IDENTIFICATION AND CLASSIFICATION OF VALUE DRIVERS FOR A NEW PRODUCTION HOMEBUILDING SUPPLY CHAIN

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ABSTRACT

The United States homebuilding industry experienced significant consolidation over the past ten years. The largest builders in the industry grew from building around 7,500 homes per year to over 30,000 homes per year. The supply chains for homebuilding were not designed to facilitate this level of mass production of homes. To achieve economies of scale in the Denver production homebuilding market, recent process improvements have been made by USBuild Corporation, a new player in the supply chain. These improvements have focused on using the Internet, a proprietary information system, and a new distribution channel to integrate information and material flows. The resulting opportunities for value creation in USBuild's "e-chain" supply chain during the first six months of operation in 2001 were significant. This paper identifies the value drivers in the case of USBuild's supply chain intermediation in the Denver market. Further, the value drivers are classified using an established framework for how Internet-enabled information technologies are impacting the extended supply chain.

KEY WORDS

Supply chain management, Internet, information technology, production homebuilding.

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INTRODUCTION

The United States homebuilding industry experienced significant consolidation over the past ten years. The largest builders in the industry grew from building around 7,500 homes per year in 1990 to over 30,000 homes per year by 2000. The 400 largest "production" builders today build 32.6% of new homes in the United States (Reichardt 2002). But by 2011, it is predicted that 75% of new home construction will be controlled by the 20 largest production builders in the country (DeCain 2002).

The existing supply chains for homebuilding, however, were not designed to facilitate the current and growing level of home mass production. Lurz (2002) postulates that achieving the level of consolidation predicted by DeCain is not feasible given current practices. Though this growth has been fueled by access to capital, low cost of capital and some economies of scale, the current supply chains are simply not designed to supply the unique demands of large consolidated builders.

The production builders have been able to take advantage of economies of scale associated with community development costs, land purchasing and improvement costs, merchandizing, advertising, and to a lesser degree labor costs. However, the largest single contributor to home price at 30.2% is building material costs (O'Toole 2002). The economies of scale on materials are largely limited to brand loyalty reward programs between manufacturers and homebuilders, which are difficult for builders to manage across a decentralized national organization when trade contractors purchase materials.

A compounding factor to the inability of large builders to achieve economies of scale is the fact that material delays represent one of the four most significant impediments to labor productivity management (Tucker, et al. 1999). In other words, labor costs that contribute 21.8% to the price of a home (O'Toole 2002) are being impacted by inefficiencies with the current distribution channel.

EMERGING PRODUCTION HOMEBUILDING SUPPLY CHAIN

SUPPLY CHAIN PAST TO PRESENT

The supply chains that exist in homebuilding today were developed largely as a result of the housing boom that followed World War II. With the passing of the Housing Act of 1949, almost a million new housing units were planned to provide decent, low-cost housing in the United States (NAHB Public Affairs 2001). To meet this unprecedented new housing demand, supply chains were formed that focused on the needs of trade contractors that provided turnkey bids to homebuilders.

The distribution channels that emerged in the housing boom of the 1950's are for the most part servicing the same supply chain players today. Typically trade contractors include labor and materials in their bids with material markups ranging from 10% to 15%. Though this situation is mutually agreeable for the custom homebuilders that they serve, the larger production builders are looking for ways to take advantage of their size to control costs, improve delivery, and reduce cycle times.

CONSTRUCTION AND INFORMATION TECHNOLOGY

With the widespread use of information technologies in construction, contractors are racing to keep up with the pace of technological change while learning to apply those technologies in their enterprises. More than ever business processes that were collected together within a construction firm are subject to competition from outside forces. Davidow and Malone (1992) in their visionary book, “The Virtual Corporation,” predicted that information processing capabilities would result in a business revolution. They believed that firms that could meaningfully restructure themselves to focus on core activities and outsource other processes could achieve “cost-effective, instantaneous production of mass-customized goods and services.”

Numerous construction-oriented virtual communities emerged on the World Wide Web from the mid 1990’s to present. Most of these intermediaries attempted to create a role for themselves in the construction process without providing sufficient perceived value to the construction industry. Because of this, and because of the slow innovation adoption attitude of the industry (Koskela and Vrijhoef 2000), many of these firms failed to establish a sustainable role for themselves and have since ceased operations. However, a significant opportunity exists to use information technologies to provide value-adding solutions to remove waste and latency from supply chains (Howell 1999) (Ballard and Howell 1995). The efforts of the International Group for Lean Construction are an indication of the trend in this direction in construction (Alarcón 1993) (Melles 1994) (Tommelein 1998).

CASE OF USBUILD CORPORATION’S SUPPLY CHAIN INTERMEDIATION

In 2001, USBuild Corporation (http://www.usbuild.com) launched a solution that provides significant value for production homebuilding by combining new information technologies with the creation of an entirely new supply chain. The most significant contributor to value is the fact that this new supply chain intermediation is focused entirely on the needs of the growing segment of production homebuilders. In creating the “e-chain” distribution channel, USBuild focused on integrating information and material flows into restructured hubs (Figure 1).

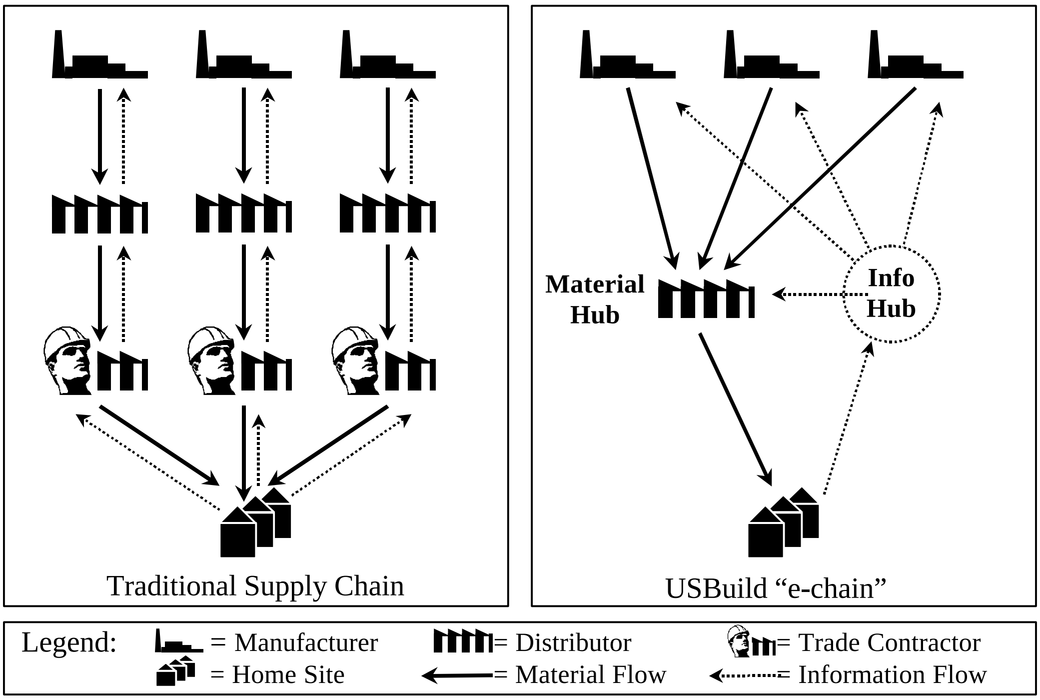

Figure 1: Traditional Supply *Chain vs. USBuild’s “e-chain” for Production Building*

The USBuild material hub was designed to handle material flows from multiple distribution channels and today handles approximately 550 SKU's. USBuild initially focused their efforts on five key distribution channels. These included the channels for rough-in plumbing materials, finish plumbing materials, fireplace materials, rough-in HVAC materials, and finish HVAC materials. In each of these cases, the trade contractor no longer takes delivery of the materials and in each case USBuild replaces the traditional distributor role.

By merging the flows from multiple channels and by implementing sophisticated warehousing techniques, USBuild has greatly improved material flow efficiencies in the production homebuilding supply chain. However, they experienced difficulties in the initial implementation of this solution. Trade contractors initially felt threatened by the "e-chain." To facilitate the introduction of the "e-chain," through educational programs USBuild created a "trade pool" of trade contractors interested in doing business in a new way. This required a substantial effort to attract interested trade contractors through holding numerous meetings and events with relevant trade contractor groups.

USBuild also experienced some reluctance in the implementation of its information hub. Manufacturers were not accustomed to operating a "pull-driven" supply chain and have still not taken full advantage of the greatly improved demand lead times to produce to order (instead of produce to stock). The "e-chain" information hub consists of two key components, both connected to customers and suppliers via the Internet.

The first component of the information hub is USBuild's demand capture application called "HOMER." This application captures demand at the point of sale when the customer decides on the optional attributes of their new home. Next, the "e-chain" information system creates a bill of materials and provides this information directly to manufacturers. The information hub reduces the lead time lag by several weeks as compared to the traditional supply chain.

Surprisingly, though the USBuild supply chain offers distinct cost and time advantages, the adoption of the solution by production homebuilders has been slower than expected. As put forward by Koskela and Vrijhoef (2000), change is resisted in the construction industry. USBuild plans to increase adoption by maintaining its 98.5% quality on-time delivery status, by making it clear to production builders that the "e-chain" does not require them to change their existing technology, and by increasing the number of product categories it distributes.

VALUE DRIVERS OF USBUILD E-CHAIN SOLUTION

INFORMATION FLOW IMPROVEMENTS

There are three primary value drivers in USBuild's e-chain solution related to information flows; reducing demand distortion, improving demand signal capture, and pooling demand (Figure 2). Compared to the poor information flow in the multi-step distribution of the traditional supply chain, the e-chain provides a true demand signal from the homebuilder to the manufacturer. Further, trade contractors in the traditional supply chain were responsible for manually determining material quantities from home plans, the e-chain preloads this information so that the demand signal contains fewer errors, takes less time to generate, and is more easily shared. Finally, for building materials with low homebuilder and homebuyer specificity, the e-chain pools demand to obtain reduced material pricing for builders.

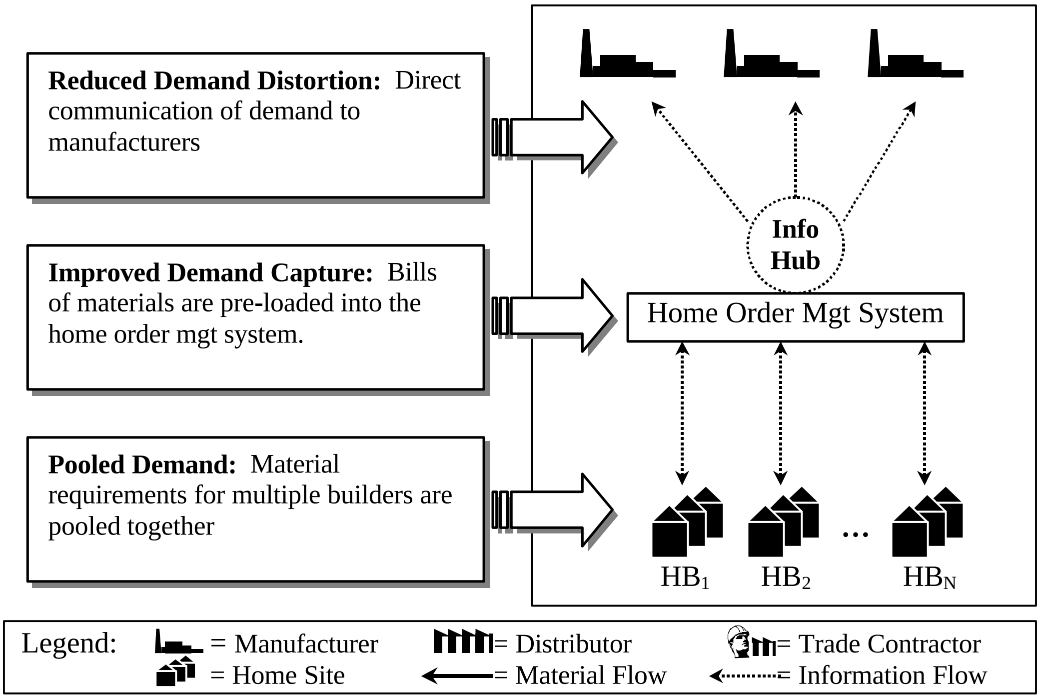

Figure 2: E-chain Information Flow Value Drivers

Reduced Demand Distortion

When considering the node-to-node communication of even the simplified traditional building material supply chain from Figure 1, the complexity and difficulty of information exchange is evident. In the traditional supply chain in Figure 1, there are nine separate material flows and communication flows. Each of these nodes is charged with making forecasting and production and ordering decisions based on the downstream demands, internal capacity and upstream constraints of nodes in the chain with which it interfaces. Because of an inability or unwillingness to share information, the demand signal is often distorted as it flows upstream leading to a phenomenon known as the "bullwhip effect" (Lee et al. 1997).

Procter & Gamble first coined the bullwhip effect during a replenishment pattern study for disposable diapers (Nahmias 1997). Procter & Gamble noticed that even though diaper demand was relatively stable, the upstream orders were amplified. Taylor and Björnsson (1999) described how this phenomenon impacts construction supply chains. In construction, variability increases upstream in the supply chain as each node creates its own forecast, schedule, inventory decision and material requirements plan. This effect is compounded by the fact that ordering is typically based on the immediate needs of the downstream customer. As a result, manufacturers carry far more inventory than necessary.

By limiting coordination to node-to-node communication, the supply chain is unable to flexibly meet the demands of the end customer. Effective operational control of a supply chain requires centralized coordination of key data (Lee and Billington 1992). For industrial manufacturing, this typically has meant forecasts, inventory status at all sites, backlogs, production plans, supplier delivery schedules and pipeline inventory. In other words, supply chain integration requires all nodes in the network to communicate and share detailed, current information.

USBuild's e-chain has created this level of integration by providing an information system hub in the supply chain for production homebuilding. The e-chain information hub provides current demand information simultaneously and directly to manufacturers, production builders, and the USBuild material flow warehouse hub. In the traditional supply chain trade contractors were notified of upcoming projects with narrowly defined production windows several months in advance. But, this information was not provided to distributors or manufacturers, introducing significant distortion in the upstream demand signal. In comparison (per Figure 1), the USBuild e-chain has a single communication interface that captures demand from the builder. This allows manufacturers to carry far less finished goods inventory by manufacturing products to order instead of to inventory.

Improved Demand Capture

Because introducing a solution that requires changing the way people work in an industry can slow adoption rates, USBuild focused on capturing demand signal in the least intrusive manner possible. Production builders build thousands of homes from only a dozen or so unique home plans. And since traditionally material orders were made one home at a time by trade contractors, there was no need for a builder to create a detailed bill of materials. Instead the builder ordered by trade type and by home lot through trade contractors.

To mirror existing business processes, USBuild created a home order management information system. In it, they created a bill of materials for each home plan. Using a home plan configuration application they were also able to allow for several customization options that would automatically be added to the bill of materials. The final bill of materials was then integrated into USBuild's own material requirements planning system and the e-chain information hub. Thus, when a builder ordered a trade kit of materials for a certain home lot, the orders would be sent directly to the manufacturers for production. And because manufacturers can see future orders not yet placed in the system they could incorporate this probable demand into their medium-range production planning. The greatly facilitated material ordering and communication process enabled multiple builders to understand and adopt the USBuild solution quickly.

Pooled Demand

A multiple-industry study conducted by the Center for Advanced Purchasing Studies reports that purchasing through pooled procurement groups results in average savings of 13.43 percent (Hendrick 1997). When compared against the average annual cost of operating these groups, it was indicated that, on average, returns on investment of 767% were achieved. Typically, these group-purchasing arrangements are implemented in fragmented industries where the end-customer does not have much buying power and demand is uncertain and/or variable.

In a previous study by Taylor and Björnsson (1999) it was determined to be unlikely that contractors would pool together and build enough trust to form large-scale procurement coalitions. However, USBuild has entered the supply chain as a trusted third party and, as such, is able to offer a pooled procurement service to its customers. Before USBuild can offer significant pooled procurement cost advantages it needs to reach multiple homebuilding markets (they are currently operating only in the Denver market).

However, already some products with low homebuilder and homebuyer specificity are being pooled by USBuild and offered to customers at a reduced price.

MATERIAL FLOW IMPROVEMENTS

There are three primary value drivers in USBuild's e-chain solution related to material flows; removing the trade contractor link, kitting and just-in-time delivery of materials, and forward positioning of "spare and repair" inventory (Figure 3). In traditional distribution the trade contractor is responsible for handling and managing material flows. The e-chain removes this link from the supply chain. Also, because the e-chain is shipping multiple trade types of materials through its material hub, it is able to kit materials and offer just-in-time daily material shipments. Finally, materials that are subject to running short or breaking on the home site are forward positioned and continuously replenished in the e-chain.

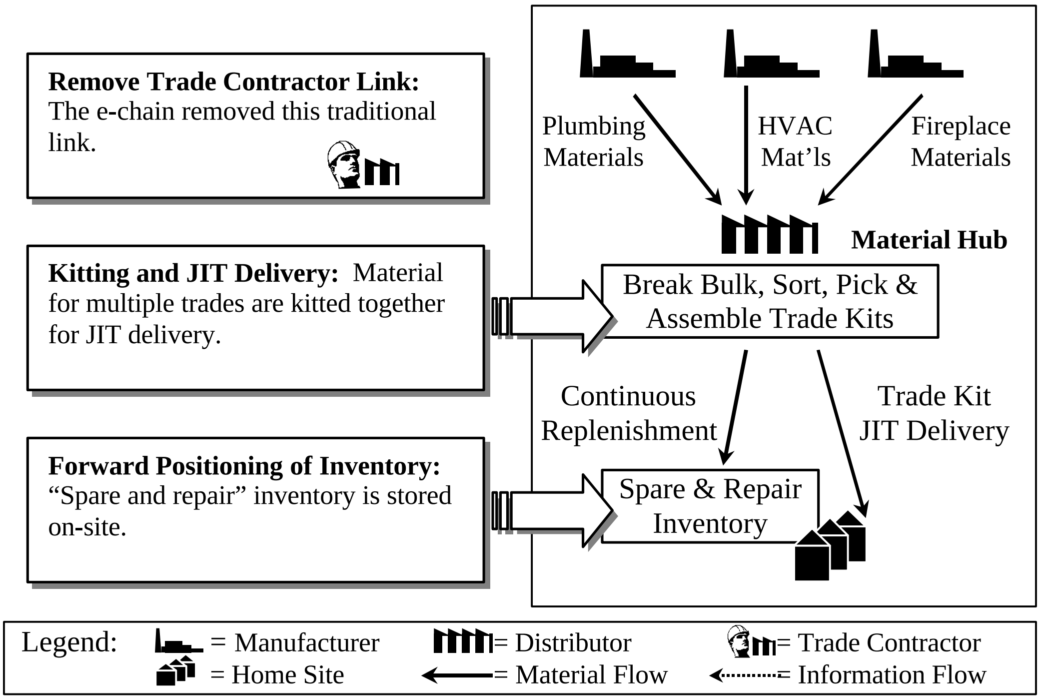

Figure 3: E-chain Material Flow Value Drivers

Trade Contractor Link Removed

Though initially USBuild met with some opposition to removing the trade contractor link in the supply chain, they were successfully able to do so. This is critical to creating value with the USBuild solution. First of all, the trade contractors were carrying inventory in their own warehouses, managing the procurement process, and often providing delivery of the materials themselves. When the core business activity of a trade contractor is to be a licensed installer of trade materials, it was sub-optimal to have them handling the purchasing and distribution as well. Further, because trade contractors are typically small business owners, they represent a credit risk to lenders and end up paying high interest rates with poor terms.

In order to remove the trade contractor link from the supply chain USBuild needed to create a pool of trade contractors willing to provide installation only. USBuild has successfully done so and several of the trade contractors who have experienced working in the reengineered USBuild homebuilding process are pleased to have the burden of purchasing removed so they can focus on what they do best. The homebuilder customers see the removal of the trade contractor link from the supply chain as one of the key value drivers of the USBuild "e-chain" solution.

Materials Kitted and Delivered Just-in-Time

The traditional supply chains, as discussed, were designed with the needs of the trade contractor in mind. When USBuild created the "e-chain," however, it had the needs of the large production homebuilder in mind. The production builders' needs are, in fact, very different than those of trade contractors. The production builders these researchers spoke with felt that the existing system was clearly inefficient as "every day a convoy of trucks would arrive on the home site … and still trade contractors would end up waiting around for building materials or have to quit early because of a lack of materials."

Trade contractors expect a distribution channel to be filled with a wide variety of products, be filled with inventory, and offer personalized service. Production builders need a supply chain that focuses on their narrow range of products so throughput can be maximized. They are large publicly traded companies that know the cost of inventory carrying so they prefer a distribution channel that carries minimal inventory so costs can be minimized. Finally, production builders order materials from a small number of home plans, a distribution channel designed for them would have few to no salespeople to help them with their purchase decisions. In fact, they do not want to have to visit the distributor at all, they just want materials to arrive efficiently on their job site just-in-time.

In order to offer the maximum value to the production builders, USBuild created a supply chain where goods come from the various manufacturers into a single flow through warehouse for each homebuilding market. In Denver, this distribution facility is located near the airport in an industrial district. This would be unacceptable to trade contractors, as they want to be able to conveniently visit the distributor. For production builders, however, the only reason they have to visit the distribution facility is to see how efficient the operations are running.

Within the USBuild material distribution hub, a sophisticated material kitting process takes place. When field superintendents at production homebuilding communities phone in an order for a trade kit, the USBuild distribution hub staff pick the relevant materials for an entire day or more of production at the home site and kit those materials together on a pallet called a "trade kit."

Once goods are kitted together, they are placed on trucks for delivery either the same evening or first thing the following morning. That way all the materials needed for the next day of production are on the site in advance of the labor crews. The homebuilders and the trade contractors both enjoy the significant value impact just-in-time delivery has had on their productivity. They no longer have to wait for tardy materials from multiple distributors.

"Spare and Repair" Inventory Forward Positioned

One of the reasons USBuild is able to offer the logistics efficiencies from kitting and just-in-time distribution, is due to the fact that a small amount of inventory of the types of materials that tend to break or run short are forward positioned at the community job site. This inventory is managed by USBuild and owned by the homebuilder. USBuild created a continuous product replenishment system where field superintendents automatically trigger an order to replenish inventory when inventory is used. This inventory replenishment is normally added to an existing delivery so no additional distribution costs are incurred.

By keeping these materials which homebuilders and trade contractors have come to call "spare and repair" inventory, USBuild can play a significant role in keeping the production moving forward in an uninterrupted fashion on the job site. It was estimated in a recent National Association of Homebuilders Research Center study (Caldeira 2002) that on average, reducing the cycle time of building a home by one day saves a homebuilder $291.00. It is estimated that this savings could range from $50.00 to $500.00 per home per day. USBuild is working closely with both homebuilders and trade contractors to reduce the cycle time of building a home from 90 days to as low as 45 days.

CLASSIFICATION OF USBUILD E-CHAIN VALUE DRIVERS

Sharman (2002) proposes a framework for classifying the impact of information technology solutions on supply chains. According to Sharman, the full potential of Internet-enabled information technology solutions will only be realized when companies move beyond e-commerce to initiatives that fundamentally change the supply chain. In his framework, information technologies can impact transaction costs, non-coordination costs, and core costs. USBuild's solution impacts each of these three cost structures (Table 1).

Table 1: Classification of E-chain Value Drivers

Classification	Value Driver for Extended Supply Chain	Impact
Transaction (17% of Supply Chain Costs)	World Wide Web Interface to Information Hub (not discussed in this paper)	Minimal
Non-coordination (33% of Supply Chain Costs)	Reducing Demand Distortion Improving Demand Signal Capture Pooling Demand	Significant
Core (50% of Supply Chain Costs)	Removing Trade Contractor Link Kitting and Just-In-Time Delivery of Materials Forward Positioning of "Spare and Repair" Inventory	Significant

TRANSACTION COSTS

Transaction and overhead costs are estimated to have the smallest impact on supply chain costs. These costs, in Sharman's model, represent approximately 17% of the extended supply chain costs. E-commerce solutions only impact the clerical transaction costs in the extended supply chain. Though USBuild would have an impact on these costs, because they use a combination of a phone interface and an automated web interface in their solution we estimate that the value impact in this area is not significant.

NON-COORDINATION COSTS

The impact of non-coordination costs represents a larger portion of supply chain costs at 33%. These costs are related to unnecessary inventory, shipping delays, poor delivery, etc. These costs are impacted through supply chain optimization and rebalancing efforts. Two key drivers to reducing non-coordination costs are outsourcing and collaboration.

The USBuild home order management service discussed earlier in this paper offers builders an outsourced alternative for procurement. Because the home order management service includes an automated bill of material generator, a home configuration application, and because it is linked to USBuild's material requirements planning system in the information hub, it reduces costs considerably. The information generated by the home order management service provides a true demand signal to manufacturers enabling them to reduce unnecessary inventory. Finally, because the information is integrated into USBuild's own distribution system, shipping delays and delivery problems are rare. We estimate that USBuild impacts non-coordination costs significantly resulting in a reduction in overall supply chain costs.

CORE COSTS

Improving core supply chain costs can make the greatest impact on costs. These costs, which represent approximately 50% of costs in the supply chain, are the real costs of processing goods (i.e., transportation, handling, storage, inventory). In order to tap into these costs it is necessary to restructure the supply chain. In USBuild's case, this was done first through the removal of the trade contractor link in the supply chain. As discussed in this paper, this had both the effect of removing the costs of the trade contractor link as well as the effect of reducing the amount of inventory held at the distributor link.

The kitting and just-in-time delivery of materials represents a restructuring of the supply chain also as it was executed by eliminating the multiple distributors previously present in the distribution channel for production homebuilding. Finally, the forward positioning of inventory on the project site with a system for continuous replenishment contributes value in the reduction of core costs. By eliminating the trade contractor link and by focusing the distributor link, USBuild makes its greatest impact clearly in the core costs of the extended supply chain.

CONCLUSIONS

Supply chain intermediation such as the case of USBuild Corporation's e-chain add significant and measurable value to the extended supply chain. The e-chain benefits accrue largely due to synergies between information and material flows. In information flows, synergies create value drivers such as reduced demand distortion, improved demand signal capture and the possibility to pool procurement. For material flows, the value drivers are the removal of the trade contractor link from the supply chain, kitting and JIT delivery of materials, and forward positioning of "spare and repair" materials on the job site.

Matching these value drivers to Sharman's supply chain value creation framework gives a sense of the impact the USBuild solution is having on the homebuilding supply chain. Sharman's model illustrates how the value drivers described above will have a significant impact on 83% of extended supply chain costs. Sharman's research suggests that of the final cost of materials at the point of sale approximately 10% to 25% can be attributed to supply chain costs. This demonstrates the quantifiable impact USBuild is having on the value chain.

Privileged information shared with these researchers by the USBuild management team regarding the real impact they are having on the supply chain cost structure agrees with Sharman's estimated impact. Further, the homebuilders and trade contractors have validated the value contribution of USBuild's solution through their adoption of the solution and by comments made to these researchers. Further research investigation is underway to model the USBuild model value contribution to the production homebuilding supply chain.

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REFERENCES

Alarcón, L. (1993). "Modeling waste and performance in construction." *Proceedings – 1st Workshop on Lean Construction, Espoo*, Lean Construction Institute.

Ballard, G. & Howell, G. (1995). "Toward construction JIT." *Proceedings of the 1995 ARCOM Conference, Association of Researchers in Construction Management*, Sheffield, England.

Caldeira, E. (2002). "Cycle time reduction – What is a day worth?" *Industry Report*, National Association of Homebuilders Research Center.

Davidow, W. & Malone, M. (1992). *The Virtual Corporation*. Harper Collins Publishing, New York, N.Y. 10022.

DeCain, P. (2002). "The Impending Consolidation of the Homebuilding Industry." *Analyst Report*, Andersen Corporate Finance LLC.

Hendrick, Thomas E. (1997). "Purchasing consortiums: Horizontal alliances among firms buying common goods and services what? who? why? how?" *Focus Study*, Center for Advanced Purchasing Studies.

Howell, G. (1999). "What is lean construction." *Proceedings Seventh Annual Conference of the International Group for Lean Construction*, IGLC-7, Berkeley, CA, July 26-28, pp. 1-10.

Koskela, L. & Vrijhoef, R. (2000). "The prevalent theory of construction is a hindrance for innovation." *Proceedings Eighth Annual Conference of the International Group for Lean Construction*, IGLC-6, Brighton, UK, July 17-19.

Lee, H. & Billington, C. (1992). "Managing supply chain inventory: Pitfalls and opportunities." *Sloan Management Review*, Spring, p. 65-73.

Lee, H., Padmanabhan, V., & Whang, S. (1997). "The bullwhip effect in supply chains." *Sloan Management Review*, Spring, p. 93-102.

Lurz, B. (2002). "Consolidation is temporary." *Professional Builder Magazine*, April.

Melles, B. (1994). "What we mean by lean production in construction?" *Proceedings – 2nd Workshop on Lean Construction, Santiago*, Lean Construction Institute.

NAHB Public Affairs (2001). "Housing facts, figures and trends 2001." National Association of Homebuilders, June.

Nahmias, S. (1997). *Production and Operations Analysis.* McGraw-Hill Companies, Inc., Irwin Series, 3rd Edition, Chicago, IL.

O'Toole, P. (2002). "Bigger, Better, Stronger." *Professional Builder Magazine*, April.

Reichardt, C. (2002). "Homebuilders: Born to run?" *Industry Overview Homebuilding*, Banc of America Securities, February.

Sharman, G. (2002). "How the Internet is accelerating supply chain trends." *Supply Chain Management Review*, March/April, p. 18-28.

Taylor, J. & Björnsson, H. (1999). "Construction supply chain improvements through Internet pooled procurement." *Proceedings – 7th Conference on Lean Construction, Berkeley*, Lean Construction Institute.

Tommelein, I. (1998). "Pull-driven scheduling for pipe-spool installation: Simulation of lean construction technique." *Journal of Construction Engineering and Management*, July/August, p. 279-288.

Tucker, R., Haas, C., Borcherding, J., Allmon, E., & Goodrum, P. (1999). "U.S. Construction Labor Productivity Trends, 1970-1998." *Report No. 7*, Center for Construction Industry Studies, March.