Research on Supply Chain Collaboration of Auto Industry Engineering Based on BTO

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Abstract

BTO supply chain in the application of automobile industry is a trend in the future. But the effective implementation is still a problem. The paper expounds on the application and research status and the key problems of BTO production model in the auto industry. Through comparison between BTO supply chain and traditional “push” supply chain, the characteristics and operating conditions of BTO supply chain is concluded. In the end, BTO supply chain collaboration model in auto industry is established.

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1. Introduction about Research Status of BTO mode in Auto Industry

BTO has been concerned by each big carmaker in the world early since the 1990s, and DELL firstly got a huge success. However the application in automobile industry has just started. Although this concept has been raised for nearly 20 years, the effective implementation still faces many problems. According to the related foreign investigation, now approximately 2/3 of cars purchased by customers are provided directly from existing storage, and only 1/3 of cars are produced after manufacturers receiving customers’ orders. Customers generally need to wait for 6 to 7 weeks, which means OTD (Order to Delivery) is averagely 40 days. So there exists a huge gap compared with customers’ expectations of receiving their ordered products in 20 days. This is the biggest obstacle of further promoting of BTO development.

In theory, Europe has launched many studies on BTO mode of automobile industry, including ICDP, MVP, 3 DayCar. One of the most representative is the 3Daycar system (that is to say, OTD is 3 days) studied and put forward by lean enterprise research center of British Cardiff university business school, Bath university school of management, and nearly 20 automobile manufacturing enterprises. Gunasekaran A and others proposed that BTO supply chain could improve efficiency of delivery by requiring that manufactures and retailers shorten planning cycles and production time [1]. In China, professor ChenRongqiu who hosted the international natural science key project “Research on new technology and new methods of operation management based on time competition” is

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studying how to achieve zero time in the requirements of instant customization in the automobile industry [2]. Lin Yong and others studied about the problem of compressing delivery time from the perspective of supply chain, and put forward some solutions to shortening delivery time after studying the composition of supply chain response cycle [3].

Throughout the domestic and foreign scholars’ research on BTO supply chain model, there is still very big development space about how to shorten OTD, and truly achieve 100% BTO. This paper introduces the concept of community into supply chain, and proposes a supply chain collaboration model mainly aimed at the automobile industry striving to promote the development of BTO in the way of this model.

2. The Key Problems of BTO mode in Auto Industry

For the implementation of BTO, each role in supply chain has some doubts and difficulties to different extents. For manufacturers, the existing planning, manufacturing, purchasing, logistics and sales model all need to change, so they still doubt about its flexibility; For suppliers, customers own more choices, so the delivery time, frequency, cost and quality are highly demanded. That is a big challenge. After all, the problem is how to satisfy customers’ personalized requirements with a short enough OTD time at lower cost. Only this problem is solved, every enterprise in BTO supply chain can play a good role as well as being profitable.

At present, the reason that OTD time is generally longer can be attributed to the following points:

- **Long logistics cycle**

  According to the investigation and statistics of ICDP (International Car Distribution Programme), usually, 80% of the average 6 weeks during which customers order and get their new cars is spent on order processing, planning, production scheduling, waiting for transportation and other steps that don’t produce value, but the time really used for production and distribution is just shortly a few days. Therefore, it doesn’t help a lot only by shortening production cycle, and logistics cycle plays a critical role in the whole OTD time. Danghety also emphasized that for the whole supply chain response time compression, the effect brought by shortening production early period is much smaller than by compressing logistics early period.

- **Out-dated information system**

  DELL computer is known for its direct sale model, which is a typical BTO. Just as DELL can’t do without online ordering, the support of Internet is dispensable for OTD in auto industry. But now the information systems of different enterprises in supply chain don’t have been integrated, lack of united data management platform, and can’t achieve real-time, relaxed and seamless connection and transformation. At the same time, information can’t be well shared and transferred. What’s more, the flexibility and reliability of IT system are insufficient, which makes the rhythm of order processing, plan scheduling issued, transportation and distribution of parts and vehicles and other links of supply chain not synchronous and even leads to delay. So Internet and information system is the technical base of OTD shortening.

- **Lack-of-flexibility manufacturing system**

  Because customers’ sudden and multiple change will lead to repeated and instant modification and adjustment of production rules and plans, BTO mode puts forward higher request to manufacturing process. For example, the high flexibility of process, production, quantity and so on in order to cope with the change of the market. But now when operating BTO supply chain many enterprises are lack of good automatic order arrangement system and components and assembly plans can’t be unified, which usually results in incorrect and rigid production plan and a longer production planning cycle and production preparation time.

- **Weaker R&D ability of suppliers and manufacturers**

  Developing customizable product is the starting point of realizing BTO production model. It is impossible that the BOM of BTO production model remains constant long term, so it requires that suppliers and manufactures must improve their R&D ability, create new products suitable for BTO mode, and make rapid design change according to customers’ specific needs in order to quickly respond to customers’ demands.

3. Characteristics of BTO mode in Auto Industry

There are two kinds of supply chain operation models: push model and pull model. In push model, forecast and
inventory are the power of the whole supply chain. This model results in severe inventory hoarding problems. However, the driver of pull model comes from the end users, and thus it achieves customized service according to customers’ demands. In this model, integration of the whole supply chain is higher, and information is exchanged more accurately and quickly. BTO supply chain is essentially a pull model.

There are many differences between BTO supply chain model and push supply chain model, as is shown in table 1:

Table 1. Differences compared between BTO and push type supply chain model

<table>
<thead>
<tr>
<th>Items</th>
<th>Push supply chain</th>
<th>BTO supply chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Push type (driven by storage)</td>
<td>Pull type (driven by order)</td>
</tr>
<tr>
<td>Logistics</td>
<td>Large scale, no difference</td>
<td>Fast, reliability, collaboration, customization</td>
</tr>
<tr>
<td>Production</td>
<td>Concern about the stability of plan</td>
<td>Concern about the flexibility of production</td>
</tr>
<tr>
<td>Storage</td>
<td>Higher inventories</td>
<td>Lower inventories</td>
</tr>
<tr>
<td>Supply</td>
<td>Long lead time</td>
<td>Fast, real-time, collaboration</td>
</tr>
<tr>
<td>Management</td>
<td>Need inventory and safe stock</td>
<td>Strategic alliance, e-business</td>
</tr>
</tbody>
</table>

The good operation of BTO supply chain model requires the following external conditions:

- BTO system strongly depends on the intent integration of the whole supply chain, that is to say, suppliers, manufactures, and retailers establish a strategic cooperative partnership in the way of alliance [4]. This alliance requires information exchange and sharing, profit sharing, risk sharing, and the effective integration of enterprise culture, management concepts and other aspects. And it demands to form a complete set of credit system, make a perfect set of cooperation agreement, and reach a consensus among all enterprises.

- Manufactures’ downstream enterprises, namely channel members, especially retailers must possess the ability to forecast demands and take risks.

- The realization of BTO system must establish a set of standardized operation architecture. This standardized system requests suppliers, manufactures and retailers to conduct interactive business cooperation according to a common game rules including unified parts system and supporting system, which can improve flexibility of choices and expand choice range of manufactures.

4. Establishment of BTO Supply Chain Collaboration Model in Auto Industry

The concept of community, in western traditional ideas, was firstly proposed by Aristotle. Aristotle pointed out that a single man’s wellbeing couldn’t be separated from the community’s wellbeing, everyone lived in a community, and the common pursue for common wellbeing helped people obtain corresponding interests. In recent years, with the development of globalization and the increasingly convenient communication and transportation, the concept of learning community, scientific community, intellectual community, practice community and legal profession community are proposed. And the remarkable characteristics of these communities are that all members of the community are committed to solve a set of questions with common language, common knowledge, common ideal and target, and through continuous interaction and development they reach the individual and overall benefit maximization. The key point and goal of supply chain collaboration are similar with it, so based on all the above aspects of analysis, the paper introduces the concept of community into supply chain, and establishes the BTO supply chain collaboration model in auto industry, as the figure 1 shows:
4.1. Establishment of supplier community

Supplier community is established into parts suppliers of the auto industry, striving to transform suppliers from competitors to the collaborative win-win group. The group has the common goal: through collaborative cooperation, they can satisfy all the manufactures’ demands for purchasing with high quality and efficiency; the common trust mechanism: each supplier is no longer isolated, and they come to an agreement, trust each other, develop together and achieve win-win at last; the common standard: the product coding and deal process and other information should have unified standards in order to eliminate communication barriers.

Due to the suppliers and the purchasers belonging to many-to-many relationships, so the scope of the community must be in a region (national or even global) of auto industry parts suppliers, aiming not only to a few suppliers of one supply chain, but to multilayer supply chain network of the whole auto industry. Meanwhile, this community should be open enough to allow new parts suppliers to join in, and constantly expand the scope of cooperation and coordination, and eventually makes the whole parts supply resource properly distributed, and achieves the optimal allocation of social resources.

The core leadership of the community management consists of the representatives of each big supplier, and they constitute a supplier association to manage coordination of community members, and supervise and evaluate their performance. For each supplier, there may be many unexpected situations which result in not on-time delivery, for instance, the emergency orders of manufactures, the supply delay of raw materials suppliers, and employee strike etc, which not only affect the continuous production, but also have a negative effect on the suppliers’ credibility. While probably other suppliers may own available and idle equipments and personnel, then the orders can be transferred and distributed to the suppliers with surplus production ability by community management association. This would raise utilization efficiency of the entire supply resource.

It needs to take advantage of information technology means to establish a uniform platform for dealing with the internal things of community. The platform is open to all suppliers and at any time can adapt to information processing when new suppliers join in, and can provide common external interface seamlessly connected with basic business systems of all suppliers, mainly the production system, and the third-party information service platform management system. Through the supplier community platform, manufactures can bargain price, confirm the candidate supplier, and after all aspects of comparison choose a supplier, sign a contract and issue order in the end. With the platform, suppliers also can avoid to login different platforms of every manufactures to track new order information every day. They just need to enter this platform to see all orders requested by all manufactures and can realize unified preparation of goods and management, greatly reducing the workload.
4.2. Establishment of customer and distributor community

Customers and distributors are always in the relationship of game playing, during which although one side may gain more interests than the other, both suffer losses to some extent. So the paper establishes the customer and distributor community to seek one kind of idea of cooperation among distributors and win-win between customers and distributors in order to obtain respective maximum benefit.

The scope of the community is the downstream of auto industry supply chain network. The representatives of distributors of different brands and the representatives of customers of different groups (or the representatives of consumers’ association) make up the core of leadership. The leadership needs to build a trust mechanism, coordinate the sharing of marketing channels and facilities among distributors, solve disputes of members, and stand up for consumers’ interests while guarantee distributors’ profits.

The technical support for the customer and distributor community’ operation is to build a common information technology platform. This platform integrates release and publicity of product information and provides customers a fixed trading place. By means of this platform, customers can have a whole good knowledge of all kinds of products and no longer have to spend much effort in searching all the different network platforms. Besides that, they can compare, consult and bargain prices with distributors and make an order. The distributors of the community can use the platform to conduct a comprehensive understanding and analysis of customers’ demands information and make more accurate forecasts about the whole market, and also can handle the orders more rapidly and efficiently.

4.3. Establishment of the third-party network public service platform

The third-party service platform is a public network intermediary built for the whole auto industry and can provide supply chain management, coordination, monitoring, evaluation and other related technology and information service for the most enterprises. It is also a trading place operating in the virtual Internet environments and gathering all the members of supply chain. The platform is managed and maintained by the third-party group made up of the experts of auto industry or representatives of a few big manufactures and the providers of network information service technology.

The supplier community platform, customer and distributor community platform and the heterogeneous systems of manufactures all can share information and exchange data with the third-party public service platform through Internet, so the platform is the bond linking manufactures, suppliers, distributors, and customers. The customer and distributor community transfers demand information and sales figures to the platform, and at the same time the platform passes the customized products state information to the platform of customer and distributor community in time. In one functional module of this platform, customers can refer the production status and expected deliveries at any time, so that order information is transparent to customers and keep them well informed. Besides those, manufactures can also propagate their forthcoming new products in advance. Meanwhile, suppliers no longer need to get the demand information through manufactures but just by this platform they can know more quickly, prepare parts production earlier, and then improve the strain capacity to market changes.

The third-party network public service platform not only plays the role of the bridge, but the most importantly, the experts group can use professional optimization tools to integrate and match the resource of the whole supply chain, and make the social resource reach the utilization maximization, avoiding waste. Meanwhile, the platform can provide technical support and management consulting for each enterprise, and record and evaluate the operating performance of the supply chain [5]. Of course, details of optimizing and integrating technology and assessment method are needed further study.

5. An analysis of Advantages of BTO Supply Chain Collaboration Model in Auto Industry

5.1. The third-party network public service platform makes the information and resources of supply chain in auto industry to reach optimal allocation and utilization.

The supply chain model based on the core enterprise, usually the car manufactures in auto industry, manage and coordinate the whole supply chain through exclusive management system and Internet, but this model has some shortcomings, for example: because this model is mainly in the service of the core enterprise and its upstream and downstream enterprises and customers, it can realize efficient cooperation and information sharing only in some
parts of supply chain, unable to promote lateral extension of the supply chain, thus, the coverage is narrow; In this model, information transfers with supply chain step by step, so it is easy to produce time delay and bullwhip effect, unable to realize the rapid and exact response.

The third-party network public service platform not only provides supply and demand information and electronic trading and other functions, but also can monitor and manage the supply chain network of the whole industry by seamless link with information system of each node of enterprise, and free the manufactures from the burden as the core enterprise. It not only reduces the bullwhip effect, achieves agile response but also helps business process reengineering of supply chain. At the same time, the credit mechanism of the platform can effectively reduce conflict and risk of trading, and give each partner the sense of fair and safety.

5.2. The third party logistics makes supply of raw materials and parts and delivery of vehicles operate in a high efficiency.

The model logistics need an efficient operation center with unified management, large scale operation, strong ability of control and coordination, high-level comprehensive technology, all kinds of effective business strategies. What’s more, due to parts of auto industry are more various and production processes are more complex, the supply chain model based on BTO puts forward higher requests. So all the automobile groups should consider using the existing large automobile logistics channels to reform the logistics facilities, integrate functions and resources, and build the virtual net of automobile logistics collaborative distribution on the national scale. It can maintain the relatively independent third party logistics center within each automobile group, as well as sharing logistics resources on a larger range which can solve all aspects of disadvantages of automobile logistics.

5.3. The establishment of community transforms each enterprise from competition and game to cooperation and win-win. And promote the overall profit of the whole supply chain community to increase

Strategy community is a kind of collaborative relationship across the organizations, and it can provide solutions to management dilemma for all the community members. The members of the organization cooperate to form and carry out a specific business idea, and create new needs, markets, technology and knowledge. The community is a gradually expanding form of organization, as shown in figure 1. There are suppliers community, suppliers and manufactures community, distributors and customers community, distributors and manufactures community and the whole supply chain enterprises community etc.

In all community whether in the small scope or on a large scale, the overall profits of every community follow the law $1+1>2$, and with the expansion of the scope of community level by level, the profit will increase in multiples. The following text has made some proof by establishing a mathematical model.

We assume that $P_1$ represents the price of materials or parts that suppliers sell to manufacturers, here we settle accounts when every vehicle is off line, and it is suppliers’ decision variable; $P_2$ represents the trade price of vehicles manufactures sell to distributors, and it is manufactures’ decision variable; $P_3$ represents the increased price based on $P_2$ by distributors, and it is distributors’ decision variable. $C_i$ represents the cost of materials or parts produced by suppliers; $C_2$ represents the manufacturing cost per vehicle paid by manufacturers; $C_3$ represents the cost of sales per vehicle paid by distributors. In this paper, we assume $C_1, C_2$ and $C_3$ are constants. $F_1, F_2$ and $F_3$ are respectively profit functions of suppliers, manufacturers, and distributors; $F$ represents the total profit function of the whole supply chain community. $Q$ is market demand.

The model is assumed in imperfect competition market, and distributors lead price. Demand function expression transforms to $Q=a-b\cdot(P_2+P_3)$

So profit function is as following:

Suppliers: $F_1=Q\cdot(P_1-C_1)$
Manufacturers: $F_2=Q\cdot(P_2-P_1-C_2)$
Suppliers: $F_3=Q\cdot(P_3-C_3)$

The whole supply chain: $F=F_1+F_2+F_3=Q\cdot(P_2+P_3-C_1-C_2-C_3)$

According to game theory, suppliers, manufacturers and distributors reach balance by price adjustment. Without considering optimisation of the whole supply chain, three communities each pursue their respective maximizing profit, so it must satisfy the conditions: $F_1|_{P_1}=0; F_2|_{P_2}=0; F_3|_{P_2}=0.$
After calculating, I get the following results:

\[ Q = \frac{(a-bC_1 - bC_2 - bC_3)}{4} \]

\[ F_1 = \frac{(a-bC_1 - bC_2 - bC_3)^2}{16b} \]

\[ F_2 = \frac{(a-bC_1 - bC_2 - bC_3)}{8b} \]

\[ F_3 = \frac{(a-bC_1 - bC_2 - bC_3)^2}{16b} \]

\[ F = F_1 + F_2 + F_3 = \frac{(a-bC_1 - bC_2 - bC_3)}{8b} \]

When all suppliers, manufacturers and distributors agree on the same target, and pursue the benefit maximization of the whole supply chain strategy community, from the overall profit function, we can get:

\[ F' = 5 \frac{(a-bC_1 - bC_2 - bC_3)}{4b} \]

Obviously, compared between \( F \) and \( F' \), we can easily find that the overall profit increases:

\[ F'' = F' - F = \frac{(a-bC_1 - bC_2 - bC_3)}{8b} > 0 \]

About the profit distribution in the community, we take the risk and benefit symmetry principle first, which is to say that inputing costs and making a profit should be proportional:

The total costs of suppliers: \( C_1' = \frac{C_1}{C_1 + C_2 + C_3} \cdot \frac{F}{4b} \)

The total costs of manufacturers: \( C_2' = \frac{C_2}{C_1 + C_2 + C_3} \cdot \frac{F}{4b} \)

The total costs of distributors: \( C_3' = \frac{C_3}{C_1 + C_2 + C_3} \cdot \frac{F}{4b} \)

Therefore, under the principle of risk compensation, the profits distribution is shown as the following:

The profits of suppliers: \( F_1' = \frac{(a-bC_1 - bC_2 - bC_3)}{4b} \)

The profits of manufacturers: \( F_2' = \frac{(a-bC_1 - bC_2 - bC_3)}{4b} \)

The profits of distributors: \( F_3' = \frac{(a-bC_1 - bC_2 - bC_3)}{4b} \)

6. Conclusions

This article brings suppliers community, customer and distributor community into supply chain, and establishes BTO supply chain collaboration model in auto engineering industry, which provides a solution for further promoting the development of BTO supply chain. The core ideas of the model is to advocate collaboration and win-win, and establish communities of different levels in the entire supply chain network in pursuit of optimized allocation and efficient utilization. This model may also promote change dramatically for the whole manufacturing engineering.

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