

Delays in Construction Project Supply Chain

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Abstract. This paper analyzes the delays in construction project management through the methods and theories of supply chain management. At the beginning, it introduces the definition of various construction project supply chain and its differences with manufacturing supply chain. The definition of supply adapted to Chinese conditions is chosen, study scope which is network formed by the contractor, designer and client/owner and mainly includes the designing and constructing process is determined. Then the causes of delays in information flow, material flow and cash flow are analyzed. The negative effect is enlarged when the three sorts of delays interweave. Finally, the conclusion was gotten that a high efficiency running of construction project supply chain needs efforts of every participator.

Keywords: project management; supply chain; construction; delay

1. Introduction

Supply chain management is an advanced system management thought in the present management field, and it expands the competition among corporations into competition among supply chains. The competitiveness of corporations in the chain is improved through the strategy of cooperation, share and integration so as to get the win-win aim. Mostly, people attach their attention to the duration delay, but they don't think it over systematically according to the method and theory of supply chain management. In view of the nonrecurring quality of construction project, uniqueness of natural and the social environment, complexity of material and equipment, big and concentrated amount of investment and irreversibility of construction process, this paper analyzes the differences between construction supply chain and manufacturing supply chain and the necessity and probability of applying the supply chain management thought into construction industry. The supply chain of construction project not only includes the information delay in the process of design but also includes the material delay in the process of transportation. Both of them affect each other which reduce the efficiency of the whole supply chain. This paper tries to establish the general procedure of supply chain of construction project so as to do further research.

2. Construction Project Supply Chain

Great master in the field of system dynamics modeling, John Sterman, once pointed out as in [1] that there were five dynamic features of construction project: (1).Extremely complex. It is composed by many interdependent elements. (2).Highly dynamic. (3). Includes multiple feedback flow. (4). Includes non-linear relationship. (5). Includes "soft" and "hard" data. Those five dynamic features are the main causes of delay and all of them have relationship with supply chain. So, it is reasonable to use the supply chain theory to do qualitative analysis and quantitative analysis for the construction project delay[2].

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Different scholars give different definitions of construction project supply chain and they all think it over deeply. For example, Ruben thought that construction project supply chain refers to those processes which are before the construction material becomes terminal parts of building or other installations; it includes permanent and temporally supply chain. Permanent supply chain is independent of all kinds projects and the temporally supply chain is built for one special construction [2]. London, however, pointed out that construction project supply chain refers to the network, which is used to transfer value to customers, among core companies in the supply and need system [4].

Keesoo studied the construction project supply chain from the view of commission network of the construction;

TABLE I. Comparison between Construction Project Supply Chain and Manufacturing Industry Supply Chain

Construction Project Supply Chain	Manufacturing Industry Supply Chain
Supply chain of constructing according to orders	Supply chain of production according to market forecasting
Nonrecurring and non-replicated quality of construction project	Volume production and large-scale duplicate
All material is installed on the construction site	Different parts of production can be produced at different place
Suppliers are accepted through bidding	Suppliers are chosen through negotiation
The relation between supply and demand among companies in supply chain is temporary	The relation between supply and demand among companies in supply chain is a long term
The relatively independent task among companies leads to the division of supply chain	Customers only accept the terminal product and connect the companies closely
Long cycle, much uncertainty factors, hard to share information of construction production, and each company inclined to evade responsibility	Production term is fixed, plan is equable, information is easy to share, and long time cooperation makes companies easy to trust

the setting up of construction commission network is that contractor gives certain work to sub-contractor, and then contractor delivers the finished building to client/owner; this kind of description aiming at delivering likes the definition of manufacturing industry[3]. It is not reasonable to employ other industry's supply chain theory and method to the construction project, such as Table1, after comparing, we can see that the own characteristics of construction project makes itself different from other industry's supply chain.

Based on realizing those differences and considering the factors of current China construction industry operating mechanism and operability of supply chain management in construction industry, Wang Yaowu gave one narrow definition of construction supply chain. It is that construction supply chain refers to the construction network which centering on contractor and is composed by contractor, designer and client/owner and mainly includes the design and construction two core process [5]. Therefore, this paper will start discussion from the scope determined by this definition's "three parts and two processes".

3. Analysis on Construction Project Supply Chain Delays

Because the construction projects require certain construction duration, which is different from the situation of the manufacturing supply chain that products are made first, then buyer pay for them after seeing the products, and there is no delay in the process of getting product, which belongs to spot trading. When client/owner needs to buy a building, he can get it only after the designing and constructing process, which is a future trading. And it also involves other two participators. First, the designer make the drawing according to the information of natural information of the site, government planning, and client's/owner's intent, then, the contractors construct the building according to the drawing. The period from having construction planning to the delivery of the keys is client's/owner's waiting time, which is an inevitable delay of getting the building; however, the delay caused by uncertainty and unknown situation is time delay. Generally speaking, construction projects all contain certain uncertainty, and delay and time delay appear at the same time. So, the construction project supply chain is divided into information flow, material flow, capital flow and they are refers to different delay situations.

3.1 Three Delays of Construction Project Ssupply Chain

Surveying the whole process of designing and constructing of construction products form the aspect of supply chain, we can see that there are three delays, information flow delay, material flow delay, and capital

delays corresponding to the information flow, material flow and capital flow. The reasons of the three delays are different, which are summed up in the Table2.

As for information delay, information come form designers. In the process of construction project, drawing is definitely the summarizing of construction product information, and the detail level of description of drawing determines the accuracy of following construction and purchase of contractor. If the drawing is not clear because of all kind of reasons such as natural situation and unclear requiring function of client/owner, this will be the most direct information flow. Moreover, because the designers and construction are independent with each other, the workers’ incomplete understanding on the site to the meaning of designers is a distortion of information transfer. We can see that designing is the bridge and platform to communicate client/owner with contractor and drawing is the precondition of communication. Client/owner, designer, and contractor are independent with each other, and complementarities of information is not so good, lengthways information flow in each organization delays, level of outer transversal communication and coordinating is low, and it is hard to set up highly efficient information platform of whole process. Moreover, the frequent changing and compensation of project aggravate the low efficiency of supply chain.

As for material delay, in order to finish a construction project with full function, it is needed to purchase a series of material and equipment. As for material, the concrete, rebar, sand, locks, switches and wire are all needed. As for equipment, pumping appliance, pipe, ventilation, heating plant, air supply equipment, elevator, telecommunication equipment, and network equipment are all needed also, which involves special subcontracting and special designing. Besides, because of the restriction of construction site, many material and equipment are entering as the constructing.

TABLE II. Causes of Three Delays in Construction Project Supply Chain

	Information flow delay	Material flow delay	Capital flow delay	
Person Responsible	Designer	Contractor	Client/owner	
Flow direction	Takes design units as center, parallel flow	From market to contractor, form construction product, from low level to high level	From contractor to design units, contractor, from high level to low level	
Causes	Unknown natural conditions Design changing Distortion and noise of information transfer Low efficiency of information transfer Normal Plotting cycle	Underestimation about market, Market shortage, and deliver delay Information of ordering Material deficiency Capital deficiency	Outer causes	Capital Payment is slow Economic crisis policy changing
			Inner causes	Supplier (including designing units, contractors) can not supply on time and quality is not acceptable. Delay payment on purpose so as to get time value of money

Purchasing work is based on the time limit plan and project progress. Big equipments, such as elevator etc, are not suitable to be placed outdoor, so they enter only when the project progress get certain level. Contractors deliver goods through material flow; the process may meet material delay and is affected by weather and payment.

As for capital flow, capital comes from client/owner, and is paid to designer and contractor so as to get the drawing and building. Client/owner first has to pay according to contract. But, because construction project usually cost a lot of money and planning of paying affects greatly the capital flow of client/owner. If money is paid too early, client/owner can not exert pressure on the designer and contractor and the quality of drawing and building can not be ensured. If it is paid too little, delays or cannot be paid, the purchasing of lower reaches may be affected. The material and equipment can not be supplied on time which may affect the time limit of work, and that is the delay. The whole construction project’s regular operation is based on the fluent capital supply.

3.2 Superposition and Enlargement of Delays

In the Fig. 1, three different arrow lines refer to the information flow, material flow and capital flow, and they clearly show the direction of three flows in the client/owner, designer and contractor. Through this kind

of circulation, tripartite finish the two processes of construction project——designing and constructing, and produce the two different products of drawing and building. Watching them independently, we can find that information flow's circulation refers to the short broken line in Fig.1, and information delay refers to the circulation that designer deliver the drawing to contractor, contractor feedback the discrepancy of the drawing to the construction site, then designer revise the drawing according to the feedback and there is a circulation delay. In the other hand, when the client/owner's idea is transferred to designer, there is delay of converting the ideas into drawing. In the Fig. 1, the real line refers to material flow, because general contractor are the originator and integrators of all kinds of material, equipments, manpower and special subcontractors. So the model is simplified here, which only reflects the process of final delivery of building from contractor to client/owner. However, in reality, material flow only comes from the material and equipment supplier. Because the purchasing amount is very big, different supplier deliver goods from different place and to named place within set time according to general contractors' order. In this process, there are two delays which are ordering information delay and transporting delaying. Capital flow corresponds to the long dotted line. Client/owner is the provider of money which flowed to designer and general contractor. Capital delay is caused mainly by client/owner, since they can't provide the money on time and so all the work can not be developed ordinarily ,which is one of the inducement of other delays.

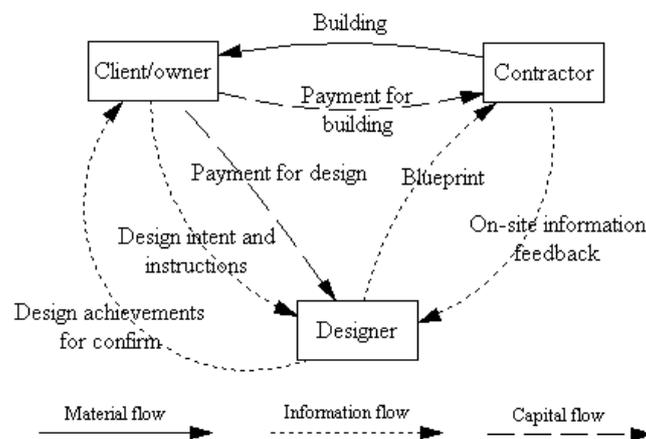


Fig 1: Three flows in three parts

Suppose the construction project is under ideal situation, and there is no delay. Propriety sent the information properly and designer can understand exactly and design, drawing can be delivered to contractor on time, contractor constructs exactly according to drawing, and client/owner pay on time, the purchasing of all material and equipment is very smooth, there is no working again because of poorly done work, and project is finished on time at last. No changing and uncertainty happen in the process. So the following supply chain formed by tripartite is needed to finish:

Give designing orders (client/owner) → design (designer) →confirm design and pay at the same time (client/owner) →accept drawing and begin construction (contractor) →pay the construction debt(client/owner) →deliver construction product(contractor) →receive (client/owner).

However, in the implementing process, the project is affected by a serious of factors from the national policy to the own adjustment of the project. It is full of uncertainty in the whole process. It has been found that the adjustment of the advancement and scope is a very common phenomenon even it is a very good construction project. And the root of producing is a response to all kinds of irregular changing, and all these changing will lead to the serial response of the supply chain of the construction project, it will convey certain delays to deal with the serial response. Information flow, material flow, and capital flow will not come up independently, and their relation is casual and interweaved. One delay may arouse one or two other delays, and even it may cause repeatedly circle, which may enlarge the affection of the delay. If correct quantity of material or module is correctly delivered on the correct place and it is promised and at last, proper advancement and quality of project meet the demands of client/owner, the affection of the delay in the supply chain will be reduced.

4. Conclusion

Different with the manufacturing supply chain, construction project supply chain has its own particularity. It is consisted by client/owner, contractor, and designer. Its existence is mainly for the finishing of drawing and building. There are three delays in this special supply chain: information delay, material delay and capital delay. The relation among three delays is a kind of interlacement which reduces operating efficiency of the whole supply chain.

So the success of a building project needs the joint effort of every part. In the early stage of the project, an information platform centered in the design should be developed and they should carefully prepare the project scheduling, identify the demand of the client/owner, make sure the genuine and reliability of the information which helps to transfer the information to the contractor and the sub-contractors. In the process of the project, the client/owner should ensure the promptness of the project funding so as to make sure the running of the material flow centered on the contractor. Only in this way, can they consign a satisfactory building to the client/owner and finish the efficient running of the supply chain from the beginning to the end.

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