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In Search of Archetypes of Supply Chain Systems

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Abstract: Supply Chain Systems (SCS) or Supply Chain Management (SCM) has been a hot issue in management, especially nowadays with the advent of information technologies. Since Forrester's model by System Dynamics in 1961, the issue still remains in industry. Some people associate SCS or SCM with software for supply problems. One big problem with the education is what materials or models instructors should use in the class. For example, some businessmen respond by saying "our situations or systems are different with your cases. It looks more complex and your models can hardly applied to our problems". We need to have some archetypes to show main phenomena related with SCS, which students should understand.

Essential Learning Points of Supply Chain Systems

In this paper we use Supply Chain Systems (SCS) to imply aspects of Supply Chain obeying to natural laws. Supply Chain Management (SCM) is used here to concern with managerial matters, subjective in nature based on assumptions by involved people.

Available literature on SCM for businessmen is mostly practical ones written by consultants. (For example, Gattorna 1995) They just mentions problems emerged in SCS companies are supposed to face, but not explaining well how the problems are generated. The aim of literature is to pick typical problems up, on which they can give consultations to the readers. On the other hand some works to generalize design of SCS appear. (New 1996, Fowler 1998). They, however, remain conceptual.

Main causal relationships focused in this paper, which are essential to understand SCS behaviors, is depicted in Figure 1. It starts with Supply Time. Supply chain problems stem from a fact that it takes time to supply to meet demand. If supply time (from taking actions to supply, such as issuing a production order to delivery to customer) is longer than customers' permissible waiting time, a source of supply chain problems is created. It means suppliers should start supply in advance of actual demand. If the permissible waiting time is zero, the supply time equals to the time suppliers should start supply earlier than the time of demand generation.

The supply time gap or delay defined as max [0, the supply time-the permissible waiting time], triggers supply failures such as over-inventory and stock-out by way of

replenishment rules. Replenishment rules are designed based on the supply time gap. The extent to which such problems give unfavorable effects on management performances is determined by abilities to design, plan & control activities and systems working during the delay as well as the uncertainty attached to the length of delay.

The delay is determined by how long it takes to meet demand by a supply capacity. The supply capacity is measured by the amount of supply per unit time. The supply per unit time is determined by the bottleneck capacity defined as the minimum capacity of all activities in the whole SCS process. Each activity is measured its capacity by throughput per unit time. The bottleneck capacity determines the delay, given a certain level of the supply requirement. Identification of the bottleneck capacity makes it possible to prepare provisions for the supply failures. (Goldratt 1992)

Replenishment rules can have influences on the emergence of the bottleneck. Actual flow of goods is controlled by replenishment rules. If one activity center makes orders smaller than theoretical bottleneck capacity, the minimum (physical) supply capacity per unit time, by forecasting too pessimistic demand, their orders create another bottleneck below than theoretical one. It invites more stock-out when actual demand is going up to the contrary of the estimated demand.

A case increasing the number of items supplied in one chain is worthy of another analysis if it involves interactions between items through common capacities such as production facilities, vehicles and assortment facilities. The case, however, is reduced to the bottleneck phenomenon because it reduces the supply per unit time by creating time for extra activities like assortment and consolidation.

The supply failures will have significant influences on future demands. Late delivery, for example, may weaken next demand. On the other hand punctual delivery increases trust of customers to invite another demand. Besides daily bottom line, future bottom line is also a main performance of SCS.

In SCS learning, the delay is a learning focus. It's essential to understand how the delay is determined and what the delay invokes. The bottleneck phenomena should be learned to know the determination of the delay. Relationships between the advanced supply commitment and the delay are keys to understand the effects of the delay on supply chain performances. These focuses give clues to extract archetypes of SCS learning. Factors like replenishment rules, multi-items and multi-echelons should be studied their effects in association with the learning points.

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Archetypes for Learning SCS

In this paper we propose 7 archetypes corresponding to factors having specific

effects on behaviors of SCS, which are described in Figure 1. Understanding each archetype brings about insights into behaviors of SCS of any structure. Key factors based on which archetypes are constructed are:

1) Time gap between demand and supply: This type shows only effects of the supply time on when and what volume students should start supplying. This features a relationship between the supply time or the supply time gap and the volume they should start to supply in advance of actual demand.
2) Uncertainty effects due to the supply time: If the supply time gets longer, their planning horizon extends. It's easy to invite big forecasting errors. Besides forecasting problems, however, this type aims to relate the length of supply planning horizon associated with the supply time gap with supply performances depending on demand characteristics. This archetype is designed to suggest various phenomena effected by involved uncertainties attached to the length of the supply time.
3) Time to deliver: This archetype tries to indicate how long it takes to deliver demanded amount to customers. The point is to calculate the supply time by knowing the required amount of delivery and the possible supply amount per unit time. Phenomena pointed by Theory of Constraints are examined here. (Goldratt 1992)
4) Replenishment rule: Well-known beer game is successful in teaching typical troubles in SCS with respect to replenishment rules. Increase of uncertainty brings about lots of effects influenced by replenishment rules imbedded in SCS. This type suggests possible problems with the rules. Just-in-Time system or Pull system concept should be checked in the archetype also.
5) Multi-items: When they supply plural items through a same SCS, the point is whether increasing of items leads to diseconomy of item or not. The diseconomy of item is associated with the longer supply time. The type is designed to indicate the effect of multi-items is similar to reducing the supply amount per unit time, due to the emergence of bottleneck, that is, reduction of available supply per unit time.
6) Flexibility of supply: This archetype describes transfers between supply chains. This effect releases the level of supply constraint and avoids over stock phenomena. This flexibility is not theoretically significant, but business people are interested in.
7) Demand-supply interaction: As famous People's Express model suggests, supply performance sometimes determines demand patterns. This causal relationship between supply and demand is a critical phase when evaluating supply chain's performances over time. This archetype conveys strategic meanings of SCM performances to management. The interaction factor between demand and supply is one of the most important relationships in SCM and deserves one archetype.

Roles of Archetypes in Designing, Planning and Control of SCS

The archetypes are devices like the X-ray equipment with which an orthopedic surgeon can examine clearly his patient. When observing actual SCS, learners can focus his lens of attention on specific part of the SCS with the archetypes. Even the SCS has a lengthy process with multi-echelons, they can ignore echelons to think only the supply time from a supply origin of the SCS to a particular stage of their interest like retail stores invoked by the first archetype, for example.

The archetypes can develop hypotheses on causes of some specific problems like too much inventory or frequent stock-out from learners. They can understand why too much stock-out is resulted by relevant archetypes to such phenomena. The archetypes suggest hypothetical reasons of specific problems of SCS. The hypotheses make them practice focused observation of their complex SCS. The learning by the archetypes gives opportunities to improve SCS step by step systematically.

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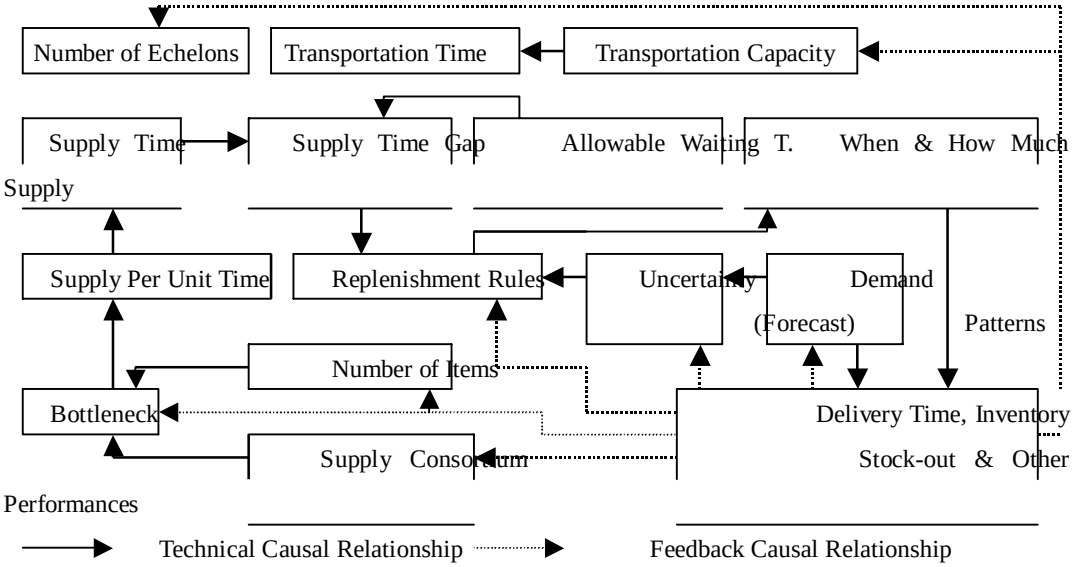
Figure 1 Main Causal Loops in Supply Chain Management



Note) Allowable Waiting T.: Allowable Waiting Time