Technology Portfolio Dynamics

Samuli Kortelainen[1], Antero Kutvonen[1], Lauri Lättilä[1]

[1] Faculty of Industrial Management of Lappeenranta University of Technology, Finland

{samuli.kortelainen, antero.kutvonen, lauri.lattila}@lut.fi

Abstract. Innovations are significant source of competitive advantage for firms. They are also a major source of dynamics that forces firms to adapt their capabilities to sustain competitiveness. In this study we analyzed how firms manage their technological portfolio in mobile phone industry. Our first finding is that firms have focused differently their technology portfolios. Then we identified that most firms change their technology portfolio over time. And finally we conclude that firms in mobile phone industry have different levels of dynamics where some firms change their technology portfolio faster than others. This research identifies new challenges in dynamic capabilities research related to the appropriate level of dynamics in technology management. This information is crucial in practice in order to correctly manage the firm's dynamic processes.

Keywords. Technology portfolio, Technology strategy, Dynamic capability, Patent research, Mobile phone industry, Technology management.

1   Introduction

Technology and innovation management have become an integral part of modern businesses as innovations have a significant effect on firm's competitive performance. Despite long research tradition on this topic, many of the concepts in innovation management are still vague and discussion is mostly conceptual. The lack of practical approaches in literature is understandable as technology is inherently challenging to measure. From the management perspective the challenge is to be able to operationalize theories into practice, which usually requires clear measures and targets.

'Dynamic capability' is a central concept in innovation management (Teece et al., 1997). According to this theory, firms need to constantly adapt their capabilities to satisfy the current and also future demands set by their business environment. This theory builds on the ideas of Christensen (1997), who noted that even dominant dynasties could fail if they cannot adapt to the critical technological changes in their business environment. There are many big firms that have failed due to radical change in technology and their inability to correctly react to this change. One of the most recent examples of this is Kodak that failed to adapt to the era of digital photography and eventually filed for bankruptcy. Therefore, the ability to adapt to or even manage change is critical for the sustained competitive advantage of the firm.

In addition to being dynamic, a second implicit factor in firm's technology management is that it needs to adopt correct technologies. Technological development is, by default, very hard to predict. This has been evident e.g. in 'technology standard wars' where predicting the winning technology has proven to be hard. The challenge is materialized in cases where technologically superior products don't necessary become a dominant technology in the market (e.g. VHS vs. Betamax case (Cusumano et al,. 1992)). Therefore firms need to manage technologies in order to cope with the uncertainty related to innovations.

A common way to manage this uncertainty is to have portfolios of different competing technologies. This enables the firm to have flexibility, as they are not tied to one specific technology. This diversifying can also extend to firms developing technologies outside their traditional domain. The firm's technology portfolio is accumulated over time, meaning that the structure of technology portfolio is based on firms past R&D activities. As technologies and their relative importance change over time it's safe to presume that technology portfolios change over time. A more challenging question is whether the emphasis on different technological classes changes also over time or do firms focus persistently on particular areas.

Despite central role of the dynamic capability theory, there are still relative few studies where the theory has been clearly operationalized (Easterby-Smith et al., 2009). The following challenge is that there are no existing best practices in theoretical discussion for measurement of firm's dynamics. Some conceptual discussion has focused on how different metrics behave, e.g. how does the 'evolutionary fitness' between business environment and capabilities affect the firm's competitiveness (e.g. Helfat et al, 2007; Easterby-Smith et al., 2009) but concrete measurements are missing. The dynamic capability literature does not offer any uniformly agreed measurement techniques.

In this study we provide an interesting way to operationalize this concept. We use patent information to measure firms' dynamics. A patent is an output proxy measure of the firm's R&D. As a measure it is not perfect, as all research projects don't lead to a patent. However, it offers a structured way to measure those technological steps that firms want to protect with legislative means. As such, patenting is likely to be common for those technologies that have significant competitive value. The value of a patent extends over time. Therefore, snapshot like analysis (e.g. per year) is not accurate, but patents need to be pooled together to form patent portfolios. In this study we then see the patent portfolio as an output proxy measurement of the firm's technology portfolio.

In this article, we focus on how firms manage their technology portfolios and how dynamic these technology portfolios really are. The research questions are as follows:

RQ1. Are technology portfolios between different companies in mobile phone manufacturer industry similar?

RQ2. Can firms be grouped based on technology portfolios?

RQ3. Do the firms change the structure of their technology portfolios over time?

RQ4. Do the firms change their technology portfolio structures differently?

The research is conducted in mobile phone industry by implementing a systematic review to each firm's patenting activity during the last 30 years. The phone industry was selected to include different types of companies ranging from phone vendors, operating system developers to technology licensors. In total the study included 13 companies. The selected firms were Alcatel (Alcatel-Lucent), Apple, Google, Ericsson (Sony-Ericsson), HTC, Huawei, LG, Microsoft, Motorola, Nokia, Research In Motion (RIM), Qualcomm, Samsung, ZTE. It is notable that some of these companies have been active in the mobile phone markets longer than others, so 30 years of data was not available for all companies.

The paper is structured so that in the first part we will develop the hypotheses for empirical research part. In third chapter we describe the research methodology and how the research data was developed. In fourth chapter we present the empirical results, which are discussed in chapter five and concluded in the final chapter.

2   Literature review

The RBV defines that all firms have a unique resource base (Barney, 1991; Peteraf, 1993). This uniqueness is built and maintained due to imperfect resource factor markets, which prevents acquirement of resources quickly from external sources (Barney, 1986). The functionality of resource factor market has since been more thoroughly analyzed in open innovation literature (Arora and Nandkumar, 2012). However, the original argument by Barney on resource factor market imperfections cannot be ignored.

The practical implication of imperfect resource factor markets is that it increases the importance of firm's internal innovation activities in building the firm's future resource base. Using the dichotomy of exploration-exploitation by March (1991), the need to accumulate new resources for the future stresses the importance of exploration activities.

The practical outcomes from explorative activities are the different types of new technologies, techniques, or processes that the firm can choose to try to utilize in the future. The common practice is to protect these entities by applying for a patent to claim the advancement. Therefore, patent information can be used as an output proxy of firm's research activities and patent information has been previously used to analyze firms' research activities (e.g. Arora and Nandkumar, 2012). The benefit of patent information is that it is naturally presented in a structured way due to patent regulation, which makes comparison between different firms over a long time period easier when compared to many other ways of measurement.

Therefore, the first hypothesis in our paper focuses on the patent portfolios of companies. If the firms truly have a unique resource base and they have to develop a significant portion of these resources by themselves due to imperfect resource factor markets, it should show in the patenting activities of the companies.

Hypothesis 1. Patent portfolios are different between the firms

The second hypothesis is tied to grouping of firms. The concept of strategic groups was introduced by Hunt (1970). The central argument of the concept is that there are companies in markets that are using similar strategies or business models to compete in the market place. These differences could be used to explain performance differences among firms within that compete in the same industry, but are part of different strategic group (ZuÏnfiiga-Vicente et al., 2004). Thus competition among these subgroups is different than competition in other areas of the market. The concept was further developed by Porter (1979) who identified that these groups actually formed different segments on the market. The strategic implication of this is that if these segments enabled the firm to profit from these markets they could also be protected against competitor entry allowing some degree of sustained competitive advantage within that market.

The aim of strategic grouping is to better understand the profitability differences between firms (Porter, 1979). Additional use scenario for the use of strategic group mapping has also been suggested to be ability to tracking and understanding industry dynamics (Harrigan, 1985). The empirical evidence has shown mixed results for the theory, which has been strongly linked to various different ways to operationalize the central concepts and methodological issues (McNamara et al, 2003). However, more recent studies (Ferguson et al., 2000; Nair and Kotha, 2001) have shown more consistent results. The theory has also been criticized from the fact that studies with a focus on the internal side of the companies, have shown that there are significant performance differences between firms within a single strategic group (e.g. Cool & Schendel, 1988). This line of reasoning led to much criticism against the founding economic theory behind strategic groups (Industrial Organization) and eventually to

the birth of the resource based view (RBV) (e.g. Barney, 1991).

Previous strategic group research has focused strongly on the market side of the firms' activities as research has been based on e.g. degree of vertical integration (Newman, 1978), investments to development (Porter, 1979), pricing policies (Budayan et al., 2009), type of clients (Budayan et al., 2009), financial performance measures (Short et al., 2007), and subjective rating of technical capability (Budayan et al., 2009). We approach this grouping from an internal perspective, as we measure firms' capabilities with higher detail by analysing a wide range of the firms' patents.

So the second hypothesis focuses on analysing the similarities among different firms by trying to group the different firms into strategic groups.

> Hypothesis 2. Firms form strategic groups based on technology portfolio analysis

Recent development steps in strategic management theory have led to development of the dynamic RBV theory (Dierickx and Cool, 1989; Helfat and Peteraf, 2003). The founding argument of this theory is that protecting the firm's unique resource base is not enough to sustain competitive advantage, but firms need to change their capabilities over time (Teece, 2007; Helfat et al., 2007). Likewise, economies of scale and scope or favorable market position (Porter, 1980; 1991) are not sufficient on the long run, where the capability to continuously innovate and renew the competitive foundations of the firm determine success (Teece, 2007). The central concepts behind this theoretical discussion have been the dynamic capabilities (Teece et al., 1997) and later the dynamic RBV (Helfat and Peteraf, 2003).

As defined above, the firm's internal research processes are crucial in defining the firm's (technological) capability base in the future. Continuing on this logic, if the firm wants to change its capability base, or in other words be dynamic, it needs these processes to adapt itself. Therefore, the second hypothesis focuses on the change of firm's patent portfolio over time.

> Hypothesis 3. The firm's patent portfolio emphasis changes over time

The final hypothesis focuses on the nature of change. Organizational adaptation presents managers with contradictory requirements of change and stability thus invoking the change-stability paradox (Klarner and Raisch, 2013). Fast-based change has been argued to be beneficial as it helps overcome organizational inertia by preventing the creation of organizational routines that reinforce current strategic direction (Amburgey and Miner, 1992), induce inertia (Hannan and Freeman, 1984) and give rise to competency traps (Levinthal and March, 1993). Due to these effects, maintaining excess stability in organizational change situations can be detrimental for long-term performance (Burgelman and Grove, 2007). Furthermore, fast-paced change can lead to establishing routines for change also called "metaroutines" (Adler et al., 1999) that lead to higher organizational flexibility and proficiency in managing organizational change and have been connected to higher performance, especially in highly dynamic environments (Brown and Eisenhardt, 1997).

However, excessively fast change can also prove detrimental to organizational performance. Periods of stability are required to allow for learning effects and establishing organizational routines that transform collective experience into performance (Levinthal and March, 1993; Eisenhardt and Martin, 2000). Moreover, fast-paced change may induce information overload for top management, where the capacity of the management to interpret new information on a level that enables making sound decisions is exceeded (Huber, 1991), thus leading to taking suboptimal decisions and formulating ineffective strategic responses (Eisenhardt, 1989). Moreover, attempting to increase the speed of organizational change will invoke time-compression diseconomies (Dierickx and Cool, 1989) leading to diminishing returns

on additional resources allocated to facilitating faster change. Recent research shows that while firms may enjoy short-term benefits by focusing on either change or stability, a balanced approach will yield superior long-term performance (Klarner and Raisch, 2013).

Scholars argue that some firms have better dynamic capabilities than other firms often due to routinizing change processes (Amburgey et al., 1993) and creating procedures for modifying or creating routines efficiently, through constant or continuous change (Brown and Eisenhardt, 1997). This would reflect that some firms are better at changing their capability base than others and that this difference in dynamic capability should be subject to time-compression diseconomies (Dierickx and Cool, 1989) and at least imperfectly (if at all) tradable, as "organizations learn to change only by changing" (Amburgey et al., 1993), thus potentially rendering it visible in the longitudinal data.

The final hypothesis focuses on this issue by assessing the amount of change in firm's patenting activity.

> *Hypothesis 4*. The pace and magnitude of change in the patent portfolio is different between firms

3   Methodology

3.1   Data development

The main data used for research is patent data. In this chapter we will describe how the data was gathered and cleared for research. The overall research process is described in the Figure 1. Table 1 describes how the number of patent data changed as the process progressed.
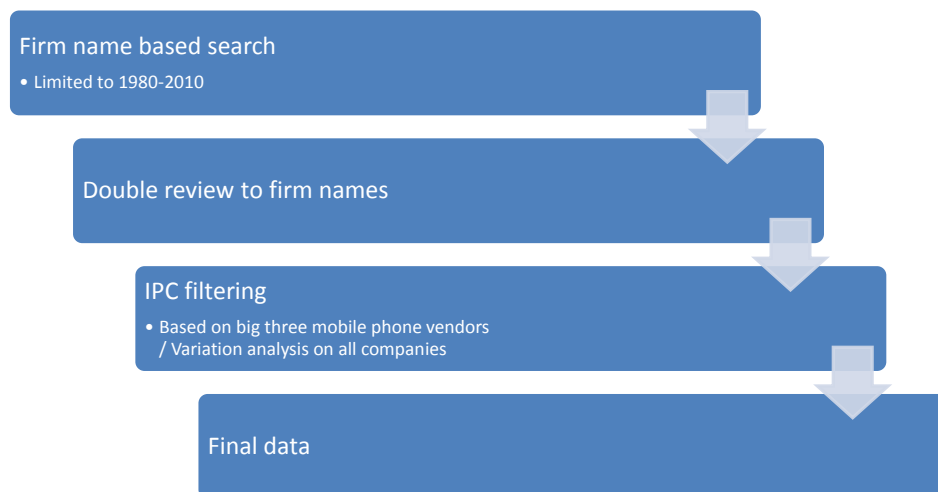

Fig. 1. Data development process

Table 1. Number of patents in different stages of research process.

STAGE	NUMBER OF PATENTS
Initial search result	1, 992, 783
Name filtering	1, 437, 608
IPC filtering	1, 299, 255

The first step in development was data extraction. The patent data was gathered from the PATSTAT database, which is maintained by the EPO (European Patent Office). The database was updated in 2012, which allows the use of reliable data until 2010. The two year delay in usability of the data is caused by the time it takes for a patent to be formally accepted by a patent office. Therefore the data was limited so that the newest patents included for the study where restricted to patents applied before 2011. The beginning time of analysis was restricted to year 1980 that precedes the launch of first commercial mobile phone (Motorola DynaTAC 8000x) by 3 years.

The patents' information was gathered by semantic searched based on the company name. Each company name was directly with wild card symbols both before and after the name. For companies which use both long and short version of their name both writing ways were used to gather data. The search words are presented in Appendix A.

The use of wildcards in semantic searches enables gathering of wide datasets but also inclusion of typos that exist in the dataset. It also creates challenges as many additional patents are included where the names of the company name letters are in same order. To counter this, to exclude extra patents from the dataset each company results were analyzed separately by two researchers. The independently made lists match rate was 98%. The 2% of names were decided based on discussion case by case by the two researchers.

The patents needed to be restricted also from another perspective. As the analysis period is long and many companies included to this study have not been active the years per firms was further restricted based on the amount of yearly patents applied. The limit was set to 50 patents where years with fewer patents were excluded from the analysis.

Another factor that has to be acknowledged is that most of the companies included to this study are conglomerate companies (e.g. Samsung and LG). Therefore, their patent portfolio is much wider and contains many unnecessary patents for making mobile phones. We filter the relevant patents by determining the core patenting classes from the patenting activity of three highly mobile phone manufacturing centric companies (namely Nokia, Ericsson, and Motorola). Each firm's top 30 most used IPC classes were combined as the filter list of central mobile phone patent classes. To avoid the potential time bias, we replicate this procedure twice based on time where first analysis includes years before 2000 and second analysis the data from last 10 years. This additional second round enables that more recent but from total time perspective smaller patent classes are included to study enabling more accurate analysis of recent dynamics. The final IPC class list included to the study is presented at Appendix B.

The final data is described in table 2. The final data describes the firm that is applying, the IPC classes the patent is applied in and finally the date when the patent is applied.

Table 2. Descriptive statistics from data

FIRM	TOTAL	AVERAGE / YEAR	MAX / YEAR
Alcatel-Lucent	141898	4434,31	16352
Apple	14007	437,72	1829
Google	4802	343,00	747
HTC	874	39,73	244
Huawei	61336	3228,21	12621
LG	240660	9626,40	30128
Microsoft	77043	2853,44	13633
Motorola	119614	3737,94	8116
Nokia	126354	3948,56	11275
Qualcomm	101221	3893,12	10073
RIM	27311	1517,28	4291
Samsung	487732	15241,63	54561
Sony-Ericsson	614768	19211,50	43157
ZTE	34703	2669,46	8826

3.2   Research methodology

The statistical testing is based on cross tabulation and Chi-Squared testing. The 23 patent classes included to this study set a challenge for mathematical analyses. The number of different classes was reduced by using clustering to narrow the amount down. We utilized hierarchical clustering with between-group linkage and squared Eucledian distance as the clustering method. We used the relative share of patents as the data for the analysis, e.g. how large share of all of the patents of a firm were from each patent class. Meaningful amount of clusters were between two and four and four clusters were chosen as the patent classes clustered meaningfully in these four. The distribution to different clusters can be found from Appendix C.

In addition some adjustment needed to be made for longitudinal analyses. To compensate for sometimes long lead times in patent development, 3 years rolling average is used for analysis. This enables also the simulation of portfolio perspective as longer projects are seldom managed over a course of one year.

4   Results

The first analysis is the cross tabulation of firms and clusters identified in the previous chapter. The cross tabulation of results are shown at appendix C. The Chi-Square tests results are clear as the 2-sided asymptotic significance is 0, thus showing a strong statistical support. One reason for strong statistical support is the extremely high sample size. Nevertheless, the data shows significant differences in patenting activities between the firms.
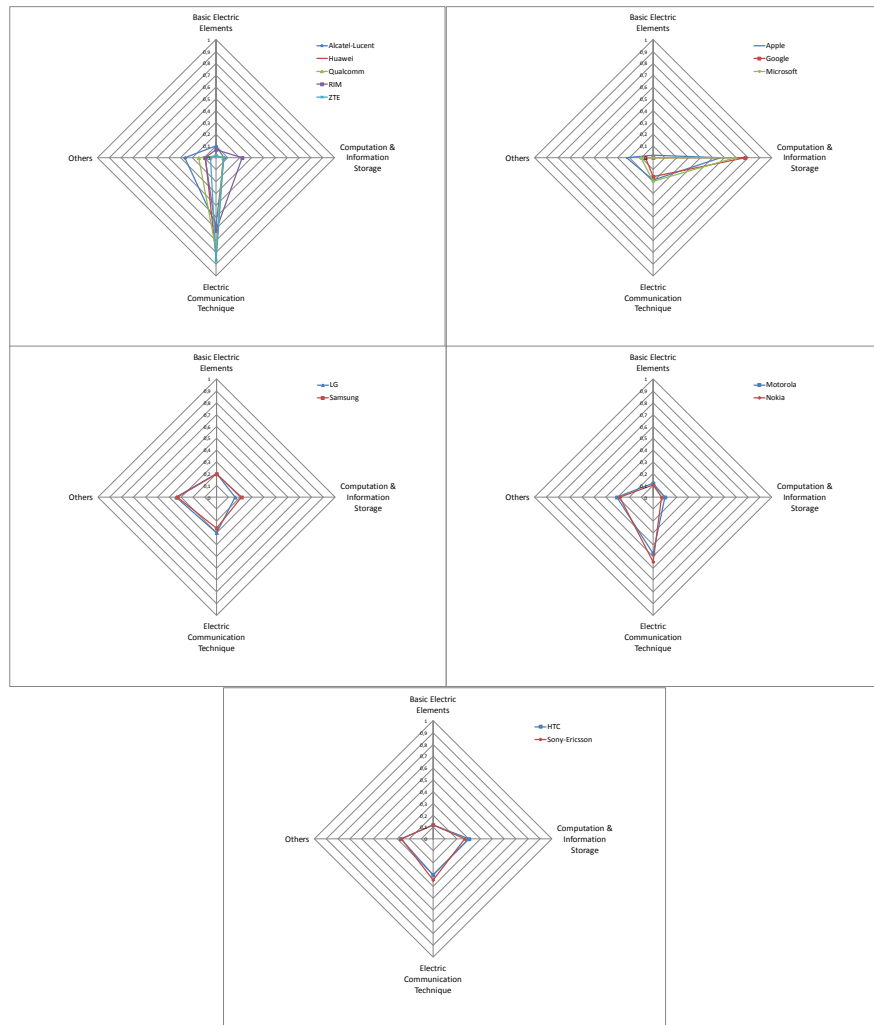
Fig. 2. Technology strategy clusters

Table 3. Technology strategy cluster descriptions

GROUP	COMPANIES	FOCUS
1	Alcatel-Lucent, Huawei, Qualcomm, RIM, ZTE	Strong focus on Electric communication techniques
2	Apple, Google, Microsoft	Computation & Information storage
3	LG, Samsung	Balanced technology portfolio
4	Motorola, Nokia	Electronic communication techniques emphasized, but also others
5	HTC, Sony-Ericsson	Relatively balanced, emphasis on electronic communication and computation & information storage

Figure 2 illustrates the relational weight of each identified patent class cluster. In total five different groups were identified within which the companies share a similar patenting activity. These groups are formed based on different kind of balances between different technology dimensions. It is notable that these measurements are all relative thus the absolute size differences among firms are not captured in these figures (Table 3).

The second part of tests was implemented by firm level cross tabulation between patent clusters and application year. The firm level analysis shows that all companies are changing their patent portfolio over time. Thus this supports the second hypothesis: firms change their patent portfolio structure over time. Figure 3 shows an example of how Nokia's emphasis to different patent cluster has changed over time. As expected the focus is strongly on electronic communication techniques, but it is notable that computation and information storage related patents have been rising steadily over the last 10 years. Also notable is the decline of other patents as Nokia turned from conglomerate to mobile phone manufacturer.
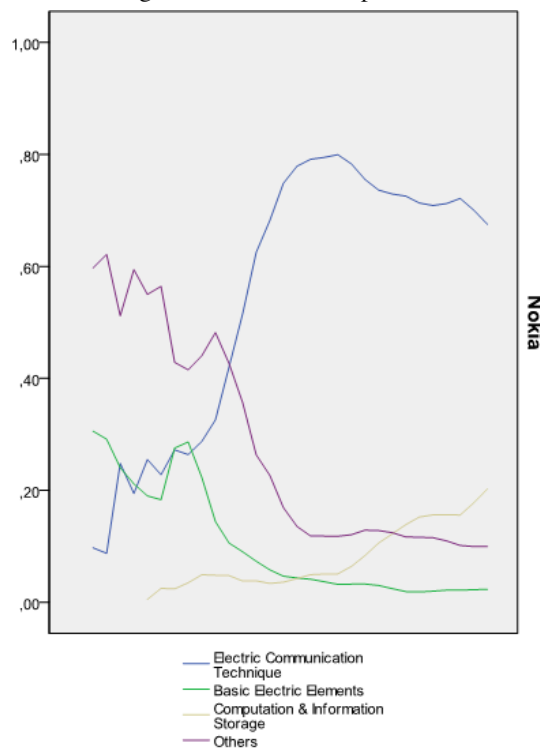

Fig. 3. Timeline of Nokia's patenting activity

The final research question was on the firm level differences in dynamics. The level of dynamics was measured by calculating for each firm the yearly relational change in each patent cluster. This crude measure gives the amount how much the company is changing its portfolio over time – higher number implies for larger change. The analysis shows that there are significant differences between firm averages over time. E.g. Nokia has much higher average change when compared to traditional phone vendors like Sony-Ericsson or Motorola.

Table 3. Dynamics of the companies

NAME	MIN	MAX	AVERAGE	YEARS
Alcatel-Lucent	0,7 %	21,9 %	5,9 %	30
Apple	1,4 %	21,6 %	7,6 %	27
Google	1,6 %	43,1 %	10,8 %	8
HTC	4,5 %	35,2 %	15,1 %	8
Huawei	1,0 %	11,6 %	5,3 %	12
LG	1,5 %	21,3 %	6,5 %	22
Microsoft	0,7 %	16,1 %	6,5 %	20
Motorola	1,8 %	13,0 %	5,6 %	30
Nokia	0,9 %	32,1 %	9,3 %	29
Qualcomm	1,8 %	16,8 %	5,5 %	22
RIM	0,9 %	56,4 %	12,1 %	14
Samsung	1,5 %	18,2 %	5,5 %	27
Sony-Ericsson	0,6 %	9,0 %	3,8 %	30
ZTE	0,7 %	4,3 %	2,1 %	9

5   Discussion

The support for hypothesis 1 is in line with the fundamental claim in RBV that firms have unique resources. Even when the number of different classes was diminished to just 4, the firms were found to be different over the whole inspection period. This finding can be expected as the study contained firms that are in different roles in the mobile phone industry. When the inspection is done only within each firm group that provide similar service to the market, the results show that firms don't have similar patent portfolios. This phenomenon occurs with the simplified patent data where only 23 patent classes were identified. As such, this finding strongly supports that even within a particular market segment firms don't have similar technology portfolios. Thus we find measured support for the basic principles behind RBV theory.

Further analysis of the firms' patent portfolios showed that the included firms could be divided to five different clusters based on overall patenting activity. These clusters suggest that there are certain technology strategies that a selected group of companies pursue. This finding supports hypothesis 2. Some of these groups were as expected based on market segmentation. For example, the software oriented firms (Group 2, Apple, Google, and Microsoft) had similar technological portfolios. An interesting finding is that despite similar backgrounds and technological portfolios only Apple has managed to successfully enter mobile phone markets with its own brand.

Another interesting finding in technology portfolio groups was that out of the dominant players the two most recent market leaders Nokia and Samsung did not

belong to same strategic group. Nokia was actually grouped with Motorola, which was the dominant firm in the market before Nokia and Sony-Ericsson, whereas Samsung was grouped with another upcoming Korean phone manufacturer LG. This finding suggests that some firms are competing in the same market with strongly differing technology strategies. The fact that the new market leader in mobile phones uses a significantly different technology portfolio than the previous leader suggests that there has been a significant shift in market needs during the time when market leadership shifted.

The third hypothesis analysed the dynamics in firms' capability accumulation. The results showed that firms change their patenting activities strongly, which is reflected in the statistical support for hypothesis 3. This finding has dual impact. First, it contradicts the original RBV theory that builds competitive advantage on protecting the firm's unique resources. Second, it supports the claim of the dynamic RBV discussion that firms need to constantly change their capabilities.

Although this evidence gives appealing support for dynamic RBV, the conclusion cannot be made so directly due to two distinctive reasons. First, the used data captures the dynamics only partly as exploitation of patents is not included. This means that based only on patent information it's impossible to analyse how companies actually decided to utilize their new technologies. As products ultimately define a firm's market performance they are critical in explaining the firm's performance on the market. Secondly, the data cannot be used to show undoubtedly strategic intent in the firm's action. As data shows that firms' patent portfolios are changing in a continuous way it suggests that this change is caused by a deliberate strategic decision to manipulate firm's technology portfolio. However, to ensure if this is caused by strategic decision the only way would be to analyse strategies either though yearly reports or interviews.

Hypothesis 4 could not be statistically tested, but the results from the descriptive analysis show that different firms have different levels of dynamics. The level of dynamics is not static but the speed of change for a firm varies over time. When looking from a longer perspective the averages show that some companies have constantly higher dynamics than others. Most of the biggest players in mobile phone industry have a moderate level of dynamics, putting them on the midrange of dynamics in our sample.

The firm's level of dynamics is also hard to describe. Our data shows that e.g. the firm's age in the market has low explanatory ability to the speed of change as e.g. HTC is one of the highest and ZTE is one of the lowest to change on average. From performance perspective the finding is also obscure. Firms like Sony-Ericsson and RIM, which have had severe performance problems, seem to have engaged in totally different level of dynamics. Sony-Ericsson had low level of dynamics versus RIM with one of the highest levels of dynamics. This finding cannot directly confirm, but it is in line with the argument by Klarner & Raisch (2013) that nor low or high dynamics is good for the firm but it's about balancing the dynamics and controlling the timing. Therefore, it can be argued that there are different levels of dynamics for firms but the important implication of these to firms' performance cannot be yet defined.

This research leaves us with interesting future research questions. In this paper we showed one way to operationalize a firm's technological dynamics. We also showed that with this measure firms can have different levels of dynamics. The question that follows is what is the appropriate level of dynamics for the firm? Is the correlation between dynamics and firm's performance linear or non-linear; is the correlation positive or negative? Also, to what degree this is a strategic decision? If firms want to change could they change faster than they actually do? These questions are still left open as in this paper we merely described the phenomenon. The managerial need for

guidelines for the management of dynamics is a serious issue and one that deserves further research.

Although the research was based on a large quantitative dataset, the analysis was done for a single industry. This effectively causes that the study is a case study that raises questions on generalizability of results. The observed phenomena of differences between firms' technology portfolios and technology portfolio dynamics were clear. During the analysis period, mobile phone industry has gone through several different technology cycles and a more fundamental shift from traditional phones to smart phones. From a technical perspective the firms have reacted to this same change in the business environment in different ways. This supports the claim that in our sample the firms have developed their capabilities differently. We argue that as the reaction from firms to external change is not standard, this phenomenon is likely to occur also in other industries. Still the only way to ensure generalizability is to replicate similar studies in other industries.

Generalizability of results leads to discussion on methodologies in dynamic capabilities research. As dynamic means change over time, longitudinal research approach is a necessity in empirical dynamic capability research. However, longitudinal research is challenging and many management studies have opted for a horizontal approach in sampling (Armstrong and Shimizu, 2007). This sets a clear challenge for future efforts to operationalize the dynamic capabilities concept. For generalizable results, research needs to adopt both longitudinal and horizontal dimensions in sampling. As such, the measurements need to be able to give relative measurements over time. In this study we used patents as proxies for measurement. They offer one way to measure dynamics, but cleansing, handling and analysing that quantity of data sets many practical challenges that need to be resolved.

6   Conclusions

In this paper we set out to analyze the dynamics of firm's technology portfolio. We make three conclusions and one proposal. First, we conclude that from the technological perspective firms seem to have unique technological backgrounds. This supports the RBV discussion that firms are unique capability combinations. Second, we found that firms can be clustered into different strategic groups. This adds to current knowledge that firms can be grouped also with internal measures as most previous studies have highlighted more the positioning of the firm in the end markets. Third, firms change their technology portfolios over time. The evidence clearly shows that firms change the structure of their technology portfolios. We cannot estimate to what extent this is a deliberate shift, but it does not change the fact that this change is happening. Finally, we propose that firms have different levels of abilities to change over time – or firms have different levels of dynamic capabilities. This however, remains only a proposition, as further research is needed to better understand this phenomenon and its determinants.

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Appendix

Appendix A. Search words for companies (is not case sensitive)

Mobile phone manufacturers	
Alcatel-Lucent	%Alcatel%, %Lucent%
Apple	%apple%
Ericsson (Sony-Ericsson)	%ericsson%, %sony%
HTC	%HTC%, %high tech computer%
Huawei	%Huawei%
LG	%LG%, %gold star%, %goldstar%, %dacom%, %serveone%
Motorola	%Motorola%
Nokia	%Nokia%
RIM	%Rim%, %Research in motion%
Samsung	%Samsung%
ZTE	%Zhongxing Telecommunication%, %Zte%

Support firms	
Google	%Google%
Microsoft	%Microsoft%
Qualcomm	%Qualcomm%