Using Big Data Analytics for Market Opportunities: A Case Study of ExporTech™ Detroit

Adela SM Lau and Nidhal Bouazizi

***Abstract*—Market expansion is a business growth strategy. The methods for expanding a market include channel expansion, new product development, new market identification, and sales expansion. With growing social media usage, consumers have changed their shopping behavior from internet surfing to social media referral. Therefore, transaction data is not the only data source to be analyzed for identifying an effective distribution channel, a new market, a new product, or a marketing strategy in market opportunity research. Big data, by, combining numerical information, textual information, image, and video together for analysis, has become the new data source. However, the challenge in performing big data analysis is the way in which the data being gathered, integrated, filtered, organized, analyzed, and presented. This paper aims to present a novel big data analytics framework with ubiquitous and self-learning capabilities able to handle the dynamical change of the market environment for market opportunity analysis. To evaluate the effectiveness of the framework, the conceptual framework was implemented in a market research project. The outcomes of the project and the lessons learned are discussed.**

***Index Terms*—Big data analytics, market opportunities, ExporTech Detroit, knowledge engineering.**

I. Introduction

Market analysis, product analysis, sales analysis, and channel analysis are commonly used methods for market opportunity research [1]. The data and techniques used for these analyses can be classified into three main categories. A group of researchers uses market surveys and consumers' comments to analyze consumers' preferences and product opinions for new product development [2], [3]. They extract and integrate data from customer reviews and market surveys to assess buyers' satisfaction on products' features and customer services, and to identify new products for market expansion. Another group of researchers focuses on identifying the optimal marketing channels for increasing the sales of existing products in market expansion research. They use company transaction data to segment customers into different groups to discover their buying behavior and channel choices and to identify optimal channels for distribution [4], [5]. However, the limitation of this method is that it does not consider the local and global market environments for market expansion. Therefore, other researchers study the companies' business environment, competitive advantages, branding position, sales performance, and pricing strategies to expand the market locally and globally [6], [7]. They integrate the market news, economic indicators, import and export data, annual company reports, companies' website information and transaction data to analyze existing industry environment, business environment, competitors' competitive advantages, and products' differentiation for new market opportunities.

Since the data from company transactions, market surveys, company websites, consumers' reviews, and so on are dynamic and in different formats and are interrelated to each other in market analysis, this paper aims to develop a big data analytics framework for integrating those numerical and textual data to perform a more complete market analysis and provide ubiquitous and self-learning capabilities to cope with the dynamical change of the market environment. The next chapter will review the existing market expansion analysis methods and discuss its drawbacks and the technologies used. A novel big data analytics framework and information architecture in the knowledge engineering perspectives will be then proposed. A case study of adopting this novel framework in a new market opportunity research will then be presented and discussed. The lessons learned and the future work involved will be discussed in the conclusion.

II. Literature Review

A. An Overview of the Current Market Expansions Analysis Methods

Traditional market selection methods can be classified into qualitative and quantitative approaches [8]. Qualitative approaches identify a shortlist of countries based on the pre-defined objectives and constraints for market expansion. It collects the data of government policies, commercial environment, distribution channels, countries' demographics, social environments, customers' purchasing power and preferences, foreign market visits for analysis, and so on in the market screening process. The tradition data analysis methods used in qualitative approach include scoring and ranking. The drawback of this method is its biased analysis and its high dependence on researchers' experience and knowledge in a specific country and their perceptions on market opportunities there.

Quantitative approaches compensate for the limitation of qualitative approaches and the use of secondary data, such as import and export data, economic indicators, and so on to perform analysis. The methods used in quantitative approaches can be classified into market grouping method and market estimation methods. The market grouping method clusters countries into similar groups based on their

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social, economic, and political factors. It uses macro indicators to cluster similar countries into groups and compare across the market performances within the clusters for identifying potential new markets. The data analytics techniques used for market grouping include clustering and classification [9]. However, the market grouping method may not be able to reflect the market opportunity for specific products.

Market estimation methods are employed to compensate for the limitation of the market grouping method. They analyze market potentials on firm-level [10] and country-level [11]. The firm level method uses the data of customer reviews, customer preferences, customer satisfaction surveys, transaction data, and so on to perform analysis. In addition to the analysis, it reviews company objectives, products' profitability, and managerial experience and knowledge to evaluate the firm's readiness to expand the market. The data analysis techniques used in firm-level market estimation method include natural language processing, text mining, opinion mining, sentiment analysis, sales prediction, marketing optimization, and channel optimization. However, this approach is limited to firm-level analysis and does not compare itself with the competitors' or other brands' market penetration rates.

Therefore, a country-level method allows companies to analyze and compare countries' import and export data of certain products to identify potential country-product combinations for export. This method analyzes product-specific market growth, market size, and level of competition and barriers for trading to identify right products for new market expansion. It uses porter's five forces model and strength, weakness, opportunities, and threats (SWOT) model to analyze the external and internal business environments. In addition, it uses data of economic indicators, import and export data, Harmonized System Codes (HS Code), market penetration rate, market survey, competitors' website information, consumer reviews, consumer preferences, company products' characteristics, and so on to perform analysis. The data analysis techniques used in the county-level market estimation method include scoring, ranking, graph theory, network analysis, association rules, and some other techniques used in firm-level market estimation.

To summarize, each of the above methods has its strengths and limitations, and they can compensate for each other's limitations. Therefore, an integration of the above methods for identifying new markets was recommended in this study. Since government policies, commercial environments, distribution channels, and customers' purchasing power are the most critical factors for success in trading, a preliminary screening using a qualitative method for identifying potential countries to export was recommended. Second, an in-depth screening using market grouping method to classify the similar countries for export analysis was recommended. The advantage of screening the groups of similar countries is that it can reduce the time and resources for analyzing the country-product combinations in each country. Once the groups of similar countries are identified, companies can only target the cluster groups for further analysis. So, a preliminary selection to identify country clusters and product combinations using country level market estimation method was recommended in the third stage. Potential products for export in similar countries are identified in this stage. Once the target country clusters and products combination for market expansion are identified, an in-depth selection to identify the most promising products and countries to export using firm level estimation method was recommended. This stage involves the analyses of the sales data, customers' demographics, distribution channels, product profitability of the company, and so on.

B. Review of the Data Analysis Methods for Market Expansion Research

Marketing optimization and channel optimization are commonly used to analyze new market opportunities, market classification, market prediction, customer segmentation, buyers' purchasing behavior, market basket analysis, sales prediction, and pricing optimization. Data mining techniques such as regression, outlier detection, time series, clustering, association rules, and decision rules are used for these analyses [12], [13]. Regression models use transaction data to predict future market trends and sales performance. Outlier detection finds out abnormal sales patterns that may be caused by a marketing campaign or a sudden event. Time series provides analysis on buying's purchasing patterns and predicts seasonal sales cycles for marketing campaign planning. Clustering analyses classify the customers or markets into segments for future target marketing or market opportunity analysis. Association rules are used in market basket analysis for identifying cross-sales opportunities in market expansion study. Finally, decision rules provide decision criteria and rules for managers to perform decision-making in market expansion selection.

However, since the market changes all the time, the data analysis models also require to be changed dynamically to adapt to its environmental changes. Some researchers use machine learning methods [14] such as Bayesian classifier, neural networks, support vector machine, and so on to learn the historical market patterns for market classification and prediction, and at the same time to adjust the errors of the model caused by environmental changes during the data analysis process. Other than numerical data, social media becomes one of the important data sources for companies to perform analysis as it is commonly used by customers to share opinions [15]. Some modern methods such as natural language processing [16], taxonomy building [17], opinion mining [18], and sentiment analysis [19] are invented and applied in market analysis. However, since the vocabulary used in social media may vary and the same vocabulary in a different context may have different meanings, an ontology can be used to standardize the vocabulary categories for information integration and social media analysis [20].

Therefore, a big data analytics platform using ontology and machine learning to integrate the numerical and textual data as a whole for market learning and analysis was proposed in this study. Integration of the data of government policies, market reports, census data, economic indicators, and financial data was recommended to be collected in the market preliminary and final screening processes. Since these data are collected from various sources, an ontology will be used to structure the data in a well-organized manner

so that the content of these data sources can be co-related and integrated for analysis. After the potential markets were screened in these two stages, the transaction data, economic indicators, company websites, and consumer reviews were integrated in the third stage of market preliminary selection process to analyze the industry and business environments, competitors' competitive advantages, products' differentiation, and consumers' preferences. Researchers can extract product opinions, customers' comments, and product descriptions from social media and/or company websites for analysis. This data can be massaged with the transaction data, channel data, economic indicators to perform product comparison, sales prediction, and marketing and channel optimizations analyses. By integrating these data into import and export data, HS Code and market survey, the target products and its corresponding countries for market expansion can be found in the final market selection stage.

C. Big Data Analysis Platform for Market Opportunity Analysis

Since the data used in market opportunity research is from various sources such as social media and company websites, a big data analytics framework is required to integrate these data for market opportunity analysis. In current studies, only a few researchers studied how to use big data analytics for marketing [21], [22] and networked business [23]. No studies have investigated how to use and integrate the transaction data, government policy, market reports, census data, economic indicators, financial data, import and export data, HS code, website information, social media data, and so on as a whole for market opportunity analysis. Therefore, this section uses a knowledge engineering approach to analyze how numerical and textual data can be collected and integrated for market opportunity research, and how they can be used together with data mining techniques and machine learning methods for market opportunity discovery.

To extract data from public domains including social media platforms, trading websites, financial websites, and company websites, the commonly used method is web crawling [24]. The most popular web crawling tools [25] include World Wide Web Wanderer, Lycos Crawler, Internet Archive Crawler, Google Crawler, Mercator Crawler, and so on. Researchers used broad crawling, focused crawling or continuous crawling method to extract the data from the well-structured webpages. Since the vocabularies used in those public sources may vary, it is difficult to understand and identify the required data for extraction. So, an ontology [20] with defined vocabularies and synonyms can be used to overcome this problem. The standardized vocabularies can integrate the data from various sources as a whole and the rules embedded in the ontology can be used to reason and co-relate the types of sentiments, opinions, product categories, as well as some other data, such as government policies, economic indicators, market penetration rates, product pricing, channels, and so on to analyze market opportunities.

Other than that, to identify market opportunities, a Harmonized System (HS) code is commonly used for finding out the import and export data of different countries for analysis. The HS code is one of the critical data sources for successfully identifying the potential products for export and market expansion. However, the existing HS Code classification method can only be done manually. In some cases, the HS code of the product is difficult to identify because the description of the products in the HS code classification system is unclear, and the vocabularies and languages used in product descriptions and the classification systems are different. As a result, researchers cannot find out the corresponding HS code for market expansion analysis. Although some researchers attempted to adopt an artificial intelligence method to map the HS code patterns to the product categories [26], [27], the problem is still unsolved. Therefore, in the proposed big data analytics framework, an ontology was used in the knowledge engineering layer to map the product descriptions to HS codes. The statistical methods and data mining and text mining models were built on the top of the knowledge engineering layer to perform new market analysis, product analysis, sales analysis, and channel analysis. The machine learning models were used to learn the historical market pattern and to adjust the errors of the predictive and optimization models caused by the dynamical changes of the environment. The graph theory, network analysis, and visualization tools were finally built to present the integration results for managers to perform decision-making regarding market expansion.

III. Proposed Big Data Analytics Framework for Market Opportunity Analysis

Therefore, a novel big data analytics framework using ontology and machine learning for identifying new market opportunities was proposed as below (see Fig. 1).

A. Knowledge Engineering Layer

In the proposed framework, a web crawler for social media data collection was implemented. Ontology repositories for product analysis and consumer analysis were built using taxonomy and folksonomy building methods. The ontology rules and data mining techniques and natural language processing were used for relating, reasoning, and cross-referencing the related entities for big data integration.

B. Intelligence and Logic Layer

Data mining techniques, such as similarity measurement, clustering, classification, and association rules, and text mining were used to build the intelligent data analysis models for product comparison, competitor analysis, opinion mining, consumer preferences analysis, and buyer purchasing behavior analysis. In order to identify a market for expansion, predictive models were used to predict industrial growth and marketing campaign performance. Association rule and prescriptive model were used for finding out the relationship between channels and product characteristics and for identifying the optimal marketing channel respectively.

C. Knowledge Management and Presentation Layer

Lastly, graph theory, network analysis, and machine

learning were used to identify the import and export relationship relating to the impacts of the business environment to import and export performance and identifying new potential markets respectively. A ubiquitous market locating engine and channel marketing were built with machine learning and business intelligence tools. A big data visualization tool was used to summarize and visualize all the analysis for managerial decision making.

The big data analytics information architecture is summarized below (see Fig. 2).

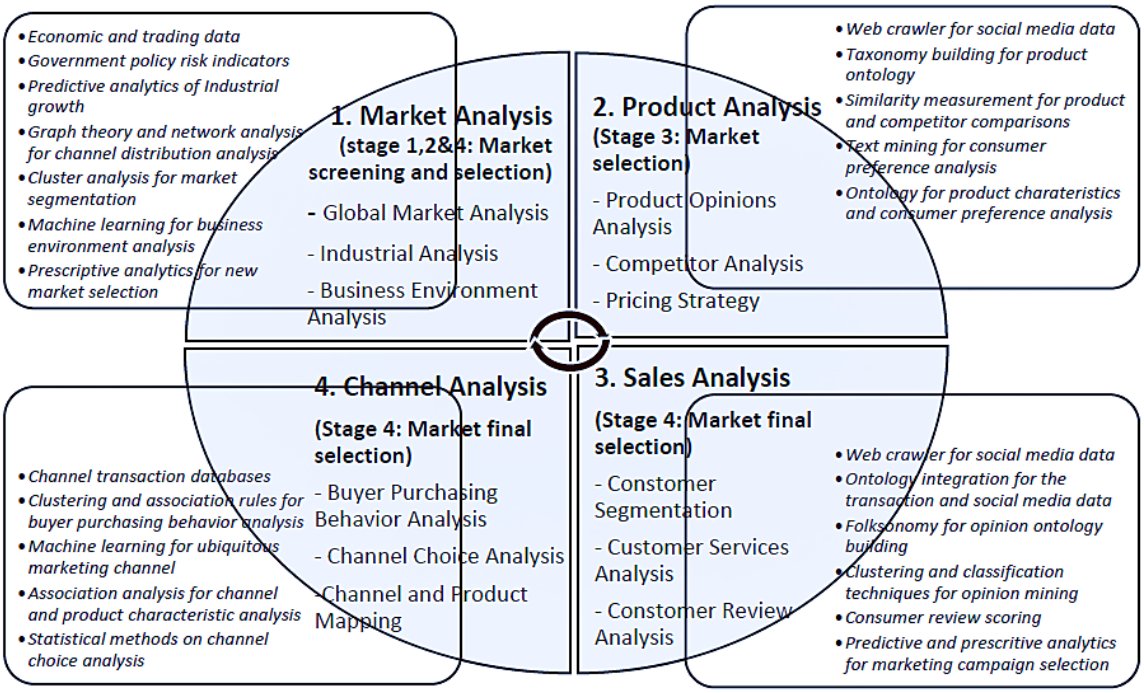

Fig. 1. An overview of big data analytics framework for market opportunity analysis.

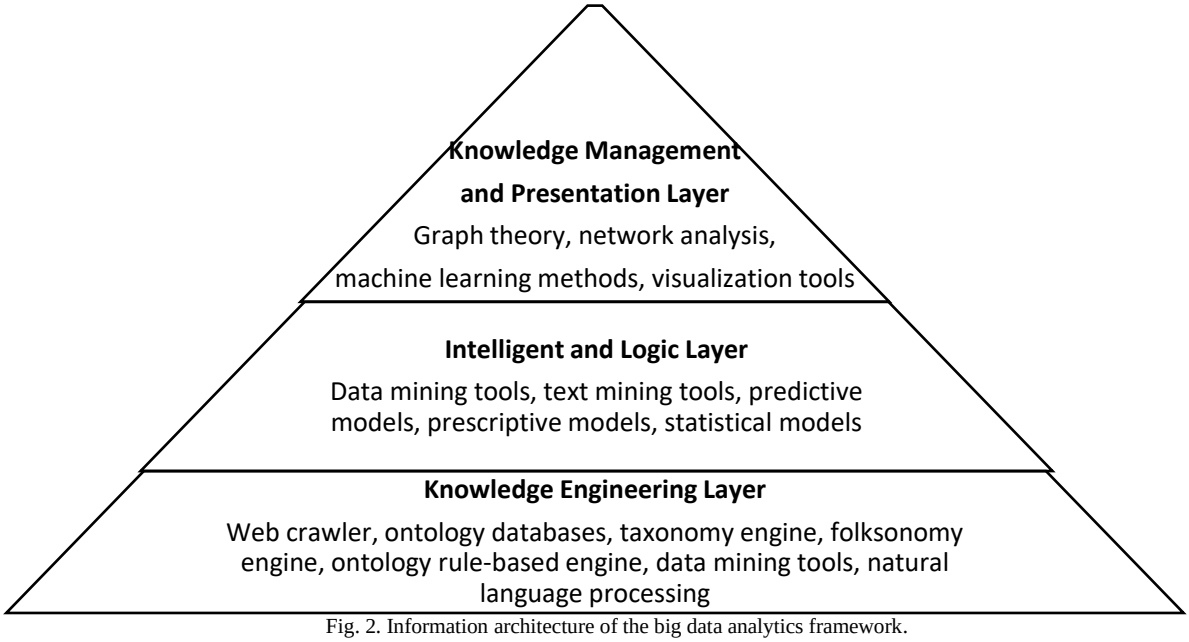

Fig. 2. Information architecture of the big data analytics framework.

IV. A Case Study of Market Expansion Project

In order to assess the effectiveness of the framework, a case study of using this framework for identifying new market opportunities was done. In this chapter, the case background, problem and objectives are presented. The results of using this framework for new market identification are also summarized. The challenges, the lessons learned, and future work are discussed at the end of this paper.

A. Case Background, Objectives and Problems

ExporTech™ is a national export technical assistance program developed by the US Department of Commerce [28]. It aims to help companies that are developing an export strategic plan. In Fall 2018, U.S. Commercial Service (East Michigan), Detroit Economic Growth Corporation, Michigan Economic Development Corporation, Michigan Manufacturing Technology Center, and NIST

Manufacturing Extension Partnership partnered with Madonna University in this ExporTech™ Detroit project. Madonna university offered a service-learning based consultancy service to ExporTech™ Detroit's participating companies. It helped companies analyze market expansion opportunities. The research problems were concerned about how to determine what data should be collected and to discover what methodologies can be used to analyze potential market opportunities. The objectives of this project were to identify the data for analysis, develop information architecture, and build a predictive model for ranking potential markets.

B. New Market Analysis Results and Summary

This project used the big data analytics framework to implement an information architecture for new market analysis and developed a data analytics model for scoring the international market opportunities. A HS code repository for product identification was implemented and the porter model, SWOT model, and business environmental analysis model were used to build a business environmental indicator database. The import and export data, business environment indexes, economic indicators, and government policy risk indexes were used to build a predictive scoring model for predicting and ranking the market opportunities of various countries. The scores of the potential markets were calculated. The results were presented to the company, and they aligned with the company's analysis in its previous preliminary research.

V. Lessons Learned

The challenges and difficulties of using the big data analytics conceptual framework are summarized below.

A. Web Crawler for Social Media Data Repository

In order to crawl the import and export data for network analysis, a web crawler was implemented. The difficulties of the crawler implementation are the accessibility of the web pages and the variation of the page format and layout [25]. The crawler is required to be written for each new page found. The copyright and timestamps to crawl the updated import and export data form the second issue. A learning agent using a machine learning approach was recommended to implement web page behavioral monitoring.

B. Web Mining for HS Code Mappings to Product Ontology

To build a product ontology, the HS codes of the products were found using the official HS code classification system [29]. The challenges of HS code identification were the unclear product description and the different names used by the company and HS code classification system. Therefore, folksonomy [17] was used to identify the keywords (metadata) and synonym of the product name. A text analysis on the product description and similarity measurement [25] for HS code mapping requires to be researched for building the product ontology further.

C. Predictive Model for Implementing the Business Environmental Indicators

To determine the business environment for market expansion, a predictive model was built with Porter five competitive forces analysis, SWOT analysis, experts' evaluation on environmental risks, and market import and export data. The challenge of the predictive model was the dynamical changes of the environmental factors and the variation of expert evaluations on the business environment impacting to the accuracy of business environmental risk indicator prediction. Therefore, a machine-learning algorithm to adjust the errors caused by the changes of the environmental risks, and the import and export performance was recommended in future work.

D. Predictive Scoring Model for Market Opportunity Ranking and Identification

A scoring model for market expansion prediction was built. The challenge of the model was the prediction errors in industry and business environment analysis propagating to the market opportunity scoring. Therefore, machine learning which would provide a feedback loop for the predictive model was recommended so that a weighting factor can be calculated to adjust the propagation error impacting the market expansion prediction in future work.

VI. Conclusions and Future Work

In conclusion, big data analytics [30], [31] will become the next generation of artificial computing methods for analyzing industry growth, international markets, business environment, product features, competitor performance, consumer segments, customer services, and buyer purchasing behaviors in market opportunity research. Ontology was recommended to be used to relate, reason and cross-reference the transaction data, social media reviews, advertisement pictures and videos for predicting and forecasting the new markets. From the case study, it showed that the big data analytics conceptual framework and information architecture provided a guideline on how to use the market data, social media data, and public data to identify market opportunities. It used statistical methods, data mining, and machine learning techniques to develop an intelligent and ubiquitous robot for market analysis and prediction. The future work of this study is to research other machine learning methods for improving ontology mapping, taxonomy, and folksonomy building, and predictive model calibration.

Conflict of Interest

Adela SM Lau and Nidhal Bouazizi declare that they have no conflicts of interest on this project. The work of big data analytics framework for market opportunity analysis, the information architecture for the big data analytics framework, and the information architecture design for the ExporTech™ Detroit project were solely done by Adela SM Lau. The work of the case study was completed when Nidhal Bouazizi was the dean of School of Business at Madonna University, who connected ExporTech Detorit to Adela SM Lau for the case study in this paper. The affiliated institution of Nidhal Bouaziz in this paper is his current study institution. All intellectual property right of this research work belongs to Madonna University when both authors were employed by Madonna University, and does not belong to Nidhal Bouazizi's affiliated institution in

this paper.

AUTHOR CONTRIBUTIONS

In this project, Adela SM Lau initiated and developed a novel big data analytics framework for market opportunity analysis, and an information architecture for the big data analytics framework before she was connected to the case study of the ExporTech Detroit. Adela SM Lau applied the information architecture design for the ExporTech™ Detroit project afterwards. The lesson learned is the experience sharing by Adela SM Lau when she led this ExporTech™ Detroit project at Madonna University. Nidhal Bouazizi obtained this ExporTech™ Detroit project opportunity and connected Adela SM Lau to the organizers of the ExporTech™ Detroit and his students on this case study.

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