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Monitoring Evolutionary Trends in Electronic Business Models: A Dynamic Patent Analysis Approach

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Abstract. The enormous numbers and the increased complexity of electronic business models (e-BMs) render monitoring the evolutionary trends in e-BMs extremely difficult. Industrial practitioners need the support of well-organized information, as the manual task by experts is time-consuming and labor-intensive. Numerous approaches have been devised to systemize this burden, but have not been useful in practice due to lack of applicable data and customized methods. This study proposes a dynamic patent analysis approach to developing dynamic BM lattice that can analyze complex relationships among BM patents and visualize the evolutionary trends in e-BMs over time. Given the complexities involved, our approach is designed to be executed in four distinct steps: data collection and preprocessing, construction of morphological BM context using text mining and morphological analysis, development of two types of dynamic BM lattice – horizontal and radial – using modified formal concept analysis, and in-depth analysis based on quantitative indicators. We believe our method can improve the efficiency of business monitoring process, and can serve as a starting point for a more general model.

Keywords: business intelligence, electronic business model, evolutionary trend, business model patents, patent analysis, morphological analysis, formal concept analysis

1. Introduction

The explosion of the Internet and the advance of software programs have revolutionized the way people do business and created unpredicted business opportunities [1]. A variety of business models (BMs) have newly emerged, and grown from a standing start to a juggernaut of $228 billion retail and $3.4 trillion business-to-business, brining about enormous changes in a wide array of industries [2]. Given the rapid growth and continued diffusion of electronic business models (e-BMs), companies are focusing on identification and assessment of trends in e-BMs to gain and maintain a competitive edge, keeping business activities under surveillance and scanning the environment.

Several methods – lifecycle analysis, trend analysis and scenario analysis – have been suggested to understand important aspects of trends in e-BMs. While all these models are useful for different contexts, many researchers have pointed out significant problems and deficiencies, which provide our underlying motivation, in two areas: data and methods. Firstly, in terms of data limitations, previous methods cannot provide objective information about trends in e-BMs based on the objective data since most research focused on case-based conceptual frameworks. Even though statistical analysis and trend extrapolation have been applied to indirect measures to enhance the objectivity of analysis results, it can only describe the overall directions and processes of development of e-BMs. It is critical to secure the applicable data and offer the objective information to provide more detailed guidelines. Second, in terms of method limitations, previous models have attempted to analyze the trends in e-BMs at the macro level despite of idiosyncratic nature of e-

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BMs across industries. Thus, the explanatory power lies mainly in the general pattern of changes in e-BMs, and less in the specific trends within a particular industry.

More widely available business databases and more intelligent computational algorithms have facilitated the development of more powerful and more effective methods [3]. One such area – patent analysis – has been considered to be a useful analytic tool, and significantly benefited from the use of computerized methods such as text mining and bibliometric analysis. Since the patentability of BMs was formally acknowledged by the US Patent and Trademark Office (USPTO) in 1996, the number of applications for BM patents has sharply increased, climbing from 1,320 in 1998 to nearly 8,000 by 2001 [4]. In fact, analyses of BM patents have been made to grasp the overall picture of the current status of BMs in e-commerce. However, albeit easy to understand and simple to use, they could not give a full descriptive picture of evolution process due to limited use of data and uncustomized methods [5]. Because of these considerations, we propose a dynamic patent analysis approach to developing a dynamic BM lattice that can analyze the complex relationships among BM patents and visualize the evolutionary trends in e-BMs over time. Specifically, we use the label 'evolutionary' to refer to our proposed method's use of this analysis to capture the detailed changes in components of e-BMs over time. At the heart of the suggested approach is the morphological analysis (MA) for structuring patented inventions and the modified formal concept analysis (FCA) for analyzing the relationships of BM patents over time. Given the complexities involved, our approach is designed to be executed in four distinct steps: data collection and preprocessing, construction of morphological BM context using text mining and MA; development of two types of dynamic BM lattice – horizontal and radial – using modified FCA; and in-depth analysis based on quantitative indicators.

The rest of this paper is organized as follows. The general background of MA and FCA is presented in Section 2. The proposed dynamic patent analysis approach is explained in Section 3. Finally, this paper ends with conclusions in Section 4.

2. Background

2.1. MA

MA, developed by the Swiss astrophysicist – Fritz Zwicky, is a method for structuring and investigating the possible forms of a system which consists of several dimensions [6]. The distinct advantages of MA lie in its ability to examine all the configurations of complex problems and flexibility to be integrated with other methods. This stimulates creativity to identify a new concept or more improved sets than present levels. The basic procedure of MA is as follows. The first step is to identify the fundamental dimensions of the system. All dimensions should be mutually exclusive and collectively exhaustive so that the system could be fully explained with dimensions. The next step is to list all the possible attributes in which each dimension can manifest itself. Finally, once a morphological matrix is constructed by assembling dimensions and attributes, the cross-consistency is assessed to reduce the time spent on analyzing infeasible configurations. The infeasible configurations are mainly caused by logical contradiction, empirical constraints, and normative constraints. At this moment, all the configurations are identified and infeasible configurations are eliminated.

2.2. FCA

FCA, first proposed by Wille (1982) based on the lattice theory, is a mathematical tool for analyzing the relationships among objects with shared properties in an amount of data [7]. The basic notions of FCA are a formal context and a formal concept denoted as context and concept, respectively. First, a context (O, A, I) consists of a set of objects O, a set of attributes A, and relations I between O and A. A formal context is represented by a cross table as depicted in Fig. 1(a). The elements on the left side o_i ($\in O$) are objects and the elements at the top a_j ($\in$A) are attributes. If an object o_i has an attribute a_j, the relation between them is represented by the cross. Second, a formal concept for the formal context (O, A, I) is defined as a pair of (O_S, A_S). Here, O_S is the extent and A_S is the intent of the formal concept (O_S, A_S). The extent covers all objects belonging to the formal concept while the intent comprises attributes shared by all those objects. In Fig. 1(a), the objects o_1 and o_2 have attributes a_1 and a_2 in common. Thus, $(\{o_1, o_2\}, \{a_1, a_2\})$ is a concept of the context; the subset of objects $\{o_1, o_2\}$ is the extent and the subset of attributes $\{a_1, a_2\}$ is the intent of the concept. The set of all concepts of a context is ordered by inclusion relations between the extents (or intents)

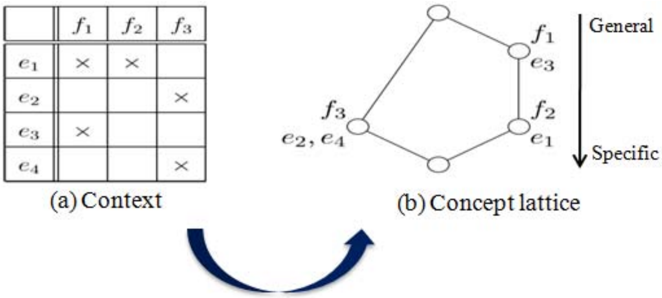

Fig. 1: Basic notion of FCA

of the concepts. If the objects in the extents of a concept c_1 include all objects in the extents of concept c_2, c_1 is defined as a super-concept of c_2, and c_2 is denoted as a sub-concept of c_1[1]. As can be seen in Fig. 1(a), $(\{o_1, o_2\}, \{a_1, a_2\})$ is a super-concept of $(\{o_2\}, \{a_1, a_2, a_3\})$ while $(\{o_2\}, \{a_1, a_2, a_3\})$ is a sub-concept of $(\{o_1, o_2\}, \{a_1, a_2\})$. Based on the hierarchical orders of all concepts in the context, a *concept lattice*, which is a graphical representation of inclusion relations between concepts, can be generated as exemplified in Fig. 1(b). Each node corresponds to a concept. Nodes are placed and connected to each other to represent their order relations. The concept lattice shows a hierarchical clustering of objects and attributes, where super-concepts display unique objects and common attributes with sub-concepts, while sub-concepts display common objects with super-concepts and unique attributes.

3. Proposed approach

As Fig. 2 shows, the model employs various methods to monitor the evolutionary trends of e-BMs. Involving many methods and complex algorithms may lead to conceptual misunderstanding and imprecise use in practice, so the model is designed to be executed in four discrete stages.

3.1. Data collection and preprocessing

Patents of focal business field are collected from the patent database using relevant search conditions. The patents are unstructured documents expressed as text, and in need of preliminary preprocessing. They are parsed based on the structure of documents in order to be transformed into a structured patent database.

3.2. Construction of morphological BM context

A keyword-based morphological BM context is constructed to be utilized as an input of modified FCA.

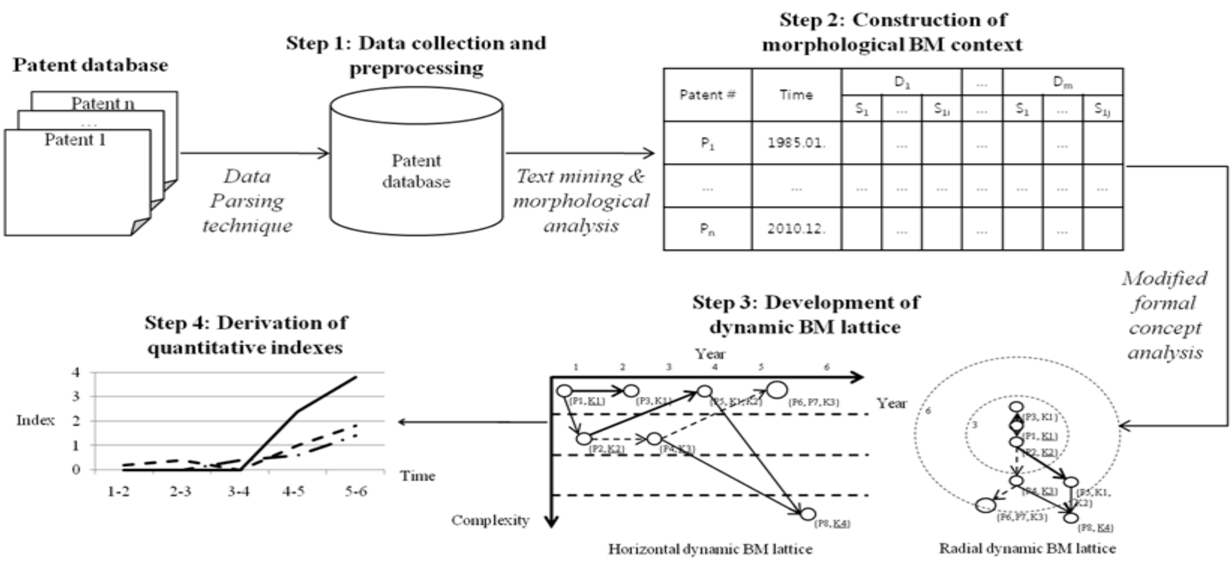

Fig. 2: Overall process of the suggested approach

[1] Mathematically, a super- and sub-concept relation is represented by ≤ and defined as:
$(O_{S1}, A_{S1}) \leq (O_{S2}, A_{S2})$ *if* $O_{S1} \subseteq O_{S2}$, where (O_{S1}, A_{S1}) is a sub-concept of (O_{S2}, A_{S2}), and vice versa.

It is an integrated form of original formal context and morphological matrix composed of three parts: issued date, patent number, and keyword vector. A field of issued date is added in order to take time periods into account while the patent number and keyword vector correspond to the object and attributes in the original formal context. Taking a MA perspective, the field of keyword vector is divided into dimensions and attributes. Here, how to define the morphological structure relies firstly on software programs and secondly on experts' judgments. After the keywords with high importance are identified from the dataset, they are precisely refined by excluding non-related keywords. The morphological structure of focal business field is then defined based on keyword lists extracted to manifest the properties of e-BMs. Since such an automated method has a limitation in that it may fail to reflect the intrinsic features of e-BMs, this process must be supported by experts in the relevant domain. A keyword-based morphological BM context is exemplified in Fig. 2. The issued date and patent number are represented in the text format, and the keyword vectors are arranged by binary value; '1' means that the patent is related to the corresponding keywords, while '0' means that there is no relationship. For instance, P5 was issued in 2008 and related to A_{11}, A_{21}, and A_{nm}.

3.3. Development of dynamic BM lattice

The conventional concept lattice only shows the order relations among concepts without time considerations and changes of attributes; consequently, simply applying the FCA to e-BM monitoring problem is not appropriate because it is difficult to structure and analyze the evolutionary trends in e-BMs over time. Thus, the FCA is extended to take into account time periods and changes of components in BM patents.

The modified FCA algorithm is summarized as follows. First, in contrast to the conventional FCA, it is an iterative process which generates the dynamic BM lattice based on the issued date. Only patents issued earlier than the target patent are taken into account in constructing the dynamic BM lattice. In other words, two different patents having the same keywords, but issued at different time periods, generate two different concepts. Second, the order relations among concepts are derived by index of the cosine similarity instead of a concept of subsets. The cosine similarity is the most frequently adopted similarity indicator in calculating similarities of documents [8] and defined as $\cos\theta = A \bullet B / |A||B|$ where A and B are keyword vectors of documents. Specifically, when the target patent is comprised of all new keywords (similarity = 0), a new concept is generated without linkages. In the case of the target patent containing new and existing keywords ($0 < \text{similarity} < 1$), a new concept is generated with linkages to concepts whose similarities are greater than a pre-defined threshold. As for the target patent including only existing keywords (similarity = 1), if the dynamic BM lattice has the concept whose attributes are the same with those of target patent, the property of corresponding concept is updated. If the dynamic BM lattice does not have the concept, a new concept is generated with linkages to concepts whose similarities are greater than a pre-defined threshold. Finally, nodes and arcs differ from one another in the dynamic BM lattice according to the number of patents in a concept and types of changes of keyword. The size of nodes is proportional to the number of patents in the concept. In terms of arcs, a thick solid line shows there is no difference of keywords between super- and sub-concept where the similarity is equal to one. In the case of two concepts having different keywords, the case where the differences are induced from a new keyword that previous concepts do not have is represented with dotted lines while the other case where the differences are induced from existing keywords is depicted with thin solid lines.

Based on the modified FCA algorithm, two types of dynamic BM lattice are proposed according to the visualization format: horizontal and radial dynamic BM lattice. They can be utilized for different purposes. First, the horizontal dynamic BM lattice emphasizes the trends in e-BMs with information such as horizontal time frame and category of BM patents, etc. The horizontal dynamic BM lattice is effective in visualizing the evolution process of e-BMs over time, but has some difficulties in visualizing the structure of e-BMs due to complex and twisted arcs. Second, the radial dynamic BM lattice overcomes the abovementioned limitation of horizontal dynamic BM lattice. It is developed by transforming the horizontal time frame into concentric rings, allowing the complex and twisted arcs to be distinguishable. Consequently it is more appropriate to grasp the detailed structure of changes in e-BMs. The forms of horizontal and radial dynamic BM lattice are shown in Fig. 2.

3.4. Interpretation with qualitative and quantitative analyses

The visualized outputs are interpreted by investigating graphical forms and their indices. While analysts can derive significant implications from maps or networks by observing the distribution of information, an index presents a quantitative measurement that visual forms cannot offer. Thus, quantitative indexes need to be defined and gauged to conduct a more detailed analysis and obtain richer information. (e.g. Intensity of business patenting activity (IBPA) defined as the number of issued patents for a specific e-BM in a given period and changes in intensity of business patenting activity (CIBPA) referred to as the increasing and decreasing ratio of IBPA)

4. Conclusions

This article has proposed an intelligent approach that can analyze the complex relationships among BM patents and monitor the evolutionary trends in e-BMs. The contributions and potential utilities of this research are twofold. First of all this study theoretically contributes to e-BM research, proposing an intelligent approach that can structure, analyze, and visualize the evolutionary trends of e-BMs. Although it has not yet been widely tested, the suggested approach can be employed in the research areas such as business opportunity analysis. Second, from a methodological perspective, this study is exploratory in that an integrated approach based on the FCA algorithm and MA is first proposed for patent analysis. This research emphasizes on the details of suggested algorithm and its strengths for handling the unstructured documents for monitoring the evolutionary trends over time.

Despite all the possibilities offered by the suggested approach, as this study is at the explorative stage, our method is still subject to certain limitations concerning (i) performance of the suggested method and (ii) scope of analysis. First, in terms of performance of the suggested method, a lacuna still remains as to how to improve the performance of the method. Second, in terms of scope of analysis, different algorithms and quantitative indexes need to be devised to extend and diversify the potential information. Also, other factors such as organizational capability and market environment should be incorporated to fully understand the evolutionary trends in e-BMs. These topics can be fruitful areas for future research.

5. Acknowledgement

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6. References

[1] Y.J. Wu. Unlocking the value of business model patents in e-commerce. *J. Enterp. Inf. Manage.* 2005, 18(1): 113-130.

[2] K.C. Laudon, C.G. Traver. *E-Commerce 2010 – Business, Technology, Society*. Pearson, 2010.

[3] D.L. Mann. Better technology forecasting using systemic innovation methods. *Technol. Forecast. Soc. Change* 2003, 70(8): 779-795.

[4] S. Hunter. Have business method patents gotten a bum rap? Some empirical evidence. Working Paper 182, Center for eBusiness@MIT, 2003.

[5] C. Lee, J. Jeon, Y. Park. Monitoring trends of technological changes based on dynamic patent lattice: a modified formal concept analysis approach. *Technol. Forecast. Soc. Change* 2011, doi: 10.1016/j.techfore.2010.11.010.

[6] B. Yoon, Y. Park. Development of new technology forecasting algorithm: hybrid approach for morphology analysis and conjoint analysis of patent information. *IEEE Trans. Eng. Manage*. 2007, 54(3): 588-599.

[7] R. Wille. Restructuring lattice theory: an approach based on hierarchies of concepts. In: I. Rival(Eds.), *Ordered Sets*. Reidel, 1982.

[8] C. Sternitzke, I. Bergmann. Similarity measures for document mapping: a comparative study on the level of an individual scientist. Scientometrics 2009, 78(1): 113-130.