The development of absorptive capacity in large firm-- A longitudinal exploratory study on Garmin's Automotive/Mobile segment over time span

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ABSTRACT

This paper builds on Zahra and George's four dimensions of absorptive capacity (ACAP) trying to identify the development of absorptive capacity (ACAP) within large firm using longitudinal method. The empirical study using Garmin's automotive/mobile segment as a case, demonstrated the process development of ACAP through time span using key indicators. Based on all available public data and using content analysis, the data shows a tendency of faster ACAP development in Garmin's automotive/mobile business segment with increasing amount of R&D investment. Finally, the industry force might also act as a factor boosting the development of ACAP in large firms.

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Keywords

Absorptive capacity, longitudinal study, large firm, time span, ACAP development

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1. INTRODUCTION

In a more complex and competitive business environment, firm's innovation performance plays a crucial role in its survival (Indarti, 2010). Absorptive capacity (ACAP), as an important concept, might contribute to firm's innovation performance recently has gained much more attention to help firms develop their competitive advantage. Over the years, researchers believe firms endowed with high level of absorptive capacity could help achieve their competitive advantage and outperform their competitors. Tsai (2001) states that a firm's absorptive capacity is closely linked to its innovation performance and furthermore affects a firm's financial performance (Kostopoulos, Papalexandris, Papachroni, & Ioannou, 2011). In knowledge-intensive and rapid change sector like technology, the needs of firm's high level in absorptive capacity is needed urgently as all firms are eager to obtain the latest information and act quickly enough and trying to outperform rivals.

Since Cohen and Levinthal first raised the concept of absorptive capacity (ACAP) in 1990, prior knowledge is believed to be a crucial element that determines the level of firm's ACAP by numerous researchers. (Cohen & Levinthal, 1990; Kim, 1998). In Cohen and Levinthal (1990) 's paper, they argued prior knowledge determines level of absorptive capacity in a firm. According to Kim (2001), prior knowledge base refers to existing individual units of knowledge available within the organization, hence, the aggregation of individuals' knowledge. Large firms, have larger amount of employees, therefore a more diverse and larger knowledge base. Theoretically, it is easier for large size firms to acquire new knowledge from the external environment. Due to high capability of acquiring external, knowledge, it is easier for large firms to develop and maintain ACAP, and as time goes by, the ability will further improve through the accumulation in experience and the extension in knowledge base.

However, the research done by O'Dwyer and O'Flynn (2005) suggests that firm's willingness contribute more to the development of absorptive capacity than the ability to acquire the knowledge Jane Zhao and Anand (2009) indicates that "structural and cultural aspects of the organization are stronger determinants of the organization's ability to adapt to new practices other than the sum of the individuals' prior knowledge and experience," hence is contradictory with the theory that large firms have better ACAP due to the richness in prior knowledge. Moreover, large firms do have mature market position and mature technology, which reduces needs to acquire external knowledge (Barge-Gil, 2010). Thus, the more developed the firm is, the less need it is to learn from the environment, that is to say, the ACAP will become harder for big firms to develop or maintain since the need is low. The different views above could not conclude whether it is easier or harder for big firms to develop their absorptive capacity, however, it is for sure that development of ACAP differs from well developed big firms and start-ups. Therefore, it is interesting to figure out whether the development of the big firm will slow down or increase the development of ACAP during the time span.

Based on the original concept of ACAP (Cohen & Levinthal, 1990), researchers have extended the concept through the conceptualization process, which includes the four-dimension model by Zahra and George (2002) and the refined model of absorptive capacity by Todorova and Durisin (2007). And both models argue the routine and process characteristics of absorptive capacity, which leaves room to take an in-depth look at ACAP through observing antecedents and processes. Currently, many existing literature focused on the antecedents of ACAP both from resource based view and organization perspective(Bosch, Wijk, & Volberda, 2003; Kamien & Zang, 2000; Kinoshita, 2000; Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio, & Manjarrés-Henríquez, 2008), while lacking in the study from the process perspective in studying the development of ACAP.

Therefore, the uniqueness of this research lies in the literature gap of lacking of longitudinal study on the development of ACAP from the process perspective within a time span, let alone an empirical case study. The research conducted will demonstrate how did a firm's absorptive capacity develop during a time span and investigated deeper to find out the reason that might lead to difference in development. Furthermore, by conducing the research, firms could have a clear picture on how the inter-relation between absorptive capacity and their innovative performance during years within the firm, and this might assist management teams in firms to better understand the capability of the firm and further help to better develop their strategy by changing their absorptive capacity level through time span in order to keep their competitive advantage.

All in all, this paper will conduct an exploratory research trying to map the development of absorptive capacity over time within a large firm. The research contributes to existing research in multiple ways 1), by adding a longitudinal case study on the process perspective of absorptive capacity 2), provides empirical evidence on how could the absorptive capacity level in large firms change with time span. 3), the factors that might influence the development of absorptive capacity.

1.1 Research question

To have a better understanding the problem, the central research question is formulated as following:

How would the absorptive capacity develop over time in a large firm?

And to better answer the main research question, the following sub-questions are presented:

1. What patterns of the development of absorptive capacity could be found in large firm?

2. What might cause the change of the absorptive capacity changes over the time span?

2. THEORY

2.1 Research model

Due to the lack of a longitudinal research done regarding to absorptive capacity, no existing model could be used. The model used in this paper is initially based on "The absorptive capacity construct and its dimensions model" by Lane, Koka, and Pathak (2006), and combing with the four dimensions of absorptive capacity from Zahra and George (2002).

The original research model in Lane et al. (2006), was constructed to check how the absorptive capacity construct has been used regarding to the dimension of absorptive capacity, hence in a longitude of "how central the construct of ACAP is to the paper's topic. However, in this paper, the longitude of study focused more on the time span of the development of absorptive capacity, thus different. Furthermore, the dimensions of absorptive capacity are adopted from Zahra and George (2002), which is an extended conceptualization model of absorptive capacity by that consist of four dimension, acquisition, assimilation, transformation and exploitation respectively.

Unlike the original model quantify the data to use the model due to its longitude aspect, however, in this paper, the development of absorptive capacity is monitor through time span, qualitative collected data is directly used to better understand the change through time. In order to do so, first of all, key indicators are used to find qualitative data to each of the four dimensions. All those key indicators should be measurable regarding to the subject of study to ensure the coordination, while the specific measurement will be illustrated later on. The data of all those key indicators from each dimension of ACAP will then be mapped in a table. The table will consist of all data with a time span from 2005-2013.

With all data represented in a table, the following step is trying to find possible correlation between those key factors. And the observation especially focused on the specific knowledge flow through time span within the four phases of absorptive capacity. Finally, by linking all possible knowledge flow through the four dimensions, a trend or inter-correlation of the development of absorptive capacity should be able to observe.

Since the concept of learning organization is getting more popular, more firms are eager to learn and expand their knowledge base through various terms. Besides, with the technology development, the knowledge transfer is becoming easier. And based on all the facts, the following hypothesizes are made:

Hypothesis 1

The development of absorptive capacity now is faster in large firms than before.

Hypothesis 2

The transformation and exploitation of ACAP now is faster in large firms than before.

Hypothesis 3

The investment in R&D development could speed up the development of absorptive capacity in big firms.

2.2 The four dimensions of absorptive capacity and the development of ACAP in large firms

Absorptive capacity (ACAP) concept was first raised by Cohen and Levinthal in 1990 which they defined as the firm's ability to acquire new external knowledge to transfer and contribute to its innovation development to achieve its competitive advantage(Cohen & Levinthal, 1990). Mowery, Oxley, and Silverman (1996) defined ACAP "as a broad array of skills" which deal with the "the tacit components of transferred technology". It also mentioned the importance of transfer external knowledge into application. ACAP was later extended by Kim (1998) emphasing the skills developed through ACAP, which enables the firm to create new knowledge for innovation. Zahra and George have extended the concept and suggested four dimensions regarding to absorptive capacity that consist of knowledge acquisition, assimilation, transformation and exploitation respectively. Those four phases have further been categorized as potential absorptive capacity (PAC), which contains acquisition and assimilation and realized absorptive capacity (RAC) that includes transformation and exploitation(Zahra & George, 2002). Potential ACAP, according to Fosfuri and Tribó (2008) acts as a bridge between external environment and the internal organization, while realized absorptive capacity rather focused on the ability to exploit knowledge than transform to firm's innovation outcome (Fosfuri & Tribó, 2008).

Among all definition of ACAP, Zahra and George's four dimensions of absorptive capacity is widely used in conceptualizing the concept. **Acquisition** according to Zahra and George (2002) is the "ability to identify and acquire critical external knowledge". Cohen and Levinthal (1990) point out the importance of prior knowledge, as the basic role of absorptive capacity. Fosfuri and Tribó (2008) conclude that external knowledge acquisition search is as act as key antecedent that affects firm's absorptive capacity based on the empirical study among various Spanish firms. Kim (1998) in his paper again, emphasize the criticalness of prior knowledge at acquisition dimension as the "accumulated prior knowledge will increase the assimilate the new knowledge." Zahra and George (2002) in their paper summarized three main components in knowledge acquisition that affect ACAP, which are the knowledge intensity, speed and direction.

Assimilation according to Kim (1998) refers to the learning process of external knowledge in a form of "learning by doing and learning by using". In his paper, he also mentioned the effect of assimilation on "incremental changes on imported/external knowledge". And by doing so, the external knowledge could be digested by the organization. Zahra and George (2002) argue the comprehension at this dimension "promotes the assimilation" of external knowledge. Therefore, at this dimension firms try to interpret the external knowledge in a way that it is easy to understand and operate. All in all, assimilation dimension act as "translator" between acquisition and transformation, in a way that translates the acquired knowledge into a "language" that is easier for organization to understand.

The following **transformation** dimension is the way in which firms deal with new acquired external knowledge in combination with the exiting knowledge(Zahra & George, 2002). At this dimension firms might try to add or delete knowledge to their existing knowledge base that shape the mindset of the firm(Zahra & George, 2002). Transformation dimension also lays a solid foundation for further strategic change of the firm(Zahra & George, 2002). **Exploitation** as the last dimension of ACAP is based on previous three dimensions and it is the phase where firms apply its knowledge (Zahra & George, 2002). It is at this dimension; firms often create new competitive advantages as well as showing the ability of firms in harvesting(Zahra & George, 2002). The outcome in this dimension could also help firms build new goods on it in persistence(Zahra & George, 2002). Therefore, at this phase, the outcome has a long-term orientation, which allows firms to benefit from a long run.

The current literature on the study of ACAP in large firms have two extremely opposite believes. The main argument to support the argument it is easier to develop and maintain ACAP is based on large firms often have more resources. This argument was first supported by Cohen and Levinthal (1990), as stated that "prior knowledge facilitates the learning of new knowledge". With a more diverse knowledge base for large firms, they do have advantages in prior knowledge accumulation. A study done by Sørensen and Stuart (2000) show, with more patents the firm obtained in the past, the higher the firm's absorptive capacity level will be. Regardless of prior knowledge, large firms are usually rich in capital and R&D budget. Cohen and Levinthal (1990) first found the linkage between firm's R&D ability and absorptive capacity and state that firm's investment in R&D could improve its absorptive capacity. Kamien and Zang (2000) later confirm the theory by specifically pointing out firm's budget would influence its absorptive capacity. Eventually, firms with larger amount of R&D budget will have a higher level of ACAP; hence, the increase in R&D investment will boost the development of ACAP.

Contrarily, other researchers believe large firms have disadvantages in ACAP development. One main argument is that ACAP depends more on firm's motivation rather than recourses (O'Dwyer & O'Flynn, 2005). The other argument is based on organizational structure, which is regard as a strong determinant in ACAP (Jane Zhao & Anand, 2009). Liao, Welsch, and Stoica (2003) found small firms are usually doing better in responding to changes due to the low level of bureaucracy, while large firms always have more complex organizational structure. Moreover, some studies even suggest that for smaller size firms with low ACAP currently are more devoted in developing ACAP, as larger firms have less need (Larrañeta, Zahra, & González, 2012). Furthermore, with mature market position and technology, the need for large firms to further develop ACAP have decreased (Barge-Gil, 2010), despite that motivation plays a crucial role in firm's ACAP development.

3. METHOD SELECTION

3.1 Subject for study

As prior knowledge act as a key factor that affect firm's ACAP, the research is primary focus on knowledge-intensive industry, as it is more likely firms in the industry have intentions to develop ACAP. The navigation sector is chosen not only because of its technology intensity characteristics but also due to lacking of literature covering this sector. Navigation industry, especially the car navigation sector had a dramatic shift in the past years, which from navigation devices dominating the market to navigation apps leading the market share (MIT Technology Review, 2013). The industry shift requires a lot of information flow and knowledge exchange, which provides an excellent condition for firm to obtain external knowledge and exploit it.

This paper focused on the development of ACAP in large firms, thus Garmin as a company with 1,302 million US dollars revenue (Garmin, 2013), and around 8,800 (Garmin, 2014a) employees becomes an idea case for the study. Garmin as a leading GPS device provider (Garmin, 2014c) offers comprehensive products including automotive and personal GPS devices for customers. Its revenue from 2005- 2013 has a drastic rise and fall (see Figure 1), which is a quite interesting to study whether it has any linkage to the development of ACAP.

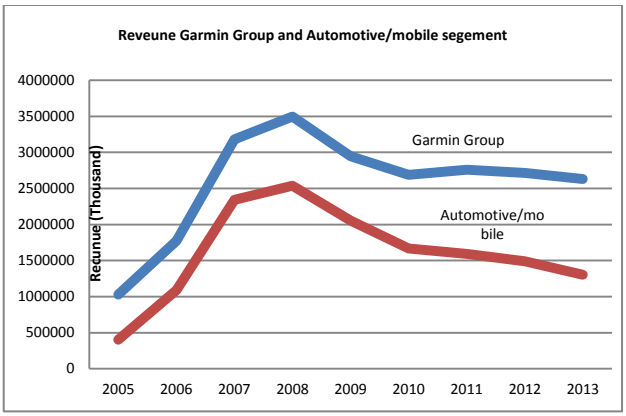


Figure 1, Revenue of Garmin Group and Garmin's automotive/mobile segment from 2005-2013.

Garmin's automotive/mobile segment is the most representative and core businesses within Garmin group, with total revenue of 1,302 million in 2013(Garmin, 2013). Garmin Group is headquartered in Kansas City, the USA currently involved in five business segments, including Automotive/Mobile, Aviation, Marine, Outdoor, Fitness (Garmin, 2014c), among which the Automotive/Mobile segment is the biggest. It is currently the leader in Automotive/Mobile devices market that occupied 34% in European market and 76% in North America market in 2013 (Garmin, 2013). Furthermore, the Automotive/Mobile segment also has the largest portion of Garmin's revenue mix that occupied 49% in 2013 (Garmin, 2013). Therefore, by studying only Garmin's automotive/mobile segment could also to some extent indicate the development of ACAP within Garmin group.

Garmin's automotive/mobile segment consists of three operating segments, which are automotive PND, automotive OEM and mobile respectively. According to NASDAQ, those operating segments are not reported separately but are aggregated within the automotive/mobile reportable segment (NASDAQ, 2014). Garmin's automotive/ mobile segment also experienced a revenue raise and fall, which shares similar patterns within whole Garmin Group; in 2008 it reached its peak point of prospers that occupies 76% of Garmin's total revenue (Garmin, 2008), followed by a sharp fall to 49% in 2013(Garmin, 2013) . In 2011, it merged the German navigation device and software manufacturer NAVIGON (Engadget, 2011) with 72 million US dollars.

News reports have blamed the revenue shrink on Garmin's failure in not signaling the development of mobile navigation market (Kansa city business journal, 2013; MIT Technology Review, 2013). It was until 2011, after the acquisition of the German navigation manufacturer NAVIGON, did Garmin start to release new series of navigation solutions for major mobile phone platforms(Garmin, 2011), and by then, many competitors were already operate in the market including Internet giants like Google. The late direct respond to mobile navigation market and the parallel declining revenue raise curiosity to find out the reasons behind this phenomenon. From ACAP perspective, Garmin might miss the signal of the rapid developing mobile navigation market or did Garmin act wrong in transforming the acquired external information. All these lead to the central

problem, what is the development status of ACAP within Garmin's automotive/mobile segment during the past years.

3.2 Type of analysis

The study will mainly use content analysis and qualitative study method collecting and observing the data. Content analysis is a methodology in the social science generally used for studying the content of communication. (Babbie, 1989) defines it as "the study of recorded human communications (such as books, websites and paintings)". The aim of content analysis is to study authorship, authenticity, or meaning of a text. This latter subject includes philology, hermeneutics, and semiotics. The study continues with several qualitative matching steps aiming to find an inter-relation between different content. Finally, this research also aims to observe patterns within all inter correlations using simple statistic method.

3.3 Measurement

To access the information to four dimensions of absorptive capacity, key indictors are introduced for better data interpretation. Starting with finding key indicators for each dimension, the **acquisition** dimension is defined as the dimension that firm could potentially get external knowledge. Currently literatures suggest business cooperation could be a source for external information. The study of absorptive capacity performance in international joint venture firms by Lane, Salk, and Lyles (2001) state that prior knowledge from a business partner could be used as an indication at acquisition dimension of ACAP. Further literature specifically mentioned R&D cooperation as an information source. Zahra and George (2002) suggest that R&D cooperation help firms acquire new knowledge, this statement is further proved by Jansen, Van Den Bosch, and Volberda (2005), with similar conclusion. In this paper, the measurement is derived from the definition of acquisition dimension (Zahra & George, 2002), extended the most common measurement of solely using R&D cooperation as a measurement to various business cooperation events, which include merger and acquisition actions, strategic alliances, supplier relationship, licensing etc.

Assimilation develops on acquisition dimension as a process to further interpret the acquired knowledge that firms could better understand. One distinctive characteristic of this dimension is the preparation for latter two dimensions. Kim (1997) in his research clearly states that R&D funds would help firms attract outside experts who would greater contributes to compress the "absorption cycle of externally acquired knowledge". Jansen et al. (2005) emphasized the action technology assimilation, hence, highlighted the importance of R&D department's involvements in order to guarantee the succession. Therefore, R&D investments/funds in Garmin's Automotive/mobile segment are used as key indicator to measure the assimilation dimension.

Transformation dimension as the process to combine new acquired knowledge with existing knowledge (Zahra & George, 2002). That is to say, the acquired knowledge at this phase has already been transfer to a firm specific knowledge. At this phase, firms might yield new insights as well as visioning its "competitive landscape" and later on, further competitive advantage can be found (Zahra & George, 2002). Patents, according to George, Zahra, Wheatley, and Khan (2001) can be used as a measurement to check firm's ability in applying or exploiting knowledge. Regardless of the specificity state of using it as the measurement for transformation dimension, however, referring to the definition(Zahra & George, 2002), exploitation focused more on incorporating knowledge into operations, while patents is a form of knowledge which firms could derived new products on in a long term. Patents are formed one step prior of exploitation product, therefore, this paper using patents as the key indictor for transformation dimension rather for exploitation.

At **exploitation** dimension, firms focus on using their obtained external knowledge to "refine, extend and leverage their existing competitive advantage or creating new ones". Soo, Devinney, and Midgley (2007) state that firm at this dimension would apply their experiences gained from former dimensions of absorptive capacity. It is at this dimension, firms will finally commercialize their obtained knowledge, as Cohen and Levinthal (1990) believe, finish the whole ACAP process. Thus, the key indictors at this dimension are newly exploited technology, product-lines, and radical innovative products.

By figured out all key indictors in each dimension, specific measurement criteria needs to be set to proceed the measurement process. Assimilation dimension use R&D budget as a key indicator and it is straightforward to find out. Transformation is use related patents as a key indictor; therefore a patent database is needed to obtain the data. The key indicators in acquisition and exploitation are more vague to measure. Therefore, content analysis is introduced to filter the information coordinated with key indicators. Content analysis filter all information by locating whether there are keywords in the "content", therefore, a codebook is essential by coding the requirements into measurable keywords.

The codebook used for acquisition and exploitation dimensions are represented in Table 1. The codebook later would also used as a search regime for data collection. In both dimensions, the piece of information must contain necessity keywords "Garmin" and a specific year number between 2005 and 2013, and in combination of any other alternative keywords. For example, a piece of information contains necessity keywords of "Garmin", "2005" and an alternative keyword "acquisition" could be regard as a piece of data.

Dimensions	Search Scope	Keywords
Acquisition	Annual reports, official social media, major news media	"Garmin", "2005" or "2006" or "2007" or "2008" or "2009" or "2010" or "2011" or "2012" or "2013" AND "Acquisition", "strategic "alliances", "cooperation", "supplier", "licensing"
Exploitation	Annual reports, official social media, major news media	"Garmin", "2005" or "2006" or "2007" or "2008" or "2009" or "2010" or "2011" or "2012" or "2013" AND "New series", "first product", "technology"

Table 1, Codebook for acquisition and exploitation dimensions

For transformation dimension, the key indictor is patent. The patent should be benefits for products or technology development within Garmin's automotive/mobile segment. Again, using content analysis, followed by constructing a codebook to filter the data. The patent must contain necessity keywords Garmin and a specific applied year. Besides, it should contain any alternative keywords relating to businesses in Garmin's automotive/mobile segment, all keywords are presented in Table 2.

Content	Keywords
Patents within the time range	"Garmin", "2005" or "2006" or "2007" or "2008" or "2009" or "2010" or "2011" or "2012" or "2013" AND "Automotive", "road", "traffic", "car", "navigation", "mobile phone"

Table 2, Codebook for transformation dimension

The development of absorptive capacity is measured through the time change of a specific knowledge flow, the cycle time. Based on the definition of absorptive capacity by Cohen and Levinthal (1990), the ability starts at recognize new information and ends at "apply it to commercial ends". The complete collectively abilities are as firm's absorptive capacity. The four dimensions raised by Zahra and George (2002) emphasis routines and processes of absorptive capacity, hence, the knowledge flow from the first dimension to the very last dimension is regard as a complete cycle. Therefore, the cycle time is calculated from the actually date of acquisition events to the releasing date of related new product in last phase. Similarly, the time span between two dimensions is used as an alternative measurement. The time span between transformation and exploitation dimension is the time between the actual patent application date and related new products launching date. All time spans are calculated in weeks.

3.4 Data collection methods

Desk searching is the main method used in this research. The paper first focuses on official data from Garmin starting with its annual reports from 2005-2013. Other official data source used is Garmin's press release(Garmin, 2014d), which is available from 2008 on. On top of the above, social media is also considered as a resource in this research, thus Garmin's official blog is used. The blog provides information on important event, products and achievements since 2005(Garmin, 2014b). Apart from Garmin's official data, reliable news reports are also regarded as valuable information that help to compensate the incomplete official data and to minimize the bias. The news reports used are mainly from major publishers to ensure the authentic and quality of the report. Finally, the US patent office database(US Patent and Trademark Office, 2014) provides a search engine to look for relative patents.

All data are collected in a large table in regard to four dimensions of ACAP with time span. Start from acquisition dimension, with all available sources, the information is filtered between 2005 and 2013; based on keywords from the codebook in measurement session, see Table 1. The data is organized in a form of events, which contains the name and the relationship of the cooperate partner. A brief explanation on the cooperation content is also included in the data, for example: SiRF, (Supplier for Garmin's new devices) (Garmin, 2005). The events then assigned to the data table with different years tags. Similar to acquisition dimension, the exploitation dimension use the same data collecting methods with only one distinctive difference, that is the data at this dimension are visible products and technologies. The data is presented in a way, which includes the name of the product or technology, together with a short explanation, i.e. c-series, c300 series (New product line with touch screen) (Garmin, 2005).

In assimilation dimension, the data of R&D investment can be found directly at Garmin's yearly financial reports. In transformation dimension, the data was gathered from the USPTO patent full-text and image database from the US patent office (US Patent and Trademark Office, 2014). Followed by the specific query requirements from the database, the application date, and assignee name are used for the search. Hence, use "Garmin" as assignee and combined with a specific year. Due to the specific query requirement, one-year time span should be presented in a following way, i.e. Jan 1st to Dec 31st. The search is conducted year by year, for example, all patents Garmin applied in 2005 can be found by enter "AN/Garmin" and "APD/20050101-20051231". A more detailed method is illustrated in Table 3. Then followed by a manual filter using all keywords from the codebook in the measurement session to determine the relativity to Garmin's automotive/mobile segment. Finally, the data is collected with patent number and patent name, for example, Navigation device with improved detour routing (US patent 7623962). (US Patent and Trademark Office, 2005a)

Searching protocol	Scope
US patent office **"AN/Garmin"** **AND** **"APD/20XX0101** **→20XX1231"**	Title, abstract, claims, description, summary, conclusion

Table 3, search protocol for patents in automotive/mobile segment by year

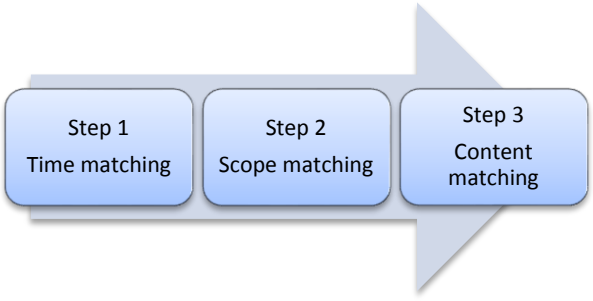
3.5 Data analyze methods

All the data are formulated in a table that illustrated the development of ACAP through four dimensions within time span. The research aims at finding the linkages between events, patents and exploitations through different dimensions. The analysis start with the correlation between transformation (patents) and exploitation (products) dimension by constructing a table that includes all patents with brief description on the vertical axis and products/ technologies on the horizontal axis. The table is constructed as in Table 4, followed by a a matching process If certain patent could found a solid trace in some products or technologies, hence, the patent and the product/ technology is matching, a mark X will be marked for later analysis. Alternatively, if only a certain level of trace is found, thus not a complete matching, then an X…will be marked. The method is illustrated in Table 4.

	Year		2005		…		2013	
	Patents/ Products	Patent No.1	Patent No.2	Patent No.3		Patent No.1	Patent No.2	Patent No.3
2006	Product No.1			X…				
	Product No.2		X					
…								
2012	Product No.1					X		
	Product No.2							X

Table 4, Correlation table between transformation and exploitation dimension.

The matching process contents three steps in total see Graph 1. First of all, time matching, it assumes the patent applied time should be ahead of launching date of related new products, due to the intention of applying patent is to protect firm's competitive advantage. If the other way around, other companies might copy the technology used in the new product, while the knowledge is not protected. Therefore, the exploitation products launching date should be later than patent applied date. Followed by the research scope matching, that is determining whether the patent applied could be used in the further product development within Garmin's automotive/mobile segment. This step is conducted through checking the summary of the patent, if failed, a through check process will go further in detailed patent description and search for keywords. An example could be US patent 8041029, Mount for an electronic device, in the description of the patent, it pointed out this technology could be used for "dashboard", hence, dashboard is the scope of the patents. (US Patent and Trademark Office, 2009) The last content matching step also benefits from the previous scope matching process since the final step determines the final correlation. In this step, a detailed search in descriptions of both patent and product are conducted. To start with, key features of the products will be listed then traced back to the patent within the same scope. The Smartphone Link technology allows Garmin's Portable Navigation Devices to received real-time data through Android devices. US patent 8023963 is a method that linking navigation systems with mobile communication devices to get data.(US Patent and Trademark Office, 2008) Hence, it is concluded that the above content matches due to the similar description. Nerveless, it is still vague to determine the similarity, thus, it is defined both contents should have at least three keywords matching.



Graph 1, matching processes

The linkage then traced back to the previously two dimensions, however, for assimilation dimension, the key indicator used is the R&D budget which suffers from a data mismatch (The rest sets of data are qualitative data), therefore, the link will be only be traced back to acquisition dimension. And to make the tracing process easier, the following step can only focus on the correlation between patents and related acquisition events. Lacking of internal data has make this stage really challenging, however, based on logic and assumptions, the linkage could still be built. The lacking of information also determines the limited events in acquisition dimension, which offers a good starting point by thoroughly checking the background information of all cooperation counterparts, which includes the following: what are the businesses the firm is operated with; which types of technology this firm hold; and to what extent could Garmin have access to the knowledge. The process is illustrated with the case of NAVIGON. The merger of NAVIGON AG in 2011 allowed Garmin's full access to NAVIGON's knowledge base. NAVIGON is a firm specialized in providing navigation services for phones. US patent 8280628 is a method, which allows phones to share its location(US Patent and Trademark Office, 2011) , and Garmin did not have similar patents before. And naturally, there must be a linkage between NAVIGON and the patent, since Garmin has little experience in developing phone navigation software, especially integrated with online functions. Based on logic, the paper believes there are linkages between the merger of NAVIGON lead to US patent 8280628.

Finally, a table, which links event, patent and product, will be presented as shown in Table 5. The final result will be based on the analysis of the trend of the development line, from Event 1 to Patent 1 to Product 1 to see whether there is a pattern lies in the trend. This analysis will be done both graphically and numerically. Through observe all the trend of all development line through time span and calculate the total time span of the development of absorptive capacity through four dimensions, a pattern could be drawn.

Dimension/ Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**…**	**2013**
Acquisition	Event No.1						…	
Assimilation							…	
Transformation				Patent No.1			…	
Exploitation								Product No.1

Table 5, Example of the result presentation

4. RESULTS FOR THE ANALYSIS

All the results have been piloted in a table, a summarized version of all data is illustrate in Figure 2. The result will first presented in each dimension, then followed by a result in realized absorptive capacity, hence the correlation between transformation and exploitation dimension. Finally, the trend of the development of ACAP through time span will be presented.

4.1 The development of ACAP in each dimensions

At **acquisition** dimension, the number of events at acquisition dimension has a rise and reached its peak in 2007 and then stays constant from 2008 to 2013(See, Table 6). In total, Garmin have two acquisition and merger events within its automotive/mobile segment, in 2007, Garmin acquired local based service provide Digital Cyclone and in 2011 the acquisition of NAVIGON.

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Acquisition (M&A, strategic alliances, cooperation)	1,SiFi (Pa) 2,Doll Thrifty Automotive Group (Co), Rent-a-car (Co)	1, Avis Rent A Car and Budget rent a car (Co)	1,NAVTEQ (Pa) 2,Digital Cyclone (M) 3, National Car Rental, Alamo rent car (Co) 5,Ford, Honda, Volvo (Pa)	1,MapQuest (Co) 2, Microsoft (Pa) 3, BMW (Pa) 4,Panasonic (Pa)	1,ASUSTek (Sa) 2,Harley-Davidson (Pa) 3,CSR (former SiFi) (Pa)	1, Chrysler (Pa)	1,NAVIGON (M) 2,Cardo (Pa)	1, Amscreen (Co)	1, Daimler AG (Pa) 2, Volkswagen (Pa 3,QNX Tec (Co)
Assimilation (R&D)	R&D expenses 17,466,000	R&D expenses 37,125,000	R&D expenses 59,390,000	R&D expenses 85,610,000	R&D expenses 110,907,000	R&D expenses 131,290,000	R&D expenses 130,179,000	R&D expenses 128,661,000	R&D expenses 136,639,000
Transformation (Patents)	6 patents	9 patents	5 patents	11 patents Mobile commination, US 8023963	4 patents Dashboard US 8041029	6 patents Estimating Cellar location for phones US 8467809	3 patents	1 patent	0
Exploitation (New product-lines, technology)	1,c-series, c300 series 2,StreetPilot i-Series™ 3,Nüvi (Multi 4,Garmin Mobile 5,Travel Guide™ 6,Navus™ (a GPS 7,Roadtech™ Quest® 8,Street Pilot 7000 series	1,nüvi™ Personal Travel Assistant™ 2,C-series, C500 3,Zūmo motorcycle navigation 4,GPS 18 5,Garmin 20 6,Garmin 10	1,nüvi 2XX family 2,nüvi 700 series 3,My-cast 4,Garmin Mobile™ XT	1,nüvifone™ 2,nüvi 880, 3,nüvi 7x5 series 4,Garmin Mobile PC	1,Nuvi 1200 1300 , 1400 series 2,Garmin's nüLink! ™ 3,nüvi 465T 4,Ciao! ™ 5,nüMaps Lifetime™ 6,cityXplorer™ 7,ecoRoute app	1,nüvi® 3700 series 2,nüvi® 2200/2300 series 3,SafeNav 4,Garmin ASUS A10 5,Voice Studio™ c 6, Uconnect® Touch system	1,dēzl™ 2,nüLink! 2300 series 3,nüvi 2400 series 4,nüRoute™ technology 5,nüvi 3400 6,StreetPilot for iPhone 7,ecoRoute™ HD 8,nüvi 30, 40 and 50 series 9,StreetPilot® onboard	1,StreetPilot® for windows phone 2,NAVIGON MobileNavigator 3,Garmin Mechanic with ecoRoute HD 4,Garmin Real Directions™ 5,Active Lane Guidance 6,Smartphone Link	1,Garmin GLO GPS receiver 2,RV 760LMT 2,HUD 3,Garmin® K2 4,fleet™ 590

Figure2: Data

Abbreviations: Co=Cooperation, Pa=Partnership, M=Merger, Sa=strategic alliances

(Garmin, 2007, 2011). And the most common method for Garmin to obtain external knowledge is by partnership, which in total have 12 events out of 21.

Year	Acquisition events	Total number
2005	1,SiFi (Pa)	2
	2,Doll Thrifty Automotive Group (Co), Rent- a-car (Co)	
2006	1, Avis Rent A Car and Budget rent a car (Co)	1
2007	1,NAVTEQ (Pa)	3
	2,Digital Cyclone (M)	
	3, National Car Rental, Alamo rent car (Co)	
	5,Ford, Honda, Volvo (Pa)	
2008	1,MapQuest (Co)	4
	2, Microsoft (Pa)	
	3, BMW (Pa)	
	4,Panasonic (Pa)	
2009	1,ASUSTek (Sa)	3
	2,Harley-Davidson (Pa)	
	3,CSR (former SiFi) (Pa)	
2010	1, Chrysler (Pa)	1
2011	1,NAVIGON (M)	2
	2,Cardo (Pa)	
2012	1, Amscreen (Co)	1
2013	1, Daimler AG (Pa)	3
	2, Volkswagen (Pa	
	3,QNX Tec (Co)	

Table 6, Acquisition events Garmin's automotive/mobile segment 2005-2013

At **assimilation** dimension, by using the indicator R&D expenses, it illustrate that in Garmin's Automotive/mobile segment, the expense has a dramatic increased from 2005 on until 2009. From 2010 on, the R&D budget has been constant, with a rising trend from 2012. In 2010, the R&D investment is more than six times of that in 2005 with a almost constant increasing rate each year.(Garmin, 2005, 2010)

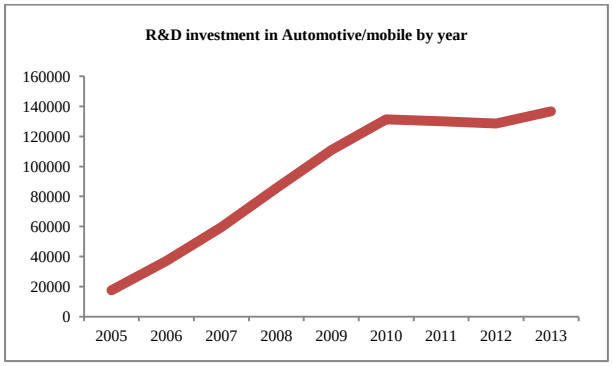


Figure 3, R&D investment in automotive/mobile segment by year from 2005-2013

At **transformation** dimension, the trend of the number of patents related to Garmin's automotive/mobile has similar patterns regarding to the number of events at acquisition dimension. There is an increase in numbers from 2005 to 2008, followed by a declining trend (See Figure 4). Apart from quantitative trend, the lately patents are more related to non-physical products, for instance, patents with calculating methods, software interface, etc. While in early years, patents are mostly connected with physical products; for example, US patent 7613566, navigation device with improved zoom function, which is a function only based on a certain kind of physical products.(US Patent and Trademark Office, 2005b)

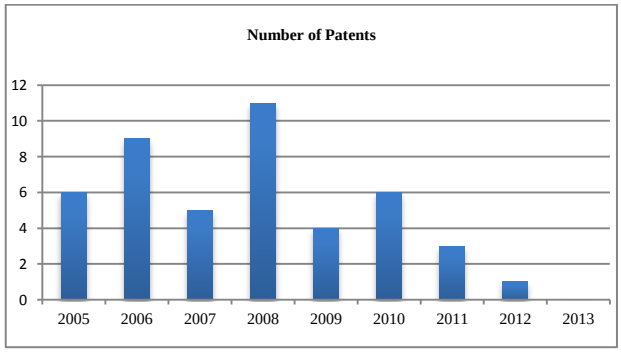


Figure 4, Number of patents within the time span

At exploitation dimension, the number of exploited products and technologies are presented in Figure 5. From 2005 there is a decrease in numbers followed by an increase until it reached the peak in 2011, which has in total 9 innovative products/technologies. Similar to the characteristic in the development in patents, the exploitations dimension also have more non-physical products within recent years, for example, the StreePilot apps for iPhones and windows phones.(Garmin, 2011, 2012)

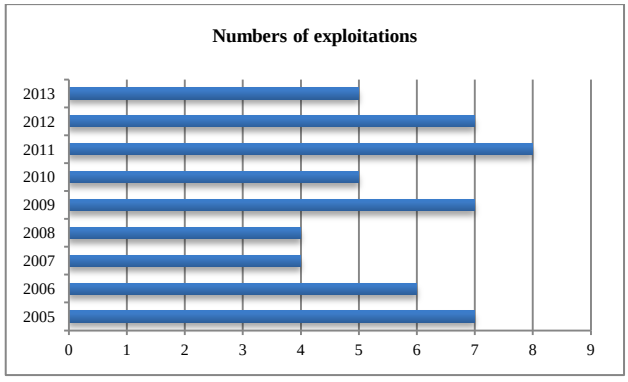


Figure 5, Number of exploitations within time span

4.2 Results on realized absorptive capacity

The realized absorptive capacity consists of transformation and exploitation dimension and as mentioned earlier, the data analysis starts here, and the method is in Table 4. Each correlation is marked as "X", which represents a connection between a patent and a related product; furthermore it also illustrates the time span between the two dimensions. To better interpret the data and show time change between the two dimensions to explain the time change in ACAP development, the correlations "X" s are then coded into series of spots. Because X represents the correlation between a patent and a certain product, it also includes a time correlation; therefore, time when the patent is applied year and the time time when the product is released. For example, the correlation X1 can be also write in this way, X1 (Product released time, Patent applied time), by taking only years into consideration, X1 then can

write in a numeric way, X1 (2007, 2005). Then coding 2005 to 2013 into 1 to 9. Therefore, all "X" will represent a spot which will be later put is on a scatter diagram as shown in Figure 6. As shown in the diagram, the spots are more condensed in near the right upper corner. Hence, it indicates that in later years, the transformation to exploitation time span is shorter than previous years.

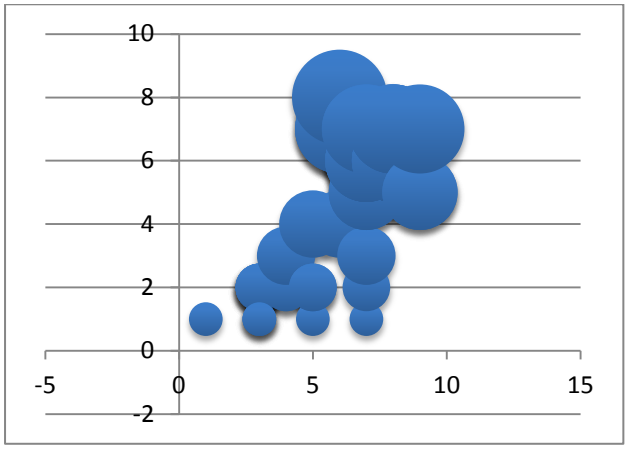


Figure 6, Time correlation between patents and products

4.3 Results of ACAP development through four dimensions

By finding correlation between patents and exploited products then traced back to the origins of the knowledge, followed by a linking process, a complete flow of knowledge within Garmin's automotive/mobile segment is drawn, some flows are shown in Figure 2, within the time span, the lines becomes steeped which indicates that the flow of knowledge is more likely to be faster. A more detailed time span of the development of absorptive capacity is shown below in Table 7, by using week as a time unit. Based on the limited data, the total time of absorptive capacity development through four dimensions has become shorter through the timeline. Regarding to times span between transformation and exploitation or between acquisition dimension to transformation it is still hard to find a pattern.

	Cases	Time from acquisition to transformation (in weeks)	Time from transformation to Exploitation (in weeks)	Time in Total	R&D expenses (USD)
2005	1,SiFI	114	47	161	17,466,000
2006	1, Customer modes (Nuvi 880)	/	70	/	37,125,000
2007	1, ASR technology	/	144	/	59,390,000
2008	1,Panasonic (Uconnect)	50	56	106	85,610,000
2009	1, Asus Tech (A10)	51	9	60	110,907,000
2010	1,Speed limit	/	77	/	131,290,000
2011	1,Event signaling	/	24	/	130,179,000
	2, Navigon (StreetPilot Onboard)	/	/	6	
	2, Dashboard interface	/	81	/	
	3, Share location	/	57	/	
2012	/	/	/	/	128,661,000
2013	/	/	/	/	136,639,000

Table 7, Time span of specific knowledge through ACAP's four dimensions

5. CONCLUSIONS

Regarding to Hypothesis 1, whether the development of ACAP now is faster in large firms than before. In Figure 2, it is clear that the knowledge flow from ASUS tech in 2009 (Garmin, 2009); result in the patent in phone cellar location technology in the next year. However, the earlier acquire knowledge from SiFi in 2005 (Garmin, 2005), was transferred into patent in 2008, then exploited in 2011, with in total 6 years time span. The trend is also approved by the detail data of time span, which is presented in Table 7. However, due to lacking of more internal data from Garmin, some patent in transformation dimension could not be traced back to their origins, therefore, it is still hard to conclude that the development of ACAP within Garmin's Automotive/ Mobile segment has speed up during the past years. Therefore, Hypothesis 1 is not yet solidly proven.

As for Hypothesis 2, concerning to the development in transformation and exploitation dimension, based on the shape of the curve in Figure 2, the change between acquisition and transformation is obviously more significantly than between transformation to exploitation. The time span between acquisition and transformation has been shortened during the past years. The time span between the acquisition and transformation time in SiFi's case is four years, while it was shortened to one year in Panasonic's case. In the detailed time mapping table, from acquisition to transformation, the time span has been dropped from 114 weeks to 50 weeks in the case of Panasonic. Nevertheless, there are only three cases that supporting the trend and it could only be one possibility; therefore, Hypothesis 2 could be proved only if more cases could be found.

Hypothesis 3 deals with R&D investment with the ACAP development. According to the limited data, it shows R&D investment has a positive relationship with the speed of development of ACAP. Nevertheless, this result is largely depends on Hypothesis 1, with the assumption that the development of absorptive capacity now is faster in large firms than before. Hypothesis 1 is not proven due to lacking of data; therefore, Hypothesis 3 would be proved only if the Hypothesis 1 exists.

Based on limited data, the paper could only conclude that absorptive capacity within Garmin's Automotive/Mobile segment has changed over the time span between 2005-2013, however, the trend could not yet be indicate. Similarly, the speed of development in transformation and exploitation is also changed. R&D investment has an effect on the development of ACAP, but whether in a positive or negative way could only be drawn if a trend of ACAP development has been identified.

Another conclusion could be draw is that merger and acquisition events often leads to more transformation and

exploitation actions compare to other forms of cooperation. For instance, with the merger of NAVIGON, Garmin produces lots of patents and new products, technologies in mobile devices, much higher than cooperating with other companies. This phenomenon might be the fact that that through merger and acquisition, firm could have fully access to the target company's knowledge base. As for other forms of cooperation, the level of involvement will be lower, and with more knowledge access, the high knowledge intensity will further improve the development of ACAP.

6. LIMITATION

In spite of authenticity of the data collected, however, the research still suffers from the reliability of data due to the qualitative way of data collecting, and this might lead to a certain degree of inaccuracy of the knowledge flow route and further affect the trend of the development of absorptive capacity. The research only used on case as an example, which the conclusion might not be applied for other cases depending on different circumstances. The lacking of internal resources also constrains the research in terms of intensity of information and limited measurable key indicators, and all these might cause bias for the results and also makes it difficult to find a pattern. Moreover, the time span is only from 2005-2013 with only 9 years data, it might be not enough to draw the conclusion on the development of ACAP since Garmin was operated much earlier in the market. Last but not least, the characteristic of the industry has not been taken into consideration; a fast changing industry differs from a stable industry.

7. DISCUSSION

This paper focusing on the development of absorptive capacity develop over time in large firm and take Garmin's automotive/mobile business segment as a case study, the paper does not yield solid conclusion on how the absorptive capacity develops due to limitations in this study. For further studies, more internal sources are needed to enlarge the available data, which in turn might lead to a convincing result. Having larger database, multiple key indicators could be introduced to measure the four dimensions of ACAP to further improve the accuracy.

However, based on the partially data and logic the following assumptions could be made by providing more internal data, the assumptions could be act as proposition for further research, the assumptions are as following:

1. The ACAP development process in large firm has become shorter as firm accumulates knowledge and experience.

2. The absorptive capacity in large firms is not declining since firms need to keep its competitive advantage.

The first proposition therefore lies in the limitation of data; the conclusion of this paper however needs further consolidate. The second proposition lies in neglecting the characteristics of the industry. In Garmin's case, the change of industry leads to more firms in favor of releasing more electronically products, for example software, which makes the knowledge transfer process much easier, and this might explain why the realized phase of absorptive capacity is shorter in recently years. The development of the industry also improved and enhanced communication, which accelerates the knowledge acquisition process.

Therefore, the industry could also act as an external force that stimulates the change of the organizations. Firms in order to keep their competitiveness in the industry need to act quickly regardless of prior knowledge or firm size. This proposition gives another perspective on the development of ACAP in larger firms, i.e. the industry force. All existing literature did not take this factor in arguing on whether larger firms have difficulties in developing ACAP, therefore, they concluded with the more mature status the company is, the less ability for the company to develop ACAP. This factor proves to be a great determinate in the development of ACAP, at least in in Garmin's case. The existence of industry factor to some extent also approves that external factors overwhelms the internal factors in affecting firm's ACAP.

Academically, this paper added an empirical case study on the study of process development of absorptive capacity within time span. Regardless of resulting a solid answer to the research question, however, some phenomenon found during the research is also significant. Furthermore, the method and measurement of using secondary data to evaluate the firm's absorptive capacity could also be used for following researchers. The research also leaves for further interpretation by introducing a comparison with small or medium firms and trying to find out the level in absorptive capacity. It would also be interesting to use more cases in the same industry to see whether industry has any influence on the absorptive capacity development.

Above all, ACAP offers firms an alternative opportunity to achieve their innovation competitiveness. Therefore, practically, this research gives managers an insight that the development ACAP should not be neglect especially in large firms. The relationship between ACAP and R&D is not opposing but complementary, that is to say the investment in R&D would not reduce the ACAP development, but on the contrary will boost the ACAP development. For firms, it is important to monitor the industry change to determine whether the change of ACAP is caused internally or externally to have an objective overview of the firm. In Garmin's case, the shift in industry also influences the development of ACAP, therefore, it is crucial for managers to make a judgment and further implement a strategy. Finally, for large firms it is important to stimulate the development of ACAP in order to keep its competitiveness.

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Original data is available upon request