Model Design and Analysis of Enterprise Vertical Integration Based on Big Data

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Abstract

With the rapid progress of mobile Internet, cloud computing and Internet of things, big data has attracted the attention of all walks of life and become the important wealth of the information society. Meanwhile, some challenges are brought to the management of enterprises. This paper proceeds from the definition and the connotation of big data and vertical integration, briefly analyzes the influence of enterprises’ vertical integration on enterprise performance management under the background of big data, and constructs a regression model to analyze the vertical integration of enterprises and to provide help to improve the enterprise economic effectiveness.

Keywords: Big Data, Vertical Integration, Model Design.

1. RESEARCH OVERVIEW

1.1 Research Background

As far as the issue of enterprise boundary decision-making is concerned, vertical integration is a significant form and receives the attention of the practice field and the western theory field. In recent years, the era of big data has witnessed a wave of innovations and changes and exerted a significant impact on the vertical integration of enterprises. Worldwide speaking, six large-scale mergers and acquisitions have appeared since the beginning of the 20th century, and vertical integration of enterprises first occurred in the second wave of mergers and acquisitions in 1920. Theoretically, economists represented by the new system, the economic school and the industrial organization school have studied this issue, formed a series of theoretical points and achieved fruitful results (Zheng, 2010). In other words, in the background of big data, the vertical integration of enterprises is facing unprecedented opportunities and challenges. The strategy of enterprise vertical integration can improve the market competitiveness of enterprises, boost the economic efficiency of enterprises and promote the development and the upgrade of the tertiary industry. Therefore, this paper constructs a theoretical model for the vertical integration of enterprises, analyzes the influence of vertical integration on the performance of enterprises, and puts forward corresponding suggestions on China’s economic efficiency promotion and vertical integration (Chen, 2010).

1.2 Research Objectives

The advent of big data age provides managers with a substantial amount of data. Enterprises need to extract effective data from an enormous quantity and various types of data to ensure the integrity and authenticity of the data, to remove data interference and noise and to facilitate enterprise management decision-making. Therefore, the main problem facing the vertical integration of enterprises and also the main purpose of this study is how to apply big data to observe the trend of the market economy, to make big data become the vane of enterprises, and to promote the healthy development of enterprises (Xu, 2010).

2. RELEVANT THEORETICAL RESEARCH

2.1 Content and Definition of Big Data
It is the internationally renowned McKinsey & Company that first anticipated the approaching of the big data era. Its company annual report point out that data is no longer a string of characters imagined by people, but factors of production that would have a significant impact on human life. In the future, adapting to the arrival of the big data era is an enormous challenge confronted by global companies (Zhao, 2007). And now, the era of big data has already approached. Big data is generally defined as a data collection whose scale exceeds the daily cognitive data collection, analysis, processing and storage capacity. The defined size is generally considered to conduct a comparative analysis from five aspects including data’s value degree, authenticity, category, processing speed and volume. It is indicated that big data is not a simple academic term, but a quantitative concept with comprehensive connotations (Lin, 2007).

2.2 Definition of Vertical Integration

Vertical integration refers to one type of jointly operated model where two or more production stages that can be technically separated are placed or concentrated under the unified ownership of an enterprise. Frankly speaking, if one producer participates in the production and the distribution stages of two or more products, it can be said that the producer embodies the management concept of vertical integration. Experts and scholars produce and propose this concept to focus on the interpretation of the comprehensive production process of products or services in the market, manufacturers and other relevant organizations, and thus to facilitate the producers to control the number of processing of a certain product at some or all stages such as production, packaging and distribution, thereby enhancing the sensitivity of the enterprise to changes in market demand and reducing the risk of production (Du, 2013).

2.3 Estimation Method of Vertical Integration

The measurement method of vertical integration of enterprises mainly include value-added value method, main and auxiliary classification method and input-output method. The input-output method is the most complicated, but its method is simple and data collection is easy. Therefore, this paper briefly introduces the input-output method (Zhang, 2013).

Assuming that an enterprise is made up of N industries and P firms, the ratio of product flow and total sales of various firms can be used to measure the vertical integration of an enterprise (VI).

\[ VI = \sum_{j=1}^{R} \sum_{k=1}^{R} \frac{X_{jk}}{X_j} \]  

(1)

X refers to the total sales of various manufacturers. \(X_{jk}\) represents the product flow from Manufacturer \(j\) to Manufacturer \(k\). Specifically, the total flow of products includes the flow generated by business cooperation. The higher the value of VI is, the higher the degree of vertical integration is.

\[ BVI = \sum_{k=1}^{R} \sum_{i=1}^{N} \frac{X_{jk}}{Y_j} \]  

(2)

BVI stands for the degree of backward integration. Refers to the ratio of the enterprise’s own payment and the industry’s total payment. \(X_j\) is the total flow output of Industry \(j\). A higher value of BVI indicates a higher degree of backward integration of the enterprise.

\[ FVI = \sum_{k=1}^{R} \sum_{i=1}^{N} \frac{X_{jk}}{Y_j} \]  

(3)

FVI refers to the degree of forward integration. Similar to backward integration measurement, it represents the ratio of product flow and total sales of industrial manufacturers. The higher the value of FVI is, the higher the degree of forward integration is.

Therefore, the vertical integration degree of enterprises can be effectively calculated on basis of the total market share of the value within the enterprise’s business scope constituting this industry, so as to provide a basis for improving the performance level of enterprises.
2.4 Calculation Model and System of Big Data

The calculation model of big data builds on different calculation characteristics and data characteristics of big data. It is a model and a high-level abstraction extracted from a variety of big data demands and computing problems, which effectively promotes the development of big data application and technology. Computational characteristics and data feature dimensions of big data processing include data processing type, data acquisition mode, data structure feature and iterative calculation (as demonstrated in Table 1). This paper employs the computing model and the system of big data to provide technical support for the model construction of enterprise vertical integration and to lay the foundation for the study on enterprise vertical integration (Tang and Xie, 2002).

Table 1 Computing patterns and systems of big data

<table>
<thead>
<tr>
<th>Big data computing model</th>
<th>Typical system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graph calculation</td>
<td>Pregel Spark Storm etc.</td>
</tr>
<tr>
<td>Memory computing</td>
<td>Hana Spark Dremeletc.</td>
</tr>
<tr>
<td>Iterative computation</td>
<td>HaLoop Spark Twisteretc.</td>
</tr>
<tr>
<td>Batch computing</td>
<td>Spark Hadoop etc.</td>
</tr>
</tbody>
</table>

3. THE IMPACT OF ENTERPRISES’ VERTICAL INTEGRATION ON ENTERPRISE PERFORMANCE UNDER THE BACKGROUND OF BIG DATA

3.1 The Initial Investment in Stable Investment Products

The arrival of big data age drives most enterprises to introduce a new business model of vertical integration so as to reinforce the supply stability of key investment products. The core issue of this production and operation model is whether enterprises will integrate the collection of raw materials of key investment products into the production and operation model of vertical integration. For example, if the raw materials of the key products of the enterprise originate from the upstream enterprises, as a consequence, this enterprise surely have an overly high dependence on upstream production. Once accidents occur to the raw materials supply of the upstream enterprises, the generated opportunity behaviors would delay the production period of enterprise products and damage the credibility of enterprises in less severe cases, and would cut off the production lifeline of enterprises and threaten the survival and development of enterprises in serious cases. Therefore, enterprises incorporate raw material collection into the vertical integration model, which is conducive to not only stabilizing the initial investment in key products and avoiding the supply risk of upstream enterprises, but also ensuring the daily production and operation of enterprises and improving the production efficiency (Li, 2016).

3.2 Improve Monopoly Power of the Market

In terms of the current big data age, stronger competitive advantages of an enterprise indicate stronger development abilities of the enterprise and stronger abilities to cope with complicated and varying digital situations in the future. Therefore, the significance of vertical integration business model is self-evident. Again, the collection process of raw materials is taken as an example. If the enterprise incorporate the collection process of raw materials into the vertical integration business model, consequently, enterprises will inevitably transform into the upstream enterprises of other enterprises. Assuming that a number of downstream enterprises have a large consumer demand for this material, a substantial amount of consumer demands will further enhance the monopolistic competitiveness of the enterprise, so that this enterprise has the pricing power of the industry concerning this raw material. Put in another way, the enterprise has the ability to price discrimination in the entire raw material acquisition market, and the direct result of price discrimination is enormous economic benefits. In addition, enterprises form monopoly advantages. At the same time, vertical integration business model is employed to internalize the external market and the relatively perfect operational mechanism in the enterprise is further applied, so as to avoid regional economic losses caused by the external market failure (Zhao, 2016).

3.3 Reduce the Transaction Costs of Enterprises

The organization forms of a transaction are divided into market and enterprise, and these two factors can be freely switched. Because in the process of transaction, enterprises will allocate the resources between the
organization costs of the open market and the transaction costs of the enterprises. In view of the statistical data volume, the enterprise’s transaction costs are low and the enterprise will choose to complete the transaction itself. If the organization costs of the open market are lower, enterprises will choose to trade in the market, and enterprises are no longer selected. However, it should be noted that, if an enterprise conducts a transaction for a proprietary product within the market, it means that the so-called transaction costs are generated due to the particularity of the product and the inapplicability to generic product transactions. Therefore, through the analysis and the study on statistical data, if the vertical integration business model is applied to replace the market transactions, the transaction costs of enterprises can be reduced; the internal management of enterprise transactions can be achieved; the versatility of proprietary products can be reinforced; a reasonable allocation of resources in the enterprise can be realized (Figure 1 illustrates the impact of vertical integration of enterprises on enterprise Performance).

![Figure 1. The Impact of Big Data Era on Enterprise Performance](image)

### 4. EMPIRICAL TEST OF ENTERPRISES’ VERTICAL INTEGRATION

#### 4.1 Research Hypothesis

The vertical integration of enterprises is to save the transaction costs of market transactions and to internalize downstream and upstream resources in the enterprises, thus stabilizing the price of raw materials, achieving the re-allocation of scarce resources, ensuring smooth channels of raw materials sales and supply and improving enterprises’ business performance. Therefore, in the context of big data, this paper puts forward the assumption that enterprise performance is positively correlated with enterprise’s vertical integration. In other words, the higher the integration degree of the related enterprises is, the stronger the profitability is.

#### 4.2 Selection and Design of Variables

4.2.1 Selection of Enterprise Performance Indexes

Enterprise performance evaluation includes two aspects: operators’ performance evaluation and enterprises’ management efficiency evaluation. Enterprises’ management efficiency is mainly represented as the growth ability of enterprises and the profitability of assets, which are financial indexes. The performance of the operators mainly reflects the contribution and the achievements made by the operators in the enterprise operation process for business development, which are non-financial indexes. Therefore, this paper adopts the development capability index and the profitability index to evaluate enterprise performance.

Development capacity index ($F_1$) refers to the continuously expanding potential by virtue of an enterprise’s operation. From the financial point of view, the development capacity index is the basic guarantee of corporate value maximization, but also an important factor to improve its profitability. Enterprise’s development capacity indexes can reflect the competitiveness of enterprises in the future development and the continuing capacity of the enterprises in the entire market competition. Therefore, this paper employs the enterprises’ year-on-year profit growth rate as the index that measures the enterprises’ development capability. Profitability index ($F_2$) represents the capability of enterprises to obtain revenue, which is mainly applied to reflect the relationship between business income and costs. The higher the costs employed by enterprises are, the less the earnings are,
which indicates a weaker profitability and stronger vice versa. However, the main purpose of vertical integration of enterprises is to elevate the profitability of enterprises and to save business transaction costs. Therefore, this article will adopt the profitability of enterprises as the development capacity index.

4.2.2 Design of Enterprise Performance Indexes

In the design of enterprise performance indexes, vertical integration index (VI) is usually selected to measure and study the degree of enterprise integration. This paper mainly adopts WES index (added value) to measure the degree of vertical integration of enterprises. The formula is as follows:

$$WES = \frac{\text{Value-added} - \text{Profit} + \text{Normal Profit}}{\text{Sales} - \text{Profit} + \text{Normal Profit}} \times 100\%$$

Specifically, net assets = total assets - total liabilities; added value = sales revenue - cost of sales.

Sales cost data and sales volume data are respectively selected from the main business cost and the main business income announced in the annual report of the enterprise. The average value of the return on net assets of the enterprise is the average yield. The net profit of the shareholders published in the annual report is net profit after tax.

4.3 Model Construction

4.3.1 Sample Descriptive Statistics

Descriptive statistics is the basis of a correct, comprehensive and accurate description of empirical analysis and is also the most commonly used method in empirical analysis if there is a deviation or an unclear description of a phenomenon or an event (Feng, 2014). The subsequent analysis is worthy of re-argument. Therefore, descriptive statistics is required for the data, thus finding the inherent laws of the data. The results are demonstrated in Table 2:

<table>
<thead>
<tr>
<th>variable</th>
<th>Number of observations</th>
<th>mean value</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_1$</td>
<td>130</td>
<td>13.33</td>
<td>8</td>
</tr>
<tr>
<td>$F_2$</td>
<td>130</td>
<td>44.32</td>
<td>112.3</td>
</tr>
<tr>
<td>VI</td>
<td>134</td>
<td>12.33</td>
<td>12</td>
</tr>
<tr>
<td>RDS</td>
<td>130</td>
<td>2.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Based on the above table, the standard deviation of the enterprise’s vertical integration index is 12. and the standard deviations of profit margin and the year-on-year profit growth rate are 8 and 112.3. These two values indicate that there exists a wide difference in the degree of vertical integration among enterprises and in the main business year-on-year profit growth rate and profit margin.

4.3.2 The Construction of a Regression Model

In this paper, a multiple linear regression model is constructed to investigate the vertical integration of enterprises. The generalized OLS is adopted to estimate the regression equation. The specific model is:

$$F_1 = A + bVI + \beta RDS + \varepsilon \quad (4)$$

$$F_2 = A + bVI + \beta RDS + \varepsilon \quad (5)$$

Formula (4) is the influence of the vertical integration of enterprises on the main business rate of the enterprises. Formula (5) refers to the influence of the vertical integration of enterprises on the year-on-year profit growth rate of the main business of enterprises. A is a constant term. $\varepsilon$ is a random error term. $b$ and $\beta$ are the parameters to be estimated.
4. EMPIRICAL RESULTS ANALYSIS TAKING IRON AND STEEL ENTERPRISES AS AN EXAMPLE UNDER THE BACKGROUND OF BIG DATA

4.1A Result Analysis on Vertical Integration Index of Iron and Steel Enterprises

The integration degree of listed companies can be analyzed through the above regression model. This paper investigates the vertical integration indexes of 20 listed iron and steel enterprises from 2010 to 2015 (as shown in Figure 2), analyzes and sorts out the data by means of the calculation model and system of big data (figure calculation, iterative calculation, loss calculation, big data query, analysis and calculation), and further analyzes the characteristics and the trends of the integration of China’s iron and steel enterprise (Liu, 2014).

![Figure 2. The trend of vertical integration of iron and steel enterprises](image)

According to the figure, the integration indexes of iron and steel enterprises from 2010 to 2015 fell first and climbed up later. The vertical integration index is the highest in 2010 and the lowest in 2012, then showing a gradual increase. The reasons for this situation include a relatively chaotic steel market in China, a drop in oil prices and higher enterprise costs from 2010 to 2012. After the year of 2012, these conditions have been improved. The costs of oil companies have been reduced; the supply of raw materials has been stabilized; the vertical integration of iron and steel enterprises has been intensified, so the vertical integration index has risen again (Mou, 2015).

4.2 Linear Regression Analysis of Vertical Integration of Iron and Steel Enterprises

By applying the calculation model of big data described above, the performance indexes (\(F_1\) and \(F_2\)) and the vertical integration index (VI) of enterprises are analyzed. The results are illustrated in Figure 3.

<table>
<thead>
<tr>
<th>variable</th>
<th>(F_1)</th>
<th>(F_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated value</td>
<td>standard deviation</td>
</tr>
<tr>
<td>A</td>
<td>4.71</td>
<td>0.68</td>
</tr>
<tr>
<td>VI</td>
<td>0.70</td>
<td>0.05</td>
</tr>
<tr>
<td>(R_2)</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>749.88</td>
<td></td>
</tr>
</tbody>
</table>

The table has showed that variables pass 1% significance level test and F test, which indicates that the explanatory variables have a strong ability to explain the dependent variable and that the vertical integration of steel enterprises produces a significant effect on enterprise performance. Furthermore, the estimation equation based on the big data calculation is as follows:

\[
F_1 = 4.71 + 0.7VI + \varepsilon
\]
\[ F_2 = -5.67 + 2.5VI + \varepsilon \quad (6) \]

The results have demonstrated that, with each additional unit of the steel industry’s vertical integration index, the profit growth rate of the enterpriserises by 2.5% and the profit of its main business increases by 0.7%. This result verifies the above assumption, indicating that the vertical integration of enterprises can significantly improve the performance of enterprises (Deng, 2004).

5. CONCLUDING REMARKS

Big data has become a symbol of the times, and network information technology has been gradually deep into all aspects of the enterprise vertical integration and brought challenges and opportunities to enterprise performance management (Li, 2013). Based on the calculation system and the model of big data, this paper establishes a vertical integration model for the enterprises, briefly analyzes the relationship between vertical integration indexes and enterprise performance, and finally proves that the vertical integration of enterprises has a significant impact on enterprise performance, directly or indirectly by means of technological innovation, market structure, transaction costs, production costs and other factors, thereby enhancing the profitability of enterprises and helping enterprises healthily progress in a competitive environment.

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