Information Structure of Buyer-Seller Relationship in the Automotive Industry and Consumer Electronics Industry – Empirical and Logical Study –

WORK IN PROGRESS

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Abstract

The authors surveyed the automotive and consumer electronics industries in North America and Japan between 1997 and 2001, and report that assembly manufacturers in these industries placed orders in week N-2 for production in week N. However, the order is supported by the 12-week rolling forecast, and more especially by the 4-week forecast, which is sent in month N-1 for the production of month N. A Japanese U.S.-based automotive manufacturer sends the 4-week forecast to Tier 1, which also supply the top three American automotive manufacturers. The 4-week forecast is useful for Tiers 1 and 2 if replenishment-based production based on this forecast is to be realised with a high degree of precision. The 12-week forecast is also rolled in the consumer electronics industry, particularly by notebook computer assembly manufacturers, and by Tier 1, particularly semi-conductor manufacturers. However, the 4- week forecast is not used in this industry: VMI is used instead. This is why demand fluctuates seriously, which is a disadvantage for Tier 1.

Introduction

The authors surveyed the automotive and consumer electronics industries in North America and Japan between 1997 and 2001, and discuss two findings. 1. The following assembly manufacturers have realised the ordering for production for week N in week N-2: U.S. automotive assembly manufacturers, Japanese U.S.-based automotive assembly manufacturers, Japanese Japan-based automotive assembly manufacturers, and Japanese consumer electronics manufacturers, which include domestic electric appliances manufacturers and notebook computer assembly manufacturers. 2. Vendor Managed Inventory (VMI) is not as important as the forecasting process which leads to VMI. In the manufacturer where VMI used, the 4-week forecast is not used probably because the degree of precision for 4-week forecast is reduced. How can Tiers 1 and 2 (which supply the customer with their VMI) organise their production to reduce the disadvantage of VMI?

Survey

The authors visited the following companies during the years shown in brackets:
(1) The top two automotive Japanese Japan-based manufacturers (2000); three Tier 1 manufacturers, which supply these two with parts (between 1997 and 2000); three Tier 2 manufacturers, which supply Tier 1 with parts (1998 and 1999); two Tier 3 manufacturers (1998). In addition, a Japanese North America-based automotive

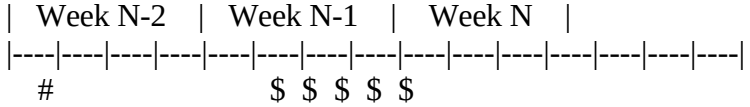
manufacturing company accepted the authors in September, 2000, arranging a personal interview survey and factory tours, which gave an insight in connection with the first point of discussion.
(2) The top three Japanese iron & steel manufacturers (1994 and again in 1996), which supply the automotive and domestic electric appliances manufacturers.
(3) The top four Japanese domestic electric appliances manufacturers, including washing machine manufacturers, (1993 and 1994 and one of them twice in 1997); two Tier 1 manufacturers (1997), which supply one of the washing machine manufacturers with parts.
(4) One of the top three personal computer manufacturers (1994); another one of the top three (1997 and 2001); four Tier 1 manufacturers, which supply HDD, LCD, semi-conductors (1999); three Tier 2 manufacturers, which supply Tier 1 with the silicon wafer (2000), glass (1999), and ABS resin (1999).
(5) Five Japanese wholesalers, which include the top three wholesalers (sogo-shosha), which deal with steel for the automotive industry and semi-conductors for the consumer electronics industry. The authors also visited five automotive dealers (1999 and 2000); and three mass sale speciality stores (1993 and 1994), which deal with domestic electric washing machines, notebook computers and so on.

Discussion

Lead Time for Assembly Manufacture - Time between Ordering and Delivery

Bhaskaran(1998) and the authors' survey show that the top three American automotive manufacturers, and also a Japanese North America-based automotive manufacturer, all send orders for week N in week N-2 to Tier 1. Further, the Japanese North America-based manufacturer sends the 4-week forecast for the next month in the last 10 days the current month, which is useful for Tier 1 because of its high degree of precision [defined as (1 - |quantity planned - quantity realised| / quantity realised) * 100]. However, Tier 1 produces products twice a week for their customers: the above-mentioned American top three automotive manufacturers and the Japanese North America-based manufacturer. The authors understand this to mean that Tier 1 produces the same specification twice a week. I hope I interpreted this sentence correctly. The production plan provides the specification and quantity for week N in week N-2. This is also applicable to the consumer electronics industry, particularly, domestic electric washing machines, and notebook computers in Japan.
The top three American automotive manufacturers finalise their orders for week N in week N-2, specifying delivery for each workday in week N. As shown in Figure 1, the assembly manufacturer places an order with Tier 1 on Wednesday (marked as #) in week N-2 for each delivery in week N (marked as $).

Figure 1 Lead Time for Assembly Manufacture



From Ordering to Actual Production

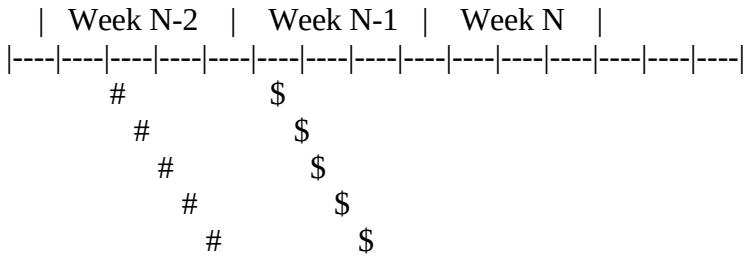
In week N-2, the Japanese Japan-based domestic electric washing machine manufacturer provides specifications and quantities to Tier 1 to deliver on each workday in week N, which gives the same lead time as the American top three and Japanese North America-based automotive manufacturers (as mentioned in the Section: “Lead Time for Assembly Manufacture - Time between Ordering and Delivery”). This

domestic electric washing machine manufacturer returned to the method just mentioned above in 1998. The company had previously changed to the following method: it sent an order to Tier 1 for the first day in week N 6 workdays before, i.e. the last day in week N-2. It sent the next order to Tier 1 for the second day in week N on the first day of week N-1. This washing machine assembly manufacturer returned to the old method because the degree of precision of the 1-month forecast was not reliable enough for Tier 1. However, Tier 1 is protected by the law because of its small capital stock, i.e. the assembly manufacturer is obliged to pay if the order is changed. Since 1998, Tier 1 has been able to produce products with a batch size of 1 week, half a week or less, because the assembly manufacturer specifies the delivery of specifications and quantities for each day in week N at the same time.

The top three American automotive manufacturers and the North America-based Japanese automotive manufacturer finalise their orders for week N in week N-2 by specifying delivery for each workday in week N. The assembly manufacturer places its order with Tier 1 on Wednesday in week N-2, as mentioned above. However, Japanese Japan-based automotive manufacturers do not finalise their orders for week N in week N-2 but accept changes in orders. The distribution may change orders 3, 4 or 5 days before the assembling of cars is finished, not in relation to the number of cars but in relation to specifications. After changing its production schedule based on changes in orders from the distribution, the top assembly manufacturer finalises its order with Tier 1 using Kanban. The upstream (i.e. the upstream processes in the assembly manufacturer and Tier 1) uses production for replenishment when it delivers the downstream process. Replenishment-based production can be realised in the following situations: (1) When the degree of precision is high; (2) When Tiers 1, 2 and 3 can smooth their production daily, both in the morning and in the afternoon, which the authors mean twice daily by.

As Figure 2 shows, another Japanese Japan-based automotive manufacturer sends orders every day (marked as #) to Tier 1 for one workday (marked as $) 6 days before. Tier 1 will produce parts over a period of 5 days, if possible. If Tier 1 cannot produce in 5 days, it will use the 12-week forecast, As described in the following Section: “From Tier 1 to Tier 2, and from Tier 2 to Tier 3 in the automotive industry”.

Figure 2 Lead Time for Assembly Manufacture, Another Example



From Tier 1 to Tier 2, and from Tier 2 to Tier 3 in the automotive industry

Tier 1, which has received orders for week N in week N-2, place orders with Tier 2 one or two days after. It takes Tier 1 one or two days to divide the number of its parts into components. As far as the order relationship between Tier 2 and Tier 3 is concerned, the 1-month or 4-week forecast (which will be described in the Section: “Forecast Supporting Orders”) is key. Tier 2 finalise the orders for month N with Tier 3 in month N-1, with daily delivery specified on the assumption that Tier 3 is small in capital stock. The most important point is that the degree of precision of the 1-month or 4-week forecast should be high.

We have an example of another process (see Figure 2), which can be called: "one day

production after 6 days ordered". Tier 1 receives the 4-week or 1-month forecast for month N in month N-1. It receives the forecast for week N in N-2. This 2-week forecast corresponds to the production period, which can be defined as the length of time needed by Tier 1 to produce a given batch of a single kind of manufactured products from input as materials to output as finished goods. The order, marked as # is placed for 1 workday of production, which is the day after 6 days and marked as $.
One day before Tier 1 receives an order placed by the assembly manufacturer (for example, on Friday, week N-2), it places its order with Tier 2 by instructing when Tier 2 should deliver the parts or components for its production. In turn, one day before Tier 2 receives the order placed by Tier 1 (for example, on Thursday, week N-2), Tier 2 places its order with Tier 3 by instructing when Tier 3 should deliver the parts or components for its production.
The most important point is again that the degree of precision of the 1-month or 4-week forecast should be high.

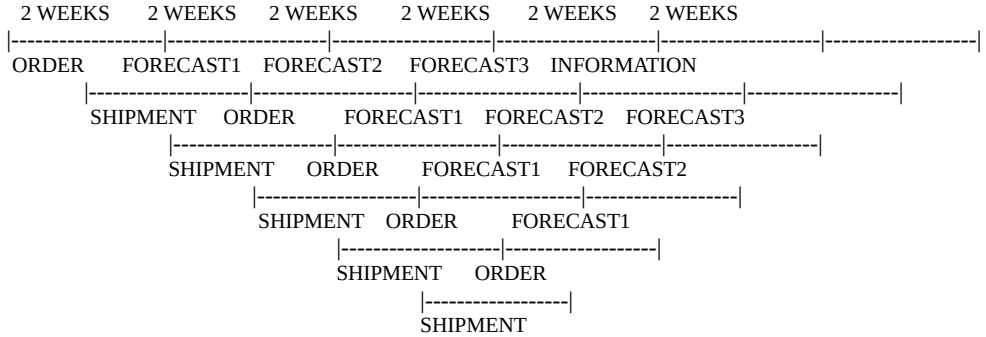
Assumed days to be in synchronisation, or conversely, days required for maintaining synchronisation

The authors have described the buyer-seller relationship of the top two Japan-based automotive manufacturers in the above paragraphs. However, we have a third example. Another Japan-based assembly manufacturer places an order for week N in week N-2, as do the top two automotive manufacturers. However, there is a contract between the assembly manufacturer and Tier 1. They agree the number of days to be in synchronisation, which can be defined as the days needed for Tier 1 to deliver the products to the customer, (i.e. the assembly manufacturer): for example, 3 days . If Tier 1 is a small-scale manufacturer, this number of assumed days to be in synchronisation contract favours Tier 1. However, if Tier 1 is a large-scale manufacturer, the customer can change specifications and quantities before 3 days, representing the number of days required for maintaining synchronisation. The authors visited a Tier 1 company in 1997, and found that automotive manufacturers other than the above-mentioned top two asked Tier 1 to deliver with some assumed days required for maintaining sychronisation.
The same system of synchronisation mentioned above is used by a notebook computer manufacturer. Before the middle of 1997, a notebook computer assembly manufacturer placed orders with each Tier 1 supplier based on the lead time agreed in each case. At that time, the number of assumed days required for maintaining synchronisation was 4 weeks for semi-conductors and related parts, whereas it was two weeks for parts or components other than semi-conductors and related parts. The authors suppose that this two week period meant that the assembly manufacturer placed the orders for week N with Tier 1 in week N-2, which was the same as the automotive manufacturer and the domestic electric washing machine manufacturer. Tier 1 was obliged to deliver based on the orders changed in week N-2.
However, the assembly manufacturer had to pay for the parts which had been ordered for month N in month N-2 if the specification was customised. The LCD (Liquid Crystal Display) was an example of such a part: Its components, ordered in month N-3, were paid for if the specification was customised. The length of time from the production instruction to the end of production of the notebook computers was 8 to 10 days. The production instruction is accompanied by a check of process capacity, which is also accompanied by an instruction to start manufacture, i.e. start manufacture and a number of processes of manufacture.
Since then, the notebook computer assembly manufacturer has made the production plan for week N in week N-2, which is the same as in the automotive and domestic electric washing machine industries. However, days required for maintaining synchronisation are still assumed. The number of assumed days was the same, 3 days,

as for the domestic electric washing machine industry. The figure of 3 days corresponds to the length of time from the production instruction to the end of production of the notebook computers. As a result, the Figure 3 has become meaningful not only for the buyer, but also for the seller if it represents the length of time from the production instruction to the end of production in Tier 1. If it takes Tier 1 longer than 3 days, it will take one of two courses of action. 1. Tier 1 keeps work in progress in reserve, and uses it to finish the production in 3 days. The information-oriented Gantt chart is useful for this first way. 2. Tier 1 keeps finished goods stocks representing three days of production, which leads to VMI (Vendor Managed Inventory).
The information-oriented Gantt chart is also useful for this. These two courses of action will be described in more detail later.

Forecast Supporting Orders
The authors have stated that the 4-week or 1-month forecast for month N sent in month N-1 will be most important for Tier 1, although the 12-week forecast is common in the automotive, notebook computer and domestic elecric washing machine industries.
Bhaskaran (1998) states: "Every week, forecasts of weekly demand, up to a specified forecast horizon (the next 12 weeks at GM), are generated at the customer end of the supply chain and transmitted to the next tier (Tier 1) of suppliers". The authors interpret week N-2 TO mean the same as 'up to a specified forecast horizon'; and the manufacturer uses the word "rolling" to mean "every week, forecasts of weekly demand ... are generated". The authors do not know whether GM stresses on the 4-week forecast or not. However, we have an example in the Japanese Japan-based semi-conductor industry. One of two semi-conductor manufacturers, which the authors visited in 1994 (this was third visit for the authors), rolled an 8-week production plan every two weeks (Figure 3), based on the forecast plus information rolled by the customer (for example, notebook computer manufacturers).

Figure 3 Rolling Production Plan for A Semi-Conductor Manufacturer



Another semi-conductor manufacturer, which the authors visited in 2001 (this was 2nd visit) , rolled a 12-week production plan every 2 weeks. The authors asked if the interval of 2 weeks corresponds to the length of time needed for the assembly process. The respondent replied, however, that it takes 2 weeks to roll the production plan based on the 'Production, Sales and Inventory meeting'. In the case of this semi-conductor manufacturer, VMI has been required by the customer of its suppliers since 1999 at least. The manufacturer can change its customer for about 60 to 70 % of its products, which means the manufacturer sells 60 to 70 % of its products to new customers.
The production period has been reduced to the same as the example mentioned above although the diameter of the silicon wafer has increased from 5 inches (in 1994)(Honda & Seto 1996) to 8 inches (in 2001). (The authors would like to point out that the cycle of model change in the notebook computer industry is not as long as for the passenger

car and the domestic electric washing machine.)
As the authors described at the beginning of the Discussion section, a Japanese North America-based automotive manufacturer sends the 4-week forecast for the next month in the last 10 days of the current month, which is useful for Tier 1 because of its high degree of precision. This is applicable to another Japanese Japan-based automotive manufacturer, whose 4-week forecast is reliable because of its high degree of precision.
Further, as mentioned before, Tier 1 produced products twice a week for their customers: The top three American and Japanese North America-based automotive manufacturers. (Tier 1, which produced for the American top three, also produced for the Japanese North America-based manufacturer in 2000). The authors think Tier 1 would prefer to synchronise with the production of the customer using Kanban (which is described in the Section: “From Ordering to Actual Production”), or EDI (Electronic Data Interchange) based on the 4-week forecast for the next month if the degree of precision is high enough to be reliable for Tier 1, Tier 2 and Tier 3 (the relationship or stream between Tier 1 and Tier 2 and Tier 2 and Tier 3 is described in the Section: “From Tier 1 to Tier 2, and from Tier 2 to Tier 3 in the automotive industry”).
The degree of precision is concerned with quantity rather than specification because the method of production is replenishment-based. In the case of 'one day production after 6 days ordered' (which is described in Section: “From Tier 1 to Tier 2, and from Tier 2 to Tier 3 in the automotive industry”), Tier 1 receives orders which will not be changed for one workday. As a result, the method of production is not replenishment-based. The difference between the two methods will be described at the Conference.
The 8- week and 12- week forecasts are useful for the semi-conductor industry and the cold strip milled steel plate industry respectively. The authors will describe the 3-month or 12- week rolling forecast in detail at the Conference.

Vendor Managed Inventory (VMI)
DELL Corporation assembles personal computers based on the orders its customers have placed. It assembles using VMI to deliver the product to the customer in 2 days, whereas the Japanese Japan-based notebook computer manufacturer decides the production, regarding both specification and quantity, for weeks N and N+1 in week N-1 with VMI. It changes the production for week N+1 in week N, which is the same as the Japanese Japan-based top automotive manufacturer. (The latter decides each production for days N, N+1, N+2, N+3 and N+4 on N-5 and N-4 without VMI). The difference between the two is whether the demand fluctuates seriously or not.
As described in the Section: “Asssumed days to be in synchronisation or, conversely, days required for maintaining synchronization”, the number of assumed days required for maintaining synchronisation has been 3 since the middle of 1997. The figure of 3 days corresponds to the length of time from the production instruction to the end of production of the notebook computers. As a result, the manufacturer started to demand VMI from Tier 1. (Note that before that time, it placed orders with Tier 1 based on lead-time.) This will mean that the customer could realise VMI procurement by realising a shorter length of time from the production instruction to the end of production.
The authors would like to stress that Tiers 1 and 2 (the LCD manufacturer, for example, is Tier 1 and THE glass manufacturer, which supplies LCD manufacturer with glass, is Tier 2.) are disadvantaged when VMI is used. They present the information-oriented Gantt chart to assist the tiers in the following section.

Information-Oriented Gantt Chart
The information-oriented Gantt chart was developed in 1994 (Seto & Honda 1995) and completed in 1996 by the top Japanese iron and steel manufacturer. This company

concentrated on synchronising its cold strip milling process (by which cold strip milled steel plate for passenger cars was produced) with automotive manufacture in 1994, and extended this to the hot strip milling process in 1996.
If we focus on the cold strip milling process, the chart consists of the following three factors: batch size, increase or decrease in work in progress, and supply line. The supply line can be drawn (1) from the beginning of the cold strip milling process to the end of the production, and (2) from the end of the production (from the customer's starting process in production) to the beginning of the cold strip milling process. The degree of necessity of the term (2) depends on the fluctuation in the customer's production process. On the one hand, the production plan in the automotive manufacturers other than the top two often fluctuates. On the other hand, the number of specifications to be manufactured for the customers had been increasing up until 1994. The number of specifications ordered, and consequently to be manufactured at the iron and steel manufacturer, was calculated to be between 4,000 and 5,000 in Japan. The work is processed through 7 to 10 processes, from the beginning of the cold strip milling process to the end of the production via the annealing, the mending of disfigured surface and the oiling processes. The different combinations of 7 to 10 processes gives a total of 50 to 70. Time reduction from input to output is important, which should, however, be consistent with cost reduction. The information-oriented Gantt chart, as the authors call it, will be useful for other industries, such as the semi-conductor industry. Seto (1999) showed that the iron & steel industry was one of the three industries, the automotive, consumer electronics and it, which has been concentrating on synchronising its production with the customer's starting process of production since 1985, when data communication were deregulated in Japan.

Conclusion

If the manufacturers can proceed from ordering for week N in week N-2 to replenishment-based production synchronised with partners, or "one day production after 6 days ordering", this decision will be based on the high degree of precision of the 1-month or 4-week forecast. VMI is based on a low degree of precision of the 1-month or 4-week forecast, if this is the case. The information-oriented Gantt chart is a way to reduce the disadvantange for Tier 1.

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