MODEL ON RANKING MANUFACTURERS OF THE NETWORK IN THE AUTOMOTIVE PRODUCING SUPPLY CHAIN

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ABSTRACT

In the automotive producing supply chain, there are many producers. Each plays a particular role in the process of manufacturing a complete product, a perfect car. It becomes crucial to determine which producer plays a more important role than the others and the rank of each producer in the chain. Then, from that point, the manager of the whole process is able know how to treat each of them in order to improve the quality of the produce and increase the interest of investors. The paper is going to model a basic automotive producing supply chain and to define the relative importance, or centrality, of a supplier in the whole supply chain network in automotive industry, and to understand how the most central suppliers to the production process behave differently. Based on the pagerank algorithm, we build a supplier-customer network matrix and computes the importance score of each company in a chain of the production process for a complete production in automotive industry.

Keywords: *graph theory; pagerank algorithm; automotive producing supply chain; the importance score; automobile industry.*

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MÔ HÌNH PHÂN HẠNG CÁC NHÀ SẢN XUẤT TRONG CHUỖI CUNG ỨNG CÁC SẢN PHẨM PHỤ TRỢ NGHÀNH CÔNG NGHIỆP Ô TÔ

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TÓM TẮT

Trong chuỗi cung ứng các sản phẩm phụ trợ nghành công nghiệp ô tô, có rất nhiều nhà sản xuất. Mỗi nhà sản xuất giữ một vai trò nhất định của toàn bộ quá trình sản xuất một sản phẩm hoàn chỉnh, một chiếc xe hơi hoàn chỉnh. Việc xác định nhà sản xuất nào có vai trò quan trọng hơn so với các nhà sản xuất khác và thứ hạng của mỗi nhà sản xuất trong tổng thể chuỗi trở nên quan trọng. Từ đó, nhà điều hành toàn bộ quá trình sản xuất hoàn chỉnh có thể đưa ra được những chính sách và kế hoạch đối với mỗi nhà sản xuất một cách hợp lý nhằm cải tiến chất lượng sản phẩm hoàn chỉnh cũng như tăng lợi nhuận sản xuất. Trong bài báo này, tác giả sẽ đưa ra một mô hình cơ bản của một chuỗi sản xuất các sản phẩm công nghiệp phụ trợ cho nghành công nghiệp ô tô, đồng thời xác định vị trí của mỗi nhà cung ứng trong chuỗi, xác định những nhà cung ứng có tầm ảnh hưởng lớn thể hiện khác nhau ra sao. Dựa trên thuật toán pagerank, ta sẽ xây dựng ma trận mạng lưới các nhà cung ứng và tính toán chỉ số quan trọng của mỗi nhà sản xuất trong một chuỗi tổng thể.

Từ khóa: *lý thuyết đồ thị; thuật toán pagerank; chuỗi cung ứng sản phẩm phụ trợ nghành sản xuất ô tô; điểm quan trọng; công nghiệp ô tô.*

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1. Introduction

We adapt the pagerank algorithm ([1], [2]) to the supply chain network of the automotive industry. We know that in the automotive production, there are a lot of component parts including the mechanical ones, electrical ones, and so forth. So, one is difficult to say that their factory alone could build up a complete car. Each component part alone is needed to be made by a particular producer. And a producer can only take care a few components. Limit our view to one car trade mark, so each producer in a network of the component-part providers for that trade mark has naturally a particular position in the entire network. There are connections among producers. One producer may provide directly or indirectly their own taking-care products to another producer in the network. So, there is possible a link between one to another. Let consider each producer as a node in the network, and consider that the link between a provider and a customer is represented by a directed arrow with the tail started from the node of the provider and its head points into the node of the customer. Totally, we have naturally a directed graph in the network, called a supply chain. The most important producer is one obtained the maximum numbers of valuable links to it. By "valuable links" we mean that those links are rooted from nodes which possesses more links than other. This observation suggest us the existence of a quantity indicating how important a certain node are in the whole chain. We then call that quantity the importance score. We now can describe that the most important producer is one who obtained the most important votes from other representatives. And from that point we can somehow see the connection between the automotive producing supply chain and the pagerank algorithm which appears at the glance in order for helping the problem of ranking webpages in a network as introduced by the founder of Google searching engine. Also from that criterion to determine the most important producer, we did distinguish the important producer and the producer whose the provided productions are very complicated. Because, for the latter, the producer is simply obtain a large numbers of votes from less valuable nodes. Find the most important producer is valuable in the sense that if an investor would wish to start his own business in building a car trade mark, the most important producer would suggest his how to use his money correctly and appropriately. Moreover, far from what we expected, we can also estimate the importance score of any node in the network. This is a simple implication from what we would harvest after using the pagerank algorithm. Then, all the producers are ranked on the basis of the importance score. Now, to start the construction of the ranking model for such supply chain, we are going to define the link matrix of the supply chain [3].

2. Construction of the link matrix

Consider the supply chain consisting of N producers. One producer connects to some others in the chain to create a directed graph. The link matrix $A = (a_{ij})_{1 \le i,j \le N}$ of the supply chain is defined as follows:

$$a_{ij} = \begin{cases} \dfrac{1}{L(j)}, & \text{if node j votes for node i,} \\ \dfrac{1}{N}, & \text{if node j has no outgoing link,} \\ 0, & \text{otherwise,} \end{cases}$$

where $L(j)$ is the number of the out-going links of node j.

Now, the constructed matrix A is a column-stochastic. It has the eigenspace of the eigenvalue 1 with dimension 1. If we normalize an eigenvector of this vector space, we get only one eigenvector whose all components are positive. And we can use this vector with its corresponding positive component as the importance score for the

corresponding node [3]. The positivity of all components is rooted from the fact that all entries of A are non-negative. Another issue could arrive when the directed graph is reducible ([3],[5]). Page and Brin presented a concept of weighted matrix to dial with this problem. This matrix is defined as

$$\boldsymbol{M} = dA + \frac{1-d}{N}\begin{bmatrix} 1 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ 1 & \cdots & 1 \end{bmatrix},$$

Where d is between 0 and 1. The constant d is called the *damping factor*. A favorite value of d introduced by Google is 0.85 ([2], [3], [4], [5]).

3. Model on ranking an automotive producing supply chain

In the chain of companies manufacturing accessories to make a complete car, we want to calculate the relative importance of the companies in that production chain.

Assumption: Having 25 companies in supply chain to manufacture main parts of a car, the companies corporate together to make a complete car. Each company is denoted by name of their products and labelled by a corresponding index number.

An arrow from company **A** to company **B** means that company **A** corporates with company **B.** The relationship between companies in the chain is just relative relationship. In reality, the corporate relationship between them is much complicated. Figure 2 shows the diagram of car parts producing company in supply chain. The calculation of the importance score is implemented in 3 steps as shown below.

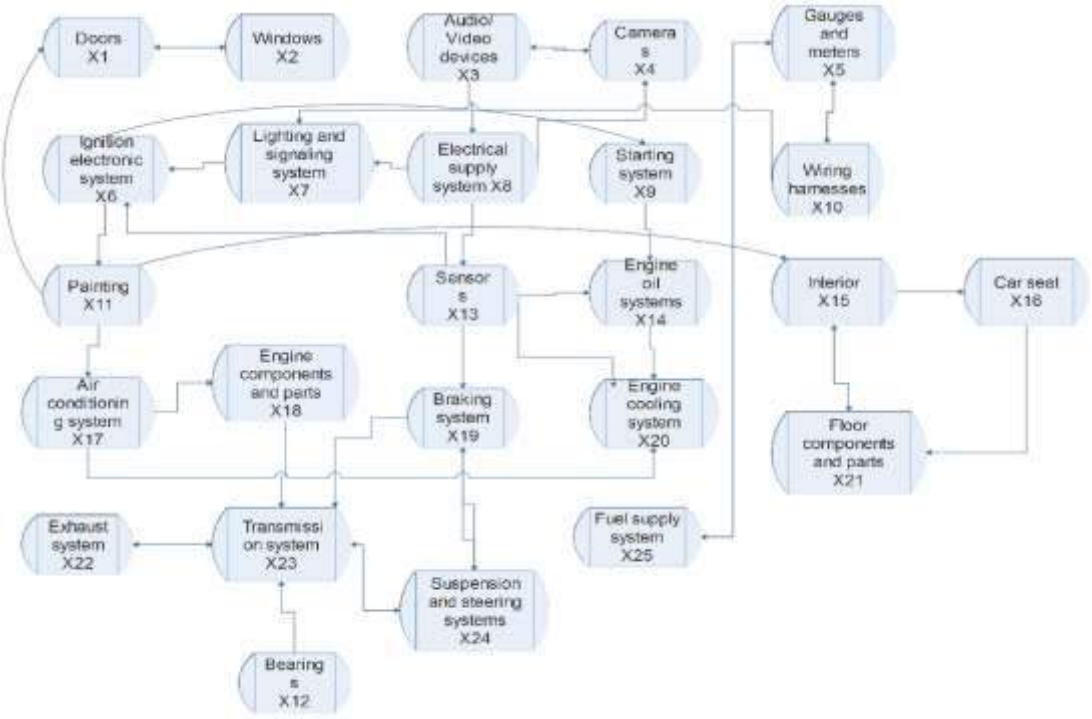

Figure 1. *Diagram of car parts producing company in supply chain.*

4. The calculation of the importance score

The calculation process is divided into 3 steps as follows.

Step 1: The Input Table containing the index numbers (IDs) and LABEL of each node (stands for each company) is depicted in Table 1.

Table 1. *The index numbers (IDs) and LABEL of each node (stands for each company)*

ID	Label	ID	Label
1	Doors	13	Sensors
2	Windows	14	Engine oil systems
3	Audio/Video devices	15	Interior
4	Cameras	16	Car seat
5	Gauges and meters	17	Air conditioning system
6	Ignition electronic system	18	Engine components and parts
7	Lighting and signaling system	19	Braking system
8	Electrical supply system	20	Engine cooling system
9	Starting system	21	Floor components and parts
10	Wiring harnesses	22	Exhaust system
11	Painting	23	Transmission system
12	Bearings	24	Suspension and steering systems
		25	Fuel supply system

Step 2: The Input Table representing the relationship between the nodes is presented in Table 2.

Table 2. *The relationship between the nodes*

Source ID	Target ID	Type	Source ID	Target ID	Type
1	2	Directed	12	23	Directed
2	1	Directed	13	6	Directed
3	4	Directed	13	14	Directed
3	8	Directed	13	19	Directed
4	3	Directed	13	20	Directed
5	10	Directed	14	20	Directed
5	25	Directed	15	16	Directed
6	9	Directed	15	21	Directed
6	11	Directed	16	21	Directed
7	6	Directed	17	18	Directed
8	4	Directed	17	20	Directed
8	7	Directed	18	23	Directed
8	13	Directed	19	23	Directed
9	14	Directed	19	24	Directed
10	5	Directed	21	15	Directed
10	7	Directed	22	23	Directed
11	1	Directed	23	22	Directed
11	15	Directed	23	24	Directed
11	17	Directed	24	23	Directed
			25	5	Directed

Step 3. The Result

Applying the pagerank algorithm, we can evaluate the relative importance score of companies in supply chain network. The result is shown as in Table 3.

Table 3. *The relative importance score of companies in supply chain network*

Id	Label	Score	Id	Label	Score
23	Transmission system	0.160932	4	Cameras	0.024885
24	Suspension and steering systems	0.079897	10	Wiring harnesses	0.022704
22	Exhaust system	0.075639	25	Fuel supply system	0.022704
15	Interior	0.073408	7	Lighting and signaling system	0.022443
21	Floor components and parts	0.07122	9	Starting system	0.019664
1	Doors	0.068742	11	Painting	0.019664

(To be continued)

Table 3. *The relative importance score of companies in supply chain network (Continue)*

Id	Label	Score	Id	Label	Score
2	Windows	0.065723	8	Electrical supply system	0.019391
16	Car seat	0.038497	17	Air conditioning system	0.012871
20	Engine cooling system	0.03821	13	Sensors	0.012793
5	Gauges and meters	0.036247	18	Engine components and parts	0.012769
6	Ignition electronic system	0.029094	19	Braking system	0.010018
3	Audio/Video devices	0.028452	12	Bearings	0.007299
14	Engine oil systems	0.026732			

5. Conclusion

As shown in result table above in Step 3, we can see that the most important company in the car's parts producing supply chain network is the company which produces "Transmission system" product with highest importance score 0.160932, and least important company is the company which produces " Bearings". The Table below shows the importance score of companies in descending order of importance score.

6. Summary

The idea of analyzing the centrality of the supply-chain network is relatively new. The importance metrics can be based on how much it supplies to the customer and/or how unique and irreplaceable the supply is. The application of the pagerank algorithm to the problem of ranking producers in the network of the automotive producing supply chain enables us to score each producer in the whole chain, therefore, we know how to treat each producer well in the sense of investment. However, this does not mean we do not take care of ones which have low importance scores. We definitely wish to control the quality of the entire process of production. So, any component part of the complete product, the car, should be examined carefully. The model we constructed here obviously need to be extended to a larger one with any detail of component part in the real problem of the automobile industry. But the idea here could be use again to rank each producer.

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