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SIMULATION OF THE RESIDENTIAL LUMBER SUPPLY CHAIN

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ABSTRACT

This paper describes the lumber supply chain for a case study of a large homebuilder, extending through multiple tiers from the homebuyer to the lumber company. The builder required its framing subcontractor to accept the risk for lumber cost fluctuations. Under this agreement, the framing subcontractor provided a fixed lumber cost, which could only periodically adjusted. The lumber supply chain leading to the framing subcontractor was found to be of long and variable duration. The function of the builder-framer/lumber yard-lumber company portion of the supply chain was simulated in order to evaluate the cost effectiveness of this strategy, using historical records of lumber prices to model commodity price fluctuations. Based on the simulation results, the risk transfer strategy appears to induce a risk premium generally in excess of the true commodity price risk.

1 INTRODUCTION

The residential sector of the construction industry is often thought of as the closest counterpart to the general manufacturing setting of all the construction sectors. This is perhaps most true for high-volume builders, or those builders of large numbers of residential units each year. Such builders usually construct near-copies of a few models several times in a subdivision, typically at the rate of one to 5 or so per week.

The homebuilders themselves have moved to a model in which they self-perform little or none of the work. Instead, the process of building a home is broken into up to 200 different activities distributed among around 50 subcontractor organizations (Bashford et al. 2003). These subcontractors are typically contracted for by the subdivision, rather than by the unit, and so experience a relatively long-term relationship with the homebuilder by construction standards.

The supply chain which arises can thus be represented as shown in Figure 1, with materials and services flowing from right to left, and monetary compensation flowing

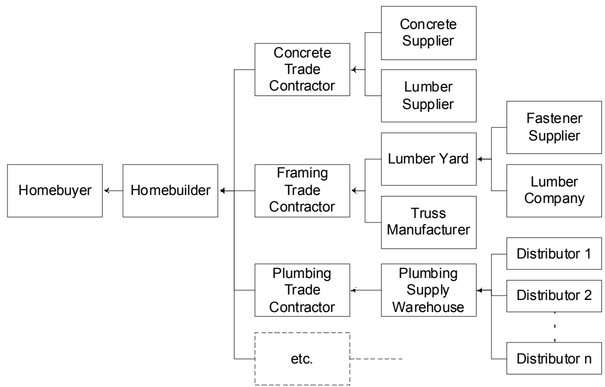

Figure 1: Schematic Depiction of Supply Chain for a Subdivision

from left to right. The homebuilder acts schedule, manage and coordinate the activities of the various subcontractors. The importance of the nature and function of the relationship between the homebuilder and its subcontractors has been presented previously by others (Dainty et al. 2001).

The largest expenditure for a single component of a typical wood-frame home goes to the lumber package. The lumber package includes all the dimension lumber used for construction of the platform frame, including exterior walls and interior partition walls, headers, floor joists, and all sheathing lumber. The roof system usually consists of a wood trusses which are prefabricated off site and lifted into place atop the platform frame. The framing trade contractor is generally tasked with installing the roof trusses, but may or may not be responsible for supplying the trusses themselves.

In this paper, the lumber supply chain for a subdivision was mapped and simulated. The lumber pricing policies of the homebuilder in this particular case were developed to reduce risks of price fluctuations. Therefore, the paper begins with a brief description of the supply chain and lumber pricing policies. The simulation model is presented, and interesting results are highlighted.

2 LUMBER SUPPLY CHAIN

Figure 1 shows the homebuyer atop a pyramid of subcontractors and suppliers, managed through the homebuilder, involved in the construction of a residential structure in the United States. The supply chain represented is of obvious and great complexity. The intention of the current study was to extract a supply chain for the lumber component, arguably the largest and most important single component of the home, and to evaluate how pricing strategies facilitate risk transfer in this supply chain.

The lumber supply chain was addressed in more detail for this purpose. A series of interviews was held with a major Phoenix-area homebuilder who agreed to provide access to details of pricing and contracting approaches for their lumber and framing supply process. The participants requested anonymity, but the builder is one of the largest in the Phoenix market, and its framing subcontractor is also a large volume company, framing several thousand residential units per year in the metropolitan area. The framing company has a wholly-owned subsidiary lumber yard, who is supplied by a major North American lumber company. The supply chain of interest, then, extended from the homebuilder to the framer/lumber yard to the lumber company. The homebuyer was left out of direct consideration, mostly because they do not directly participate in the process, but also because their buying and pricing concerns are not relevant to the lumber supply chain except indirectly.

Dramatic price fluctuations for lumber in the Phoenix market were experienced in 2001. At its peak, retail lumber prices increased nearly 60% over a few months, mostly in response to fears of changes in US government tariff policies for Canadian forest products. High-volume builders tend to build only to sales in the Phoenix market, and to have construction cycle times on the order of 6 to 8 months, with a fixed price agreed to with the buyer at the beginning of the process (Bashford et al. 2003)]. Accordingly, this lumber price increase was difficult for homebuilders to adjust to, and created fears of higher price fluctuations to come. Figure 2 represents the volatility in the lumber market, using the Lumber Cost Index (LCI) from Engineering News Record (ENR). The LCI is a compilation of prices for 13 sizes and grades of dimension lumber and sheathing products, and as such is representative of the residential lumber package. Lumber is a commodity item, with a traded futures market, and it is clear from the figure that significant fluctuations do occur over fairly short time periods in the lumber market. Interestingly, the trend over the last several years is generally downward, but the homebuilder developed a stable price strategy to guard against short term price increases. Statistical descriptors of the fluctuations over portions of this time period are presented in Table 1.

As previously indicated, the homebuilder required bidders for the subdivision of interest in this study to provide accept the risk of price changes over an extended time period. Specifically, the framing subcontractors invited to bid were asked to provide a price quote for lumber, and to hold their price at that quote for a period of at least 8 weeks. Any price changes for the lumber package required 4 weeks notice before they could be instituted, but in no case could a price be held less than 8 weeks. The framing subcontractor who ultimately won the project held a subsidiary lumber yard, which in turn obtained forest products from a lumber company. The lead time for lumber averaged about 8 weeks, but ranged from as little as 4 to as much as 14 weeks. Homes were to be built at a rate of about 1 per week based on projected sales. Once a sale was made, the framing subcontractor was notified and the price for the lumber packet was set at the current price, even though the home would not actually be ready for delivery of the lumber package for 8 weeks. Over these intervening weeks, the homebuilder would obtain permits and construct the slab-on-grade floor. Figure 3 summarizes the pricing structures and the material flows for the agreement.

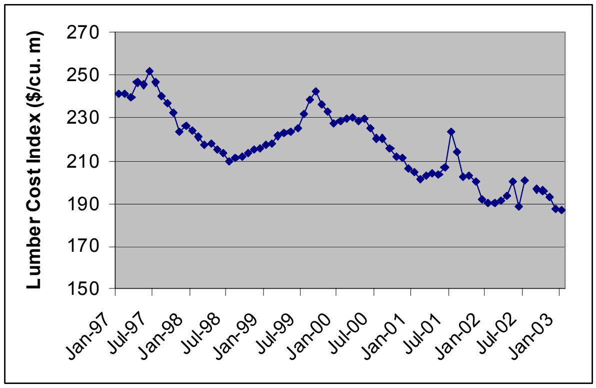

Figure 2: Lumber Cost Index Time History (taken from the monthly values reported in ENR Jan 1997 to Jan 2003)

Table 1: Statistical Summary of LCI for Several Portions of the Time Period Presented in Figure 2.

Period	Parameter	Annual Change	Weekly Change
1/97 – 6/02	Avg.	-0.1%	-0.07%
	St. Dev.	11.4%	0.55%
7/01 – 6/02	Avg.	-4.8%	-0.18%
	St. Dev.	2.7%	0.98%
Highest 24 mos.	Avg.	12.3%	0.44%
1/97 – 1/03	St. Dev.	11.4%	0.55%

3 SIMULATION OF THE SUPPLY CHAIN

The fundamental difficulty for the framing subcontractor/lumber yard in participating in the pricing agreement

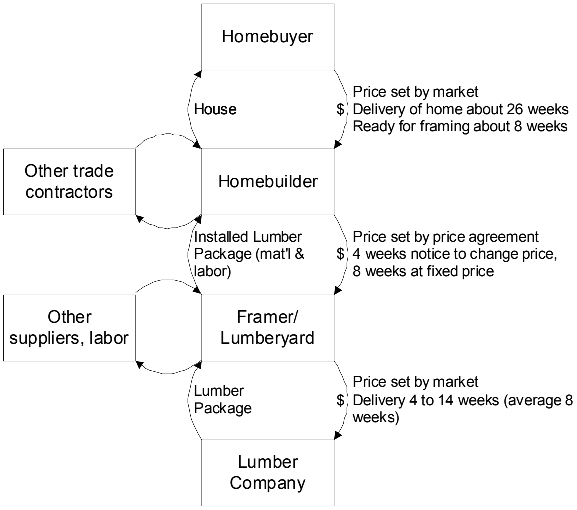

Figure 3: Pricing Structures and Material Flows in the Pricing Agreement

was the risk associated with providing a price now for material which may be sold up to 12 weeks from today (4 weeks notice plus 8 weeks at that price), and subsequently delivered a full 8 weeks later (because the price is set based on the date of the home sale, not the date of the delivery). As such, the subcontractor was placed in the position of providing a price today for material which might not be delivered for as much as 20 weeks, but which will not be ordered until 4 to 14 weeks before delivery, or 6 to 16 weeks from today.

In order to better understand the price and cost risks associated with this process, the builder/framer/lumber company triad was simulated for a 32 week period at a delivery rate of one home per week. In order to support this simulation, more detail for the supply chain function was required. Additional detail was developed through a detailed mapping process for the supply chain, generally following the recommendations of Damelio (1996) and some modifications (Bashford, et al. 2002). A supermarket was used for representing the function of inventory of bulks and specials, and transport and delivery delays were sized to approximate the known delivery history.

The simulation was conducted using the iGrafx Process 2000 tool. Process 2000 is a simple, user-friendly diagramming and modeling tool that provides an effective and logical approach to mapping. Once a process has been mapped, the Process 2000 simulation engine allows the user to obtain a dynamic view of the static diagram with built-in simulation functionality. A range of time and cost distribution functions can be built into flow models for the process diagrams developed. The diagram depicted in Figure 4 was used as a model.

The model started with an inventory of 3 lumber packages, and restock rules were developed by trial and error so that stock-outs for the particular subdivision modeled were eliminated. Only the bulk lumber products were modeled, as specials constitute only a small fraction of the lumber package.

Using a steady delivery rate to the site of 1 house per week, the order satisfaction rate was allowed to fluctuate inside a triangular distribution ranging from 4 to 14 weeks, with 8 weeks selected as the most likely value. Several different pricing and costing models were modeled, to simulate the different approaches the framing subcontrac-

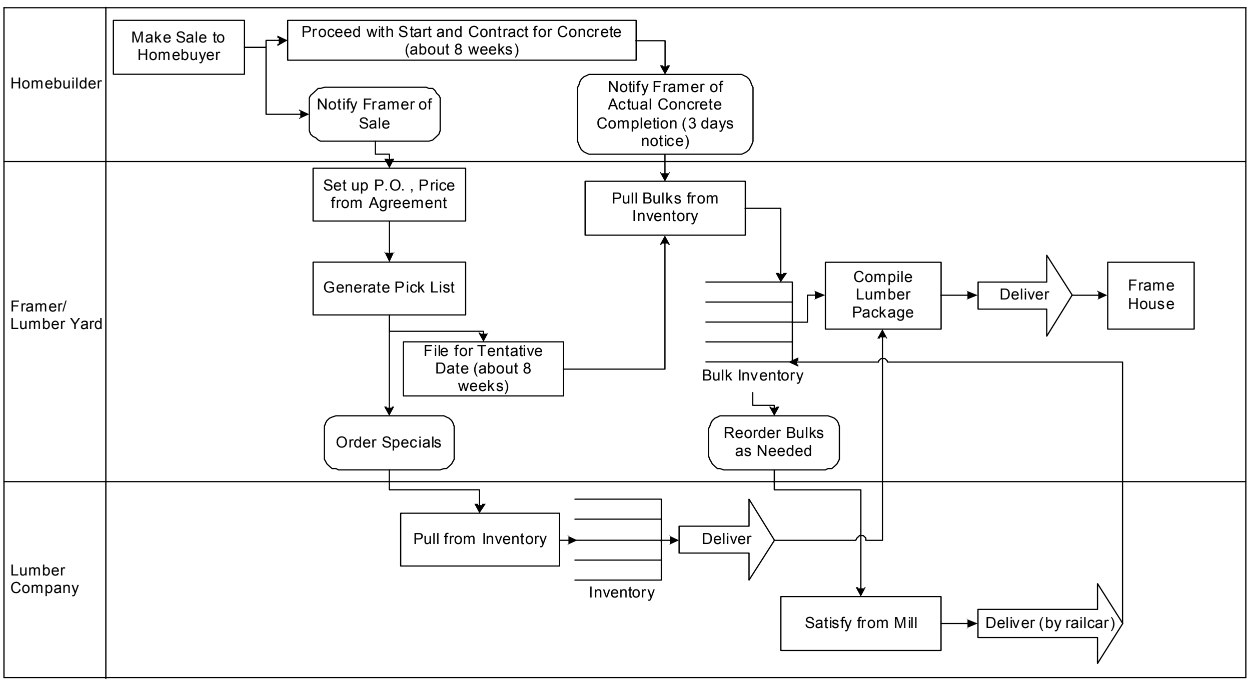

Figure 4: Process Model for Lumber Supply Chain

tor/lumberyard might take to the risk transfer. Expected returns were developed via multiple runs of the model, with 100 iterations providing stable answers.

Two basic scenarios were tested. In one case, the pricing agreement as described was used, with the lumber commodity prices allowed to fluctuate with the statistical parameters shown in Table 1. This price was adjusted upward with a risk premium of 2/3 of the standard deviation of the last 8 weeks of lumber price changes, and then marked up with a 10% margin.

In the second case, these same commodity price fluctuations were used, but under an alliance in which the homebuilder accepts the risk for price fluctuations. Homebuilder acceptance of the lumber price risk was modeled via a pass-through with an 8% margin. The results indicated that the expected return for the homebuilder is highest for the case in which the homebuilder negotiates a lower margin and accepts the commodity price risk directly, rather than transferring this risk to the framing subcontractor/lumberyard. The risk premium associated with this transfer exceeded the long-term cost of actual price fluctuations, even in an imaginary case where commodity prices were determined by the highest 24 months out of the 5 year period from 1997 to 2002. The pass-through strategy is an example of the cost transparency advocated by Lamming et al. (2001) for effective supply chain function.

4 IMPLICATIONS

Risk transfer is not uncommon in the construction supply chain generally. This study demonstrates that risk transfer, often motivated by a desire for cost savings, can have unintended consequences that may tend to increase costs. Parties to such an agreement should carefully consider the costs and benefits of such an arrangement, especially for cases where cost fluctuations may be expected to be severe.

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