The New Typology and Evolution of Multinational Corporation Subunit Roles: An Explorative Study

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Abstract: This paper conducts an explorative study to examine the evolution of Multinational Corporation (MNC) subunit roles based on the characteristics of its competence creating (CC) activities. The study focuses on the heterogeneity of firm-specific evolutionary paths in the patterns of knowledge accumulation that support competence creating (CC) activities. Using continuous variables instead of creating categorization of subunit roles, we create a model to examine the strategic roles of MNC subunits, based upon the evolutionary trajectory of a subunit's CC activities and its technological distance from its parent company. We identify and measure subunit CC intensity and subunit technological distance as the two determining dimensions that characterize an MNC subunit's pattern of innovation in terms of competence-creating. The innovative activity was observed from large firms of the general chemical industry, with data that covers an over thirty-year window, to explore the characteristics of competence creation activities, and to examine the proposed typologies. Using the longitudinal observation, we further examine the evolution of MNC subunit roles based on the characteristics of their competence creating activities, and demonstrate several real world business examples of subunit typologies. This research makes both theoretical and methodological contributions to the literature of MNC innovation and subunit strategic roles by presenting a continuous model to examine competence-creating activities of MNC subunits. A connection between statistical data analysis and individual firm examples is made in the discussion of subunit evolutionary trajectories, which can lend itself to possibilities of in-depth case studies. Using the typology designed in this study, we can further examine the relationship between MNC strategy and subunit role evolution, using the continuous variables to describe a subunit's innovative activities rather than categorizing subunits as a CC or CE type, which in turn allows for a more realistic understanding of MNC subunit behavior – as innovative firms should always have a combination of CC and CE innovations.

Keywords: Competence creating, MNC innovation, subsidiary role

1. Introduction

Knowledge management is a process that involves the development, storage, retrieval, and dissemination of information and expertise within an organization, with the purpose of improving organizational performance (Wiig, 1993; Gupta, Iyer and Aronson, 2000). Knowledge management for organizations requires an understanding of the process in which information and know-how are being recombined via internal and external learning, to create market opportunities for a firm (Kogut and Zandar, 1992). In the arena of multinational corporations (MNCs), a firm's capability of managing the sourcing and recombination of knowledge through the nest of subsidiaries would greatly influence its innovation performance.

Typically, MNCs designate strategic mandates to their foreign subsidiaries, which determines the role that these subsidiaries serve within the corporation, and this role in turn influences the knowledge seeking or creating activities conducted by the subsidiary. Subsidiaries are then categorized into different typology systems based on the different combinations of knowledge related activities. Gupta and Govindarajan (1991) created a typology of subsidiaries by applying the magnitude and the direction of knowledge flows of subsidiaries, in which they identify subsidiaries as the provider or receiver of knowledge. Their model distinguishes these four types of subsidiaries: Global innovator, integrated player, implementer, and local innovator. Birkinshaw and Morrison (1995) provided a three-fold typology which classifies subsidiaries as local implementer, specialized contributor, and world mandate. Ambos and Reitsperger's study (2004) identified technological mandate subsidiaries and task-related interdependence subsidiaries. These studies are all based on the characters and natures of intra-MNC knowledge flow. Cantwell and Janne (1999)'s research adopted a different angle to compare the technological interrelatedness of R&D activities in foreign centers with those in domestic countries. In other words, the research activities by foreign facilities are distinguished as either 'replication' or 'diversification'.

Besides the research on identification and distinction of subsidiary roles, it is important to recognize that as subsidiaries evolve with their foreign locations, their strategic roles may evolve overtime. Subsidiary evolutions are driven by both internal (initiated by subunits themselves) and external factors (investment from parent

Reference this paper: Pu, X., and Cantwell, J., 2023. The New Typology and Evolution of Multinational Corporation Subunit Roles: An Explorative Study. *The Electronic Journal of Knowledge Management,* 21(1), pp. 29-40, available online at www.ejkm.com

company or other external forces) (Birkinshaw and Hood, 1998). External forces largely shape the options of subunit, while it is the subunit managers to take the initiative to respond to the external opportunities. The idea that multinational subsidiaries are differentiated according to their technological capabilities and roles can be traced back to Ghoshal and Bartlett's study (1988) on subunit tasks. They argued that the tasks of affiliates can be classified in three categories: creation, adoption and diffusion. 'Creation' is to use subunit's own technical and managerial resources to respond to local circumstances; 'adoption' is to adopt innovation developed by parent company or a central R&D facility, or other national subsidiaries of the firm; and 'diffusion' is to diffuse their local innovations back to the parent company or to other subsidiaries. Similarly, Pearce (1999) characterized MNC subsidiaries as world product mandate and regional product mandate by distinguishing their subunit-level capabilities. Almeida et al (Almeida, Dokko and Rosenkopf, 2003) discussed the same question by unbundling the process of knowledge management, defining this process as search, transfer, and integration, and linking each of these components with subunit capabilities.

Research on subsidiary roles and strategies has recognized the explorative vs. exploitative natures of subsidiary innovation (March, 1991; Ancona et al, 2001; He and Wong, 2004). Another baseline of identifying the strategic roles of MNC subsidiaries is to examine its integration within the MNC framework and its local embeddedness (Bartlet and Ghoshal, 1989). Subsidiaries leverage knowledge and resources both internally from the MNC network and externally from the foreign host location (Cantwell, 1991; Cantwell and Piscitello, 2000), these two different focuses lead subsidiaries to be either a competence exploiting (CE) type or a competence creating (CC) type – the former assumes a role that essentially just exploits parent company competence in foreign location, whereas the latter creates new competences that learns and recombines knowledge from the host location and beyond (Cantwell, 1987; Cantwell and Mudambi, 2005). Using the scope of competence exploration and exploitation, this typology can be further tailored into international competence exploitation (ICE) subsidiaries, local competence exploration (LCE) subsidiaries, and global competence creation (GCC) subsidiaries (Pu et al., 2016).

Intuitively, there can be a trade-off effect between the subsidiary's MNC integration and its local embeddedness given the limited resource of management and investment focus. The current literature in both knowledge management and MNC strategy have generally treated the typology of subsidiary roles to be the "exploration" or the "exploitation" types. However, as suggested by researchers, in certain circumstances when the MNC operates within (and sometimes contributes to) a fast-changing environment, this trade-off effect could be eliminated, and instead, a complementary instead of competitive relationship between the involvements into the two networks (MNC network or local network) could exist (Andersson, Forsgren and Holm, 2001). Hence, a subsidiary can have local competence creating activities such as knowledge transferring and innovation based on its relations with local partners and resources, while increasingly relying on competence exploiting exchanges within its MNC group. Together, they reinforce the subsidiary's position in both the local and MNC networks. Based on this argument, a subsidiary could technically be both an "exploitation" type and an "exploration" type at the same time – depending on the various innovative activities that it is involved in. Therefore, it is sometimes inaccurate to categorize a subsidiary to be an "exploitation" type, when it has been also actively engaged in exploration (competence creating) activities concurrently, and vice versa. Thus, this study proposes a continuous model to examine the strategic roles of MNC subsidiaries, considering of all CC type innovation activities, and measure the "technological distance" in combination with CC innovation intensity. Our main research question in this explorative study is:

Do the knowledge creating activities of an MNC's subsidiary reflect its strategic role?

Upon understanding this question, we also want to examine the evolution of subsidiary roles over time based on their knowledge creating activities. The aim is to create a new way of investigating MNCs' innovation strategy and their knowledge management capabilities. Moreover, this paper discusses a few cases as examples to indicate how the subsidiary role in our new typology reflects its innovative capability.

2. Theoretical Framework

2.1 The Knowledge Based View and MNC Knowledge Management

The foundation of this research is the knowledge-based view (KBV), which in the context of multinational corporations emphasizes the "international network" of interconnected entities that create, transfer, and reconstruct knowledge as one of the key drives of their innovation process (Szulanski, 1996; Wiig, 1997; Gupta and Govindarajan, 2000; Almeida, Song and Grant, 2002). This recognition led its way into the expansion of knowledge management (KM) studies, seeking further understanding of knowledge-intensive firms and the

fundamental role of their knowledge workers (Drucker, 1993), via the creation, access, dissemination and application of knowledge (Nonaka and Takeuchi, 1995), and the study of KM has since become one of the dominating forces in understanding innovation, learning, and technological development of organizations. Further research has cross examined the concept of KM and organizational learning (OL), which involve the internal creation and external acquisition of knowledge (Huber, 1991), finding that although there are overlaps between these two concepts, KM has gradually absorbed the field of OL (Castaneda, Manrique and Cuellar, 2018). KM in its own path of development, has shifted from the technocentric view with a focus on explicit knowledge before the mid-1990s, to a more strategic focus in the 2000s, till now a characteristic of high complexity of the knowledge domain (Serenko, 2013). It is the latest development embracing the complexity of knowledge in KM, and the understanding of knowledge-based activities, that led the groundwork of this research project, which is focused on the examination of a multinational corporation (MNC)'s knowledge accumulation, creation, and innovation.

The multinationality of MNCs provides them an advantage as they can acquire and utilize knowledge across national borders via their intra-firm connections (Kogut and Zander, 1993; Nonaka, 1994; Gupta and Govindarajan, 2000). There has been evidence that the transfer of knowledge within the intra-firm network, as well as via the embedded network of home, host, and third-country (Jimenez-Jimenez, Martinez-Costa and Sanz-Valle, 2014; Berry, 2015), and cross-border knowledge management helps MNCs maintain competitive advantages by both improving the effectiveness of knowledge acquisition as well as integrating and recombining existing knowledge (Nonaka, Toyama and Konno, 2000; Darroch, 2005; Ferraris, Santoro and Dezi, 2017). Since knowledge sourcing and recombination is a key drive for MNCs' competitive advantage, knowledge management in the MNC context becomes an increasingly important topic, not only to the domain of knowledge management, but also presents great importance in the strategic perspectives of MNC and their foreign operations. This research project has stemmed from the identification of knowledge complexity and its impact on innovative activities (Pu, Cantwell, and Li, 2022), to a further examination of how these knowledge-intensive activities evolves overtime with different strategic roles held by MNC subsidiaries, thus bridges the gap of current literature between MNC knowledge management and its strategic implication on subsidiary roles.

2.2 MNC Subunits and Their Competence Creating Activities

It is known that large MNCs tend to have multiple operational units overseas, sometimes more than one subsidiary could be set up in a single foreign host country. From a business standpoint this could make sense when that particular host country provides a wide range of geographical locations suitable for foreign investment, and these investments could fall into different divisions of operation, which makes setting up multiple subsidiary entities necessary; or for certain legal or political reasons MNC needs to divide up their foreign operation into different functional companies, sometimes these registered companies may even only exist for the purpose of keeping the right paperwork. For these various reasons, it has been difficult for research on subsidiary level of MNC to match the company activities in one geographical location to the real subsidiaries of the MNC. In this study, an *MNC subunit* is defined as an operational unit of an MNC outside its home country. For each MNC, all of its operational activities in one single foreign host country are treated as one foreign subunit. For instance, Dow Chemical may have several subsidiaries in Japan registered as part of the Monsanto group, but we treat these subsidiaries as a single Dow Chemical - Japan subunit for our analysis purpose. Instead of looking at the organizational structural sense of an MNC's foreign entity, the focus of this study is on the innovative activities of the MNC that are taking place outside the home country of the parent company. Parent company, in this study, refers to the part of MNC that conducts innovative activities in the MNC's home country.

In organizational learning theories, the concept of exploitation is referred to as "the refinement and extension of existing competencies, technologies, and paradigms" and exploration as "experimentation with new alternatives that have returns that are uncertain, distant, and often negative." (March, 1991) Based on the distinction between the two concepts, studies of a wide range of management fields have shown that exploitation and exploration require substantially different structures, processes, strategies, capabilities, and cultures to pursue and may have different impacts on firm adaptation and performance (He and Wong, 2004). In general, exploration is associated with organic structures, loosely coupled systems, path breaking, improvisation, autonomy and chaos, and emerging markets and technologies. Exploitation is associated with mechanistic structures, tightly coupled systems, path dependence, routinization, control and bureaucracy, and stable markets and technologies (Ancona et al., 2001; Lewin, Long and Carroll, 1999).

Innovative activities of an MNC subunit can be influenced by several factors - the parent group pressure, the locational pressure, or the subunit autonomy. The composition of the CC and CE types of innovative activities is determined by the subunit's strategic position based on MNC parent group's initial mandate, but overtime this

composition can change in proportion or in direction. Because the creation of competence demonstrates the capability of a subunit to innovate into new profitable technological fields, which in turn earns the subunit better position within the MNC network, and hence more favorable resource allocation by the parent group, subunit management are encouraged to seek to achieve a mandate of CC by initiating local knowledge seeking or new competence creating (Cantwell and Mudambi, 2005). More recent study has shown that both CC and CE type of innovative activities have a positive influence on firm's performance, especially when there is a balanced complementary combination between these two (Zhang, Jiang and Cantwell, 2015). At the subunit level, knowledge management of the subunit is at the core of their capability of long-term success, which in tern influences the subunits capability of balancing their CC and CE activities (Andrews and Smits, 2021).

2.3 Typology Based on Innovation Pattern

Before discussing the measurement for these two dimensions, we need to refer to the index used to identify and calculate an MNC subunit's area of expertise. Revealed Technological Advantage (RTA) is an index that demonstrates the level of technological specialization for one unit of observation (in this study, a foreign subunit of an MNC) in a given technological field (Patel and Pavitt, 1991; Cantwell, 1995). The RTA index of a firm in a particular technological field is given by the firm's share of patenting in that field divided by its share of patenting in all sectors and is defined as follows:

$$RTA_{ij} = (P_{ij} / \sum_i P_{ij}) / (\sum_j P_{ij} / \sum_i \sum_j P_{ij})$$

In which P_{ij} is the total number of patents of firm i in field j. The index varies around unity, such that values greater than one suggests a firm's comparative advantage in the field of activity in question relative to other firms in the same industry, while values less than one are indicative of a position of comparative disadvantage (Cantwell and Piscitello, 2000). When this is calculated at a subunit level, the unit of analysis is then changed from firm to subunit – a firm's activities within a foreign host country.

In the past, the notion of competence creation (CC) is often times treated as itself a categorizing factor for subunit typology. Namely, using indicators measuring the amount of unique innovative activities that stem from the parent company's knowledge portfolio, subunits are then categorized with or without the "CC" role (Cantwell and Mudambi, 2005). However, as we understand, a subunit can have a complex variety of innovative activities, it can be abrupt to give the subunit a simple label to indicate its involvement in CC. We aim to design a continuous measurement for the CC activities of MNC subunits. Now if we take a look at the innovation patterns of foreign subunits, instead of their knowledge sourcing compositions, it is understandable if we shift focus to the actual competence creating / competence exploiting activities. The composition of these two types of activity could determine a subunit's strategic position within the MNC group. In this study, we will create a typology of subunit roles based on (1) the extent to which a subunit's innovative activities are CC as opposed to CE, and (2) the technological distance between the subunit and its parent company.

The first dimension is defined as subunit CC intensity. It is measured with the share of competence creating activities among all innovative activities (CC+CE) within a subunit. The construction of this variable takes two steps. First, we identified the innovative activities in fields that are categorized as competence creating vis-à-vis competence exploiting by comparing the RTA value of subunit i in field j (RTA_{ij}) to the RTA value of subunit i's parent company in field j (RTA_{pj}). If RTA_{ij} >1 and RTA_{pj} <1, field j is considered a field of CC for subunit i. This comparison is done by all subunits in all technological fields. Second, we calculate the number of patents that belong to these CC fields for each subunit, and then divide this number by the total number of patents for each corresponding subunit. The result is a percentage number indicating the CC intensity of a subunit. A higher CC intensity indicates the subunit to be more competence-creating oriented, since a higher percentage of innovative activities conducted by this subunit are identified as competence-creating type. On the other hand, a lower CC intensity indicates the subunit's innovative activities are more dependent on its parent company's areas of expertise – note that this does not mean the subunit is less innovative, but only indicates a closer relationship to its parent group R&D activities.

The second dimension is subunit distance – the technological distance between innovative activities of a subunit and its parent company. This dimension examines how far the foreign subunit's innovation has "strayed" away from its parent group. The larger the distance, the less likely this subunit is simply "exploiting" its parent group competence. A shorter distance, however, does not indicate the subunit is less innovative; it reflects a similar focus and thus a likely closer relationship between the subunit and its parent company's R&D activities.

Combining these two dimensions generates a two-by-two matrix (as illustrated in Figure 1).

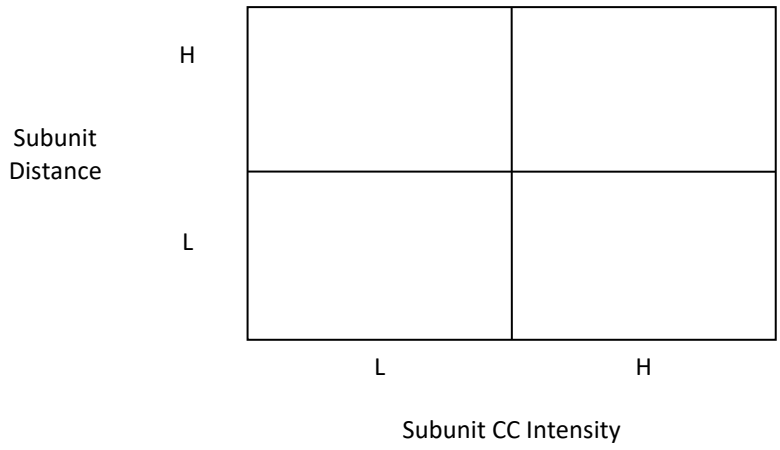

Figure 1: Subunit Typology by Competence Creativeness

Subunits that are positioned in the lower left corner (Quadrant III of Figure 1) have both low degree of CC intensity and low distance from its parent company. This type of subunit is mostly a miniature replica of the parent company in a foreign location; its innovation is mainly incremental ones based upon the technological specialties of the parent company. This fits the description of traditional subunits, which have a large share of CE activities as opposed to CC.

Subunits positioned at the upper right corner (Quadrant I of Figure 1), on the other hand, is the other extreme of the case. These subunits are not just highly innovative, but their innovation is to a large extent composed of CC activities, and their portfolios of these activities are significantly different from that of their parent companies'. These subunits are of high strategic importance to an MNC group as they bring in new potentials to the entire group, especially when some of these CC areas are matured, the group can then recognize them as part of its new core competency, and therefore spread these specialties across the MNC group's international network. Their strategic role could be categorized the ultimate competence creating type, and they are considered centers of excellence within their MNC group's network.

Subunits that fall under the category of high technological distance from its parent company while having low CC intensity (Quadrant II of Figure 1) could be the ones that has a technology portfolio that includes mostly in some certain areas of expertise that are same as the parent company's areas of specialization, but their technological field diversification is highly skewed by a few outliner fields that don't fall into the categories of parent company specialization. These subunits are developing some niche applications based on their local host country competency, while their main innovative activity is still focused on the exploitation of MNC group specialties.

In the lower right quadrant (Quadrant IV of Figure 1), subunits are found to have high degree of CC intensity with low technological distance compared to their parent companies. These subunits are the ones of most interest in my typology. They concentrate their innovative efforts on areas that are not particularly specialized by the parent company. However, these areas are not completely unrelated or brand new to the MNC group. Their technology portfolio shows consistency with the parent company, just that they tend to concentrate more on the fields that are relatively new to the group. The new knowledge combinations these subunits are making are close to the core competency, and they conduct a more focused exploration compared to those with a CC role or a Niche Application Role. We therefore categorize this type of subunit as "Core Base Extension". These subunits have the most potential to bring in new competencies to the MNC group and incorporate these new areas of technology into the development of new group level core competency.

3. Data and Results

3.1 Data and Measures

To understand the long-term effect of knowledge management activities in MNCs, this research chooses patent data as the proxy to represent outcomes (as well as sources) of innovative activities. As an indirect measure of innovative activities, patent data (in this research both granted patents and patent citations) reflects a measurable outcome of knowledge creation, whereas patent citations create connection amongst organization or individuals involved with the KM process, either directly or indirectly, hence reflects the accumulation of

knowledge. This study examines the US patent data of 147 large chemical industry firms, with patents granted between 1976 and 2006. Note that the United States Patent and Trademark Office (USPTO) grants patents to both domestic and foreign firms, this database is truly global, representing a wide range of innovative activities across the globe. Data for this study is collected mainly from NBER US Patent Database, and patent database developed by one of the authors. Both these databases were derived from the USPTO patent database, providing collective data on patents such as citation, inventor's location, technological class, etc; the former is publicly available via NBER, whereas the latter is from Dr. Cantwell's personal database accumulated over the years. Some individual patent records were pulled directly from the USPTO patent database. General chemical industry is selected as the object of this research because of its fully matured development as an industry over hundreds of years, yet widely spread into various sub-sectors of technologies with some of them being newly emerging within the past few decades. Its historically consistent concentration on technology development has brought in life not only in-depth research of fields that are closely related to traditional chemical industry, but also streams of newly emerged knowledge in fields that are expanded around the main sectors, such as pharmaceutical, biotechnology, etc. Compared with many other industries, chemical industry consistently emphasizes on the protection of intellectual property by the means of patenting; the analysis of patenting behavior in chemical industry can to a large extent reflect the actual advancement of technology in this field.

Table 1 demonstrates the distribution of home countries of the MNCs and the number of patents granted to inventors in each country (we take the first inventor's location in cases of multiple inventors).

Table 1: Distribution of Multinational Firm Home Countries

Country	Number of Firms	Number of Patents
Australia	2	100
Belgium	1	973
Canada	2	101
Denmark	2	1,144
Finland	1	102
France	7	18,747
Germany	8	31,285
Israel	1	240
Japan	30	47,405
Korea	2	154
Netherlands	2	2,084
Norway	2	375
Switzerland	6	16,496
Taiwan	2	13
UK	10	19,327
US	77	148,122
Total	**155**	**286,667**

There are 286,667 patents analyzed in this study, with about 79% granted to parent companies and the remaining 21% by foreign subunits. The primary field of technological activity of each patent is derived from the US patent class system, and these fields are grouped into 56 technological sectors (Cantwell and Andersen, 1996). This grouping is established based on the class system, providing economic meanings for each of these fields. Due to the limitation of industry sample, some fields among these 56 are not as highly represented as others; as a result, an analysis across these 56 fields of technological sectors would somehow demonstrate a skewed result. Therefore, this study further grouped these 56 fields into 31 respective ones in order to have meaningful representative numbers for each technological field so that there is a comparable structure of data distribution. Table 2 demonstrates a brief description of each technological field and patent frequencies of these fields in this research.

Table 2: Distribution of patents among technological fields

N°	Field	Number of Patents
1	Food and tobacco products	1,735
2	Distillation processes	738
3	Inorganic chemicals	4,139
4	Agricultural chemicals	5,035
5	**Chemical processes**	**13,636**
6	Photographic chemistry	9,461
7	Cleaning agents and other compositions	15,082
8	**Synthetic resins and fibres**	**37,678**
9	Bleaching and dyeing	3,130
10	**Other organic compounds**	**48,999**
11	Pharmaceuticals and biotechnology	57,747
12	Other chemicals and Related - disinfecting, preserving, textiles and explosives	815
13	Metallurgical processes	2,488
14	Miscellaneous metal products	4,080
15	**Chemical and allied equipment**	**10,947**
16	Paper making apparatus	1,808
17	Assembly and material handling equipment	1,694
18	Other specialised machinery	3,553
19	**Other general industrial equipment**	**2,813**
20	Mechanical engineering nes	3,870
21	**Electrical devices and systems**	**2,146**
22	**Other general electrical equipment**	**4,427**
23	**Office equipment and data processing systems**	**2,431**
24	Electrical equipment nes	4,290
25	Transport equipment	896
26	Rubber and plastic products	4,056
27	Non-metallic mineral products	14,143
28	Coal and petroleum products	6,579
29	Photographic equipment	2,417
30	**Other instruments and controls**	**14,019**
31	Other manufacturing and non-industrial	1,815
Total		**286,667**

The calculation of the first dimension of our typology – subunit CC intensity – is mentioned in the previous section. The second dimension – subunit distance, is calculated using the Jaffe (1986) approach which borrows the concept of Euclidean vector calculation using (1 – Cosin Similarity) to construct a measure for distance:

$$Tech\ Distance = 1 - \frac{\sum(Sub \times Parent)}{\sqrt{\sum Sub^2} \times \sqrt{\sum Parent^2}}$$

Where Sub and Parent represents the number of patents in field j granted to the subunit and parent, respectively; the $\sum$ in this equation is calculating the sum of patents through all technological fields.

Figure 2 shows a distribution of subunits among these four categories across the dimensions of subunit technological distance and subunit CC intensity. After the mapping of the full sample, we then controlled the sample size to include only large subunits – in the effort of capturing subunits with higher level of innovative activities, we included in this subset only subunits with more than 50 patents granted in a five-year window. The distribution pattern of this subset is shown in Figure 3.

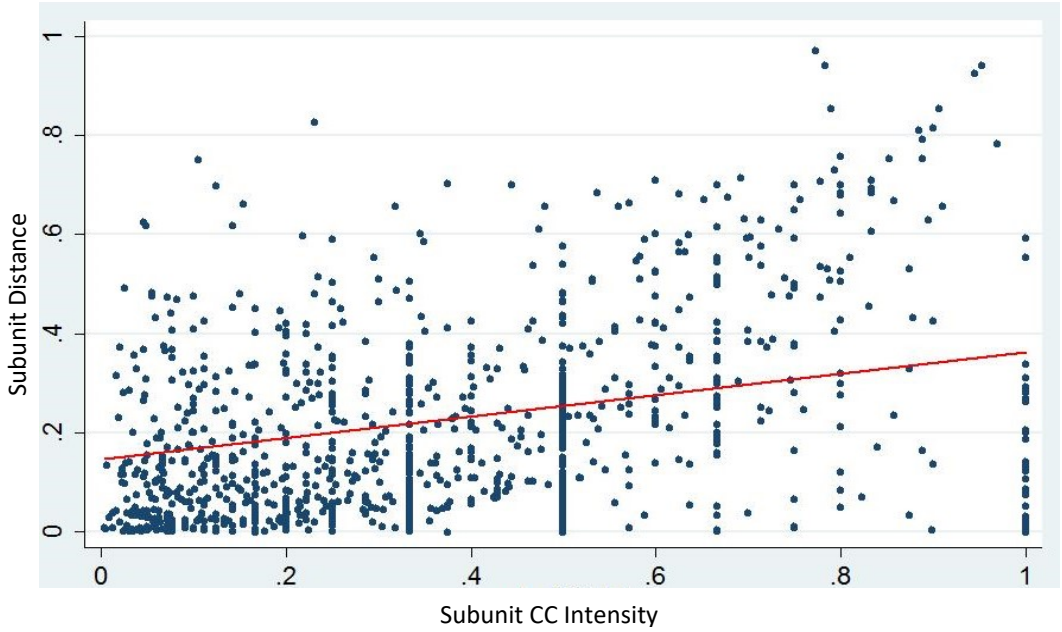

Figure 2: Subunit Distance and CC Intensity (full sample)

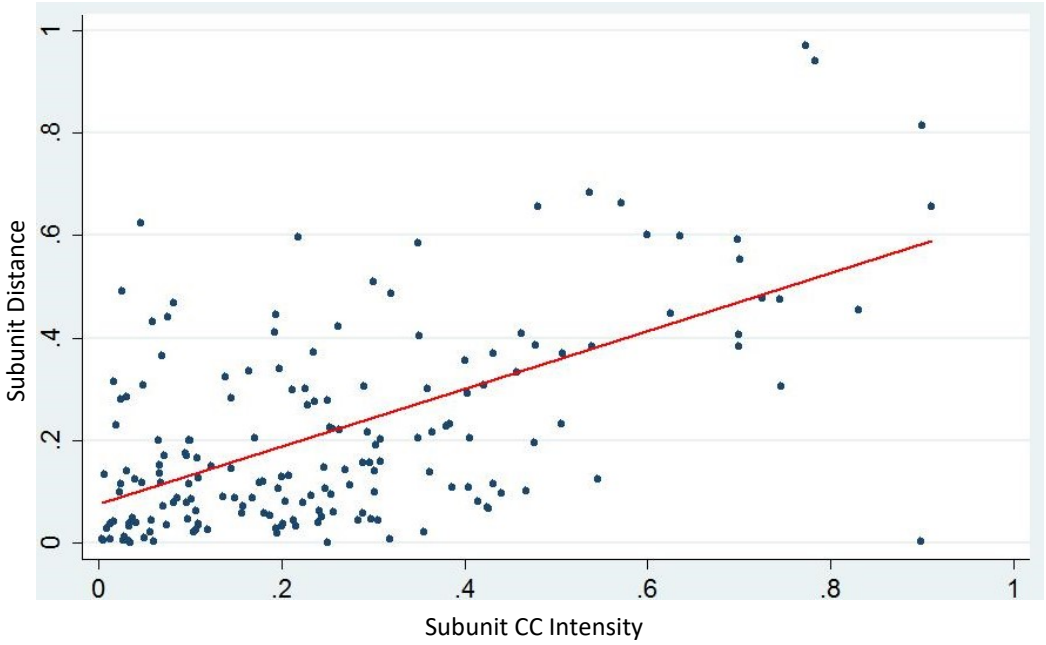

Figure 3: Subunit Distance and CC Intensity (Large Subunits)

Comparing these two figures, large subunits demonstrate a stronger positive relationship between dimensions of subunit technological distance and subunit CC intensity. Large subunits distribute more closely along the fitted regression line, while smaller subunits tend to have more various types of positioning as shown on the diagrams.

3.2 Evolution of Subunit

To examine the trajectories of subunit role evolution, we use the typology developed in the previous part with dimensions of subunit CC intensity and subunit technological distance. By examining the change in each of these dimensions over different time periods, we can construct a new model that distinguishes subunit evolution paths based on their directions of movement.

Figure 4 shows the scattered distribution of subunits' evolution patterns. Since this chart uses the change in value of the two dimensions as the axis, it is intuitive to use value 0 as the dividing cut-up point to distinguish types of subunit evolution pattern. We use all data sample in this diagram. The large subunits sample shows

almost the same results, except with fewer observations. The reason of this is that subunits have to show a consistency in their overall competence creativeness throughout more than one-time window to be included in this result. Smaller or newer subunits are not showing this consistency; therefore, it's hard to capture their evolution patterns. Large subunits, however, are more likely to show up repeatedly in this chart because of the capability of conducting continuous CC activities.

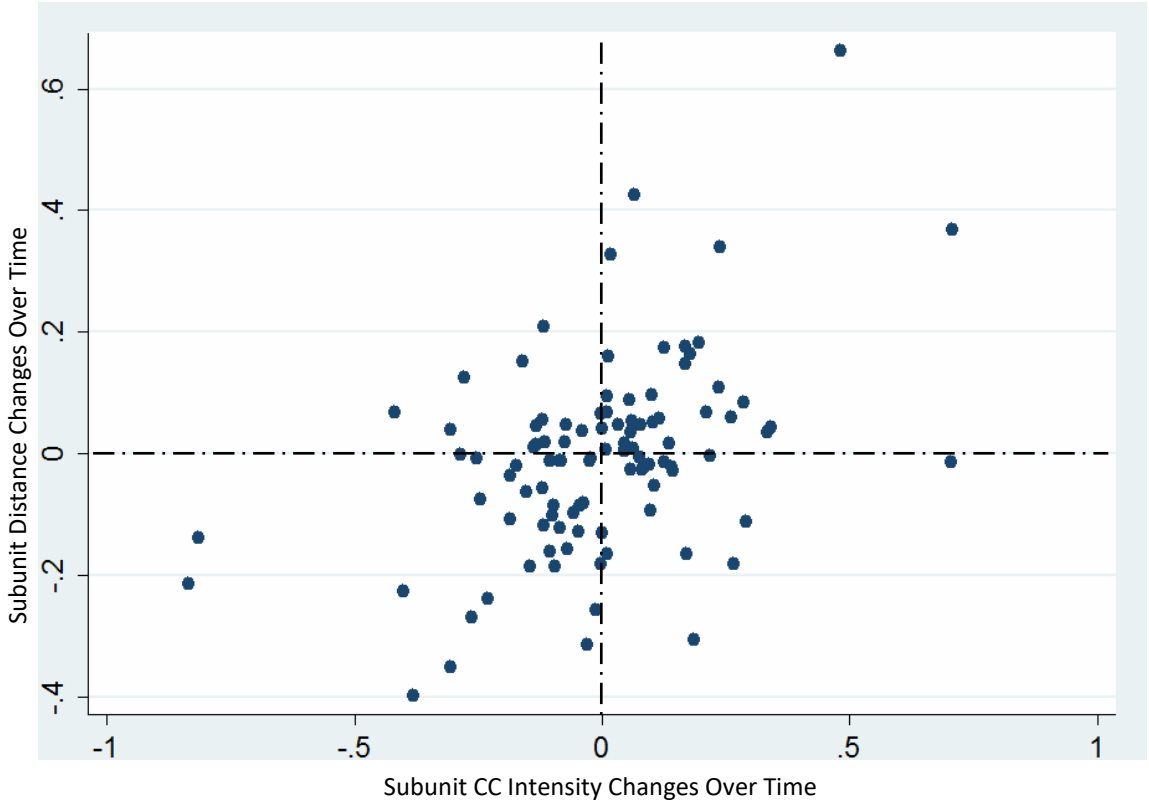

Figure 4: Subunit Evolution Patterns

In Quadrant I of Figure 4, subunits are demonstrating an increase in both their technological distance from their parent group and their CC intensity. These subunits are likely those that are heavily embedded in host country local environment while at the same time possess a favorable mandate from the MNC group to facilitate their further development of innovative activities that are new to the MNC group. 42 subunits are identified in Quadrant I, among which the most consistency is shown by the subunit of the Swiss firm Novartis in the US. Novartis is a pharmaceutical company that has its center of research and development based in Basel, Switzerland, with other key research sites located in Horsham, UK; Vienna, Austria; Tsukuba, Japan; East Hanover, New Jersey, USA. Their strategy for innovation is "focused diversification" (from Novartis website), by which they mean a concentration on pharmaceutical, biomedical innovation while encouraging diversification into related areas. It is shown in the data that Novartis US started as a traditional type of subunit, with technological distance of 0.04 and CC intensity of 0.04; in the following period this pair of numbers were increased to (0.09, 0.30), whereas towards the end of my observation period the numbers reached (0.11, 0.40). It is clear that Novartis US is on the trajectory of evolving into a category of more emphasize on CC type of activities.

Quadrant II of Figure 4 includes subunits that are increasing in their technological distance from the parent company, yet the level of CC activity intensity decreases overtime. These subunits are moving into the direction of concentrating more on CE activities, but their areas of niche application stays strong and even draws further away from the parent company. A typical example of subunit in this quadrant is ExxonMobil's operation subunit in Canada.

Quadrant III is consisting of subunits that are decreasing on both technological distance and CC intensity. Depending on the actually type of subunit, falling into this type of evolutionary trajectory could mean one of the

two possibilities: (1) the subunit is already well advanced in both technological distance and CC intensity as a center of excellence, now it is time for the competence created by this subunit to be transferred back to the parent company and then further to the international network of MNC group – as a result the subunit itself demonstrates a relatively lower level of CC intensity and technological distance overtime; (2) the subunit is less of a center of excellence, and the field of specialization which is new to the parent company is either no longer a specialty of the subunit itself, or somehow adapted by the parent company. One typical example is US company Schering Plough's operation in Germany. Its subunit technological distance dropped from 0.033 to 0.004, while its CC intensity dropped from an outlining 0.949 all the way down to 0.387. This is an extreme case due to a merger between the US company Plough Inc. and Germany company Schering Corporation. In this case, the reduction of CC activity presence is showing the effect of two companies corresponding and transmission technological capabilities into one another.

Quadrant IV indicates an increase in CC intensity while the technological distance decreases. This could be caused by a more focused effort on CC areas that are to some extent related to the parent company's fields of specialization – just like apples don't fall far from the tree. An example would be Novartis's operation in Germany, which follows perfectly to the company's strategy – "focused diversification" as explained in previous discussion.

4. Discussion and Conclusion

This study uses patent data, conducting exploratory data analysis to create a new typology for MNC subunit roles, which provides a continuous measure to examine an MNC subunit's innovation pattern. We then applied this typology to examine the evolutionary trajectory followed by the paths of technological growth of MNC subunits. There are two dimensions of subunit innovation patterns that this study identifies: subunit CC intensity and subunit distance. Using USPTO data from the general chemical industry, we are able to identify different types of subsidiaries using our new measure of CC activities, indicating the various strategic roles assumed by the subsidiaries. Our results demonstrated a preliminary understanding of our research question – knowledge creating activities of a subsidiary does reflect its strategic role. Furthermore, the over-time evolution of roles is reflected in shifting CC activity patterns.

The paper makes both theoretical and practical contributions to the literature of MNC innovation and subunit strategic roles by presenting a continuous model to examine competence-creating activities of MNC subunits. There has been a gap in the knowledge management literature on the topic of the competence creating roles of MNC subsidiaries. The current KM literature has demonstrated a keen interest in MNC knowledge transfer, but there is little discussion on how different types of knowledge accumulation, leading to either competence creation or exploitation, affects the subsidiary strategy roles. Traditionally the knowledge activities are identified at the subsidiary level, categorizing a subsidiary to be either CC or CE type, allows little flexibility or complexity for reality. This paper addresses this gap by providing a continuous measure to subsidiary knowledge activities.

Methodologically, a connection between statistical data analysis and individual firm examples is made in the discussion of subunit evolutionary trajectories, which can lend itself to possibilities of in-depth case studies. Using the typology designed in this study, we can further examine the relationship between MNC strategy and subunit role evolution, using the continuous variables to describe a subunit's innovative activities rather than categorizing subunits as a CC or CE type, which in turn allows for a more realistic understanding of MNC subunit behavior – as innovative firms should always have a combination of CC and CE innovations.

On the management and practical side, the findings of this exploratory study provide insights on the strategies of MNC and subsidiary knowledge management. Firms can apply the newly categorized roles to better define their strategic intentions for their subsidiaries, while allowing for flexibility, and anticipating the trajectory of evolution in the future. Subsidiary management can creatively engage in a combination of CC and CE activities, strategically placing their innovative efforts in areas that are related to their parent company, and in the meantime develop their own unique knowledge portfolio. As MNCs make their strategic goals for their various subsidiaries, depending on their long term visions and the location specific advantages from the host country locations, they are able to create focused yet flexible knowledge management objectives to balance the CC and CE activities in each location, therefore achieving an optimal combination between MNC strategic integration and locally embedded development.

One of the limitations of this study is due to the nature of patent database – since MNC subunit are identified at country level, there are large countries (especially the US) that can have internal variation in terms of MNC activities. Our current study does not identify these within-country variations. A future study could be designed

to identify regions of large countries and break the data of large countries down to regional level, which may provide more interesting results when MNC subunits are identified at a lower level.

Future study could concentrate more on a comprehensive empirical analysis of the evolutionary trajectory for subunits. Host country location's industry conditions could also be taken into consideration when analyzing these evolutionary trends, as the host country co-evolves with large MNC's subunits.

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