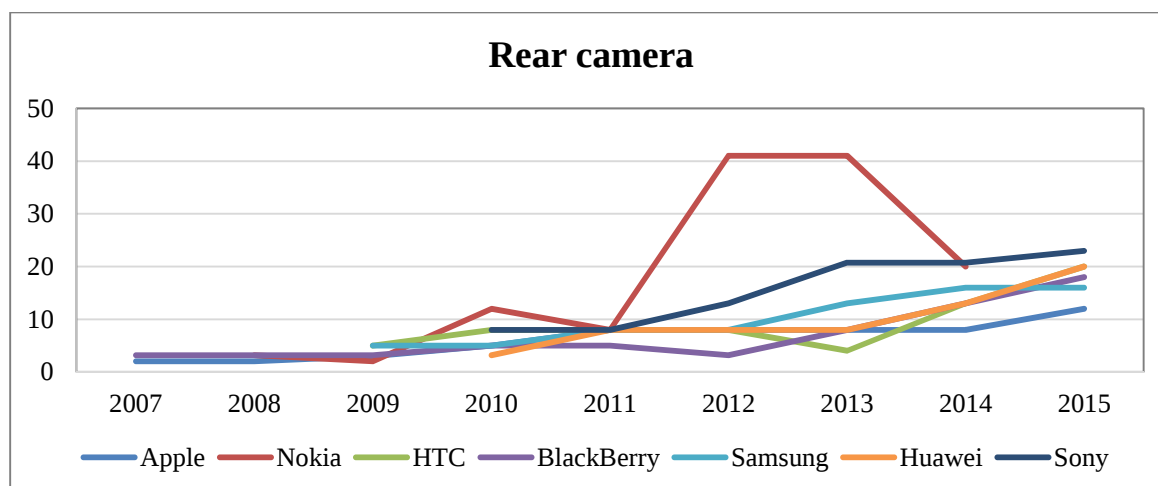


Table 34. Descriptive statistics for rear camera

year	average	st. dev.	coefficient of variation	difference compared to Samsung, Apple	difference compared to Samsung, Nokia	difference compared to Samsung, HTC	difference compared to Samsung, BlackBerry	difference compared to Samsung, Huawei	difference compared to Samsung, Sony
2015	18.17	3.82	21.01	-4		4	2	4	7
2014	14.81	4.46	30.09	-8	4	-3	-3	-3	4.7
2013	14.67	12.78	87.10	-5	28	-9	-5	-5	7.7
2012	12.74	12.78	100.27	0	33	0	-4.8	0	5
2011	7.57	1.13	14.98	0	0	0	-3	0	0
2010	6.60	2.95	44.74	0	7	3	0	-1.8	3
2009	3.64	1.32	36.32	-2	-3	0	-1.8		
2008	2.80	0.69	24.74						
2007	2.60	0.85	32.64						

Figure 40. Comparison with Samsung – rear camera

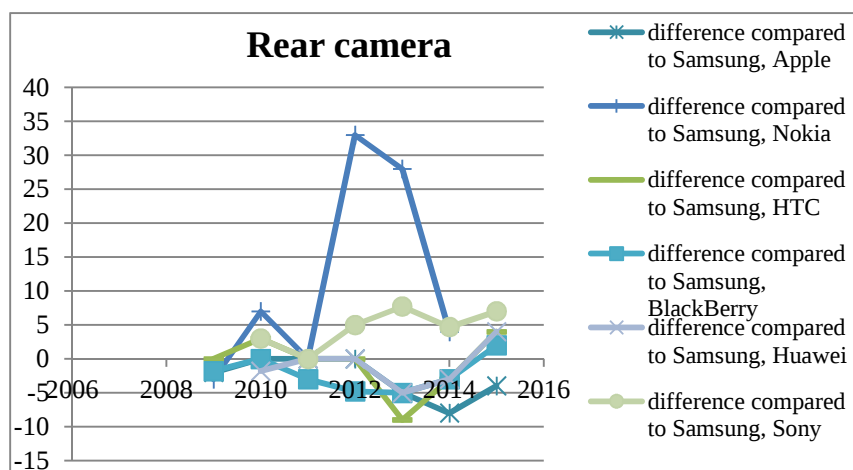


Table 35. Correlation matrix for Smartphone manufacturers – rear camera

	<i>Apple</i>	<i>Nokia</i>	<i>HTC</i>	<i>BlackBerry</i>	<i>Samsung</i>	<i>Huawei</i>	<i>Sony</i>
Apple	1.000						
Nokia	0.714	1.000					
HTC	0.742	-0.109	1.000				
BlackBerry	0.778	0.271	0.869	1.000			
Samsung	0.793	0.477	0.656	0.893	1.000		
Huawei	0.937	0.172	0.880	0.913	0.847	1.000	
Sony	0.695	0.592	0.498	0.816	0.947	0.772	1.000

Figure 41. Trend for variability – rear camera

