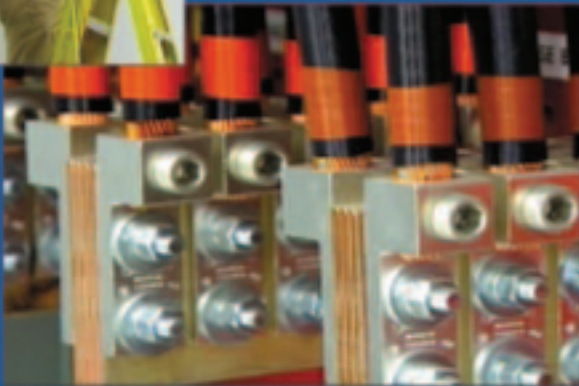


*Productivity Enhancement*



# *Procurement Chain Management in the Construction Industry*



*Project co-sponsors*



 **NEW HORIZONS**  
A Chance to Grow **FOUNDATION** An HVAC and Sheet Metal Industry Initiative™

*Conducted on behalf of*



*Conducted by  
Dr. Parviz (Perry) Daneshgari (MCA)  
and  
Samuel J. Harbin (MCA)*

# Procurement Chain Management in the Construction Industry

Conducted on behalf of:



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## 1.0 Executive Summary

Changes in customer expectations in the construction industry regarding project delivery, time, cost, and quality have forced the stakeholders to search for new operational models. Advances in non-construction industries in the areas of procurement and business management have improved the national productivity by an average of 2.7% per year from 1987 to 1996 and 3.9% per year from 1996 to 2000.<sup>1</sup> The construction industry's productivity, however, has not followed suit. The productivity in the construction industry has only increased by a mere 0.2% per year from 1987 to 1996 and -1.0% from 1996 to 2000.<sup>1</sup> One source of this static productivity increase in the construction industry is the procurement chain management system. The current practice of procurement is no longer satisfying the market requirements. Due to the urgent need for improvement of the current construction procurement model, a variety of alternative models are being practiced throughout the industry.

This research was commissioned by the Electrical Contracting Foundation (ELECTRI'21) to investigate the prevailing, existing, and alternative models of procurement. In order to adequately assess the strengths and weaknesses of each model, a neutral comparison of each model was conducted. After thorough investigation, a common problem was discovered in each procurement model being practiced:

**None of the existing and alternative models are offering an efficient, streamlined approach to procurement.**

It is the opinion and finding of this research that a new procurement process needs to be developed to achieve better

- ∞ Time
- ∞ Cost
- ∞ Quality.

---

<sup>1</sup> Faruqui, U.; Gu, W.; Kaci, M.; Laroche, M.; and Maynard, J. (2003). Differences in productivity growth: Canadian-U.S. business sectors, 1987-2000. Monthly Labor Review April 2003, 16-28.

This can be accomplished only through direct collaboration of all the stakeholders in the procurement chain to produce a horizontally integrated procurement process (See Appendix A).

A horizontally integrated procurement process would address the challenges presented by Gene Dennis, the ELECTRI'21 COUNCIL Chairman. Two of these challenges are

1. Systems thinking – Taking a holistic approach as to how this and other research will impact the entire industry.
2. Productivity improvement – Strive for a quantum leap of 50% improvement in productivity over the next 5 years.

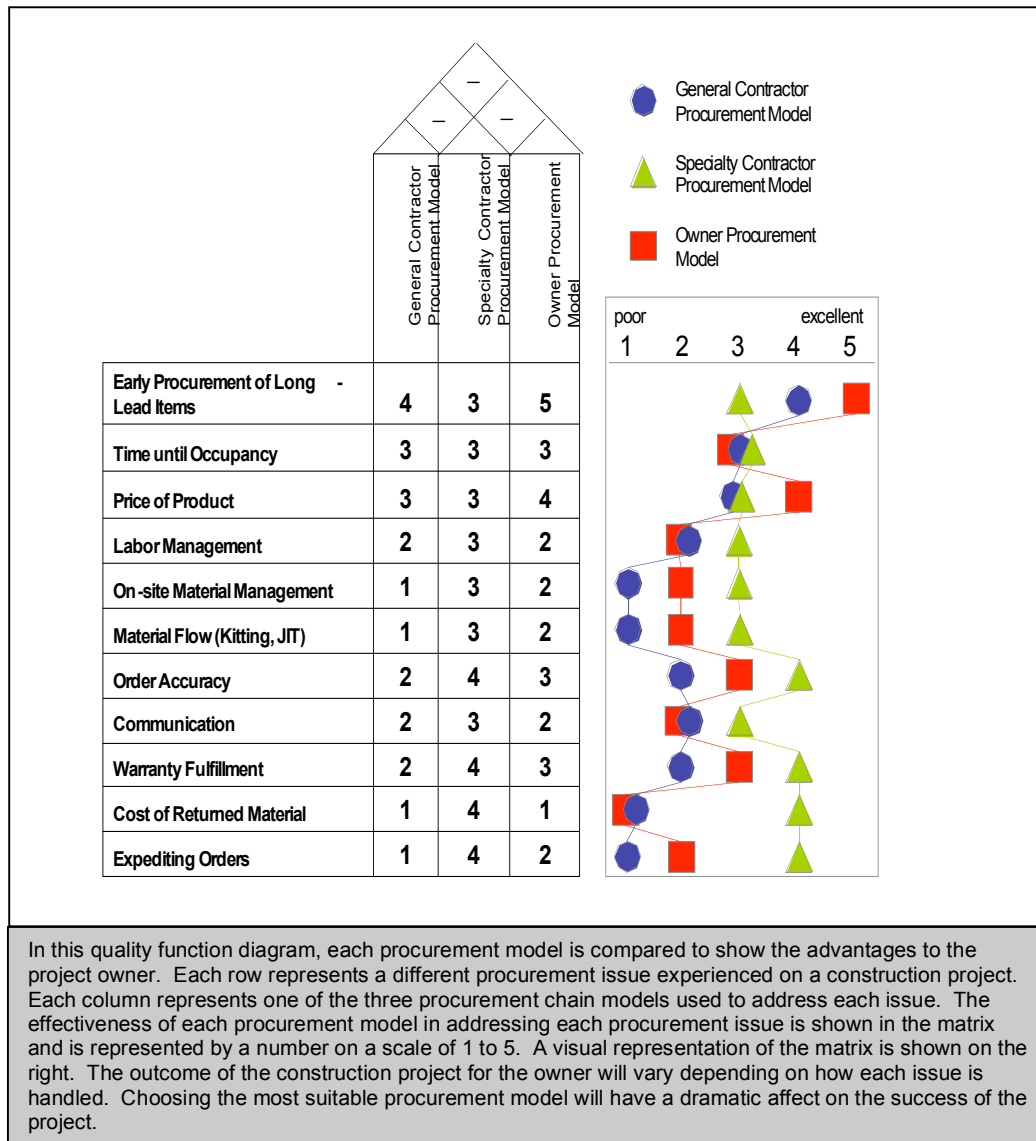
These challenges are directed at improving productivity in the construction industry. This improvement will directly impact the owner because they will experience lower project cost, faster occupancy, and higher quality construction projects as productivity increases.

Depending on the situation the project owner is facing, each model provides a certain level of value. Overall, the Specialty Contractor Procurement Model (SCPM) and the Owner Procurement Model (OPM) generally provide the highest value to the owner. The General Contractor Procurement Model (GCPM) does have some positive features, but does not provide the same value as SCPM or OPM. Table 1 and the quality function deployment (QFD) diagram in Figure 1 show a comparison of each model.

	<b>Definition</b>	<b>Cost</b>	<b>Time</b>	<b>Quality</b>	<b>Customer Benefits</b>
<b>Specialty Contractor Procurement Model (SCPM)</b>	Specialty contractor procures material and equipment for the project owner.	Material and equipment costs are similar between SCPM and GCPM.	Procurement occurs once specialty contractor is selected.	The overall quality in this model is above average. Problems and delays occur less frequently than in GCPM or OPM.	This model offers high value for project owners with relatively low risk.
<b>General Contractor Procurement Model (GCPM)</b>	General contractor procures material and equipment for the project owner.	Material and equipment costs are similar between SCPM and GCPM.	Procurement can occur before SC is selected.	The overall quality in this model is average. Problems and delays occur much more frequently than SCPM or OPM.	This model offers average value to the project owner with relatively high risk.
<b>Owner Procurement Model (OPM)</b>	Project owner procures material and equipment.	Material and equipment costs are slightly less expensive than SCPM or GCPM.	Procurement can occur before the GC or SC is selected.	The overall quality in this model is average. Problems and delays occur more frequently than SCPM, but less frequently than GCPM.	This model offers highly variable value to the owner depending on the type of project owner.

**Table 1. Basic comparison of the three procurement chain models.**





**Figure 1. Comparison of the three procurement chain models using a modified Quality Function Deployment (QFD) diagram.**

The primary issue is that the prevailing, existing, and alternative procurement chain models are not satisfying the needs of most project owners. In order to improve procurement chain management in the construction industry, a new model should be instituted that utilizes the benefits of horizontal integration (See Appendix A). Through horizontal integration of the procurement chain, the project owner and each member of the procurement chain will be able to complete a construction project at lower cost for everyone involved.

## 2.0 Introduction

The “invisible hand of market” is active once again. As Adam Smith correctly identifies in his monumental work “Wealth of the Nations,” every time the customer is unsatisfied with the prevailing economic conditions, the invisible hand of market becomes active. This phenomenon is particularly common in unregulated industries. The *laissez-faire* mentality encourages the stakeholders of the industry to vividly react to the invisible hand of market.

The same phenomenon is occurring in the construction industry. The prevailing procurement model has obvious flaws and, until they are resolved, this model will be under direct attack. The attacks can and will come from different directions. They could come from legislators or government, general contractors (GCs) or brokers, specialty contractors (SCs) or distributors, and manufacturers or owners. The issue is not identification and neutralization of the attacker; the issue is that the current model is not satisfying the needs of the customer. The attacker is not to blame; lack of understanding of the problem is to blame.

It was such a situation that gave birth to this research. A new alternative procurement model was having a cross-industry impact, and the profit pools of the construction industry recognized its impact on the stakeholders.

By creating a vertical integration (See Appendix A) model for procurement, some general contractors have tried to circumnavigate the other profit pools of the supply chain. The main goals for this alternative procurement model are better cost, time, and quality for the project owner.

In the explosive economy of the 1990s, the construction industry boomed. Contractors thrived on commercial construction as telecommunication companies and Internet ventures flooded the market with expansions and start-ups. The priority of owners in the fast-paced technology businesses was to beat their competitors to market. Construction projects accelerated beyond the usual fast pace required by owners, and general contractors had to employ unorthodox strategies to accommodate these fast-tracked schedules.

GCs met the faster occupancy challenge by immediately procuring long-lead items from the manufacturer during the initial planning stages of the project.

This strategy ensured that long-lead items would be delivered in compliance with the fast-tracked schedules. During this period, the high volume of construction projects combined with the procurement of more complex, expensive, long-lead items provided GCs with considerable buying power. GCs could secure faster availability of long-lead items and leverage their buying power to acquire lower prices than subcontractors. The practice of GCs buying material, which had historically been purchased by specialty contractors, gained acceptance and became standard practice for several GCs throughout the late 1990s.

Although the practice of GCs buying directly from manufacturers occasionally existed prior to the dot.com era, the lack of GC expertise and buying power usually proved detrimental to all parties involved. Additionally, with the downturn in economic conditions in the post-dot.com era, GCs were left with little buying power. Today, the situation hasn't changed. Having grasped the direct purchasing model, several GCs are marketing the model to owners by offering theoretical cost savings derived from the elimination of distributor and subcontractor markups. Some owners are enticed by the perceived cost savings and encourage the GCs to purchase material. Currently, several powerful GCs have adopted direct purchasing as part of their primary business strategy. The trend of GCs buying direct is growing: some are looking to buy more than just long-lead items.

Since the effects of the GC direct purchasing trend are unclear, the Electrical Contracting Foundation (ELECTRI'21) commissioned an investigation to study this procurement practice and compare it to existing procurement practices in the construction industry. Other associations have also joined the research in an effort to help determine the best procurement practice for the entire construction industry. The associations participating in this research include

1. The Electrical Contracting Foundation (ELECTRI'21), the research and education foundation of the National Electrical Contractors Association (NECA)
2. NAED Education and Research Foundation (NERF) of the National Association of Electrical Distributors (NAED)

3. The New Horizons Foundation, the research and education foundation of the Sheet Metal and Air Conditioning Contractors (SMACNA)
4. The Mechanical Contracting Foundation, the research and education foundation of the Mechanical Contracting Association of America (MCAA).

This research has also been guided and validated by a task force of experts from all levels of the construction industry including manufacturing, distribution, specialty contracting, and various associations. The task force for this research project included the following members:

1. Russell Alessi, President, the Electrical Contracting Foundation, Bethesda, MD
2. David Allen, Executive Vice President, McKinstry Company, Seattle, WA
3. Kenneth C. Borden, Executive Director, South Florida Chapter, NECA, Hialeah, FL
4. Dennis Bradshaw, Executive Director, New Horizons Foundation, Chantilly, VA
5. Robert J. Bruce, President, Bruce & Merrilees Electric Company, New Castle, PA
6. Donald Campbell, Executive Director & Chapter Representative, Northern California Chapter, NECA, Pleasanton, CA
7. Brian Christopher, President, Christenson Electric, Portland, OR
8. James Cleveland, President, Cleveland Electric Company, Atlanta, GA
9. Mike Cullinane, President, Bert C. Young & Son, Bellwood, IL
10. Thomas F. Curran, Trust Chairman, Red Top Electric Company Emeryville, Inc., Haywood, CA
11. Jeff Giglio, President, Inglett & Stubbs, LLC, Mableton, GA
12. Rob Girard, Contractor Segment Marketing Manager, Square D/Schneider Electric, Nashville, TN
13. Michael Gossman, CEO, Midwest Mechanical Contractors, Overland Park, KS

14. Michelle Jaworowski, Vice President, NAED Education and Research Foundation, St. Louis, MO
15. Arnold Kelly, Director of Construction Market, Graybar Electric Company, Inc., St. Louis, MO
16. Robert Laub, Director of Marketing, Square D/Schneider Electric, Nashville, TN
17. John McNerney, Executive Director of Government Labor and Industry Relations, the Mechanical Contracting Association of America, Rockville, MD
18. David Miles, Vice President of Operation, Ferndale Electric Company, Ferndale, MI
19. Dave Raspolich, Chapter Representative, San Diego County Chapter, NECA, San Diego, CA
20. Dick Schmid, Vice President of Marketing, Crescent Electric Supply, East Dubuque, IL
21. Daniel T. Tripp, Executive Vice President, Southeastern Michigan Chapter, NECA

In addition, an academic review board was assembled to validate the final results of this research project. The academic review board included the following members:

1. Thomas E. Glavinich, D.E., P.E., University of Kansas
2. Michael J. Horman, Ph.D., Penn State University
3. Jerald L. Rounds, Ph.D., P.E., University of New Mexico
4. Walid Y. Thabet, Ph.D., Virginia Tech

These organizations and industry professionals have come together to guide fact-finding and support the conclusions of this research to determine which procurement model provides the best value for the project owner.

### 3.0 Goals and Objectives

The direct procurement model, a form of vertical integration (See Appendix A), has gained GC and owner support due to the combination of fierce competition and a weak economy. Both GCs and owners are looking for an edge to save time and money – and have turned to direct purchasing for the solution. The practice of direct purchasing is not new to the construction industry. End-users have bought material and equipment directly from manufacturers, and recently GCs have increased their efforts to buy all the equipment and material for their projects, thus bypassing regular distribution channels. Several GCs have aggressively marketed this procurement plan to owners as a time- and cost-saving alternative. Yet, it is unclear whether the owner actually receives the benefits that are projected in the vertical integration approach of direct purchasing.

The objective of the research was to investigate various procurement chain models in order to determine the impact each has on the project owner. Three procurement chain philosophies were identified and modeled:

1. General Contractor Procurement Model (GCPM): The GC procures material and/or equipment for the project owner.
2. Specialty Contractor Procurement Model (SCPM): The SC procures material and/or equipment for the project owner.
3. Owner Procurement Model (OPM): The project owner procures his or her own material and/or equipment.

The primary focus of this research was on the GCPM and the SCPM. The OPM was included in this research, but an in depth analysis of this model was not conducted.

Three goals were established and met in this research project. These three goals are as follows:

1. Define and investigate the existing procurement chain models
2. Compare each model to determine the value provided to the owner
3. Provide a model for a more efficient procurement chain model.

A secondary goal of this research was to understand the impact of the procurement chain's vertical integration on each member of the procurement chain.

### **3.1 Research Methodology**

The objective of the research was to investigate each procurement chain practice and determine which practice provided the best value for project owners. To establish this, cost components associated with each model were identified and compared. In so doing, value-added components were separated from non-value-added components to measure the effect of each on the overall procurement process. Many factors were taken into account including: labor and material handling, cost of materials, completion time variations, rework and lead times. Each of these factors has different effects on production productivity – and therefore profitability – depending on which procurement model is utilized. In addition, the gathered data was used to understand the value-chain shift that will need to occur with the implementation of a new model and to determine the cost impact of the change.

Each of the factors can be divided into three main categories.

1. Time
2. Cost
3. Quality.

### **3.2 Data and Information Gathering**

The following steps were taken in conducting this study:

1. Literature research on each procurement chain model in the construction industry
  - ∞ Books on vertical integration, procurement chains, and other applicable topics
  - ∞ Construction and supply chain magazines
  - ∞ Supply chain-related research papers
  - ∞ News media Internet sites

- ∞ Internet sites of companies that are practicing GC procurement strategies
  - ∞ White papers conducted by companies both for and against each procurement strategy
  - ∞ Position papers published by associations in the construction industry.
2. Monthly meetings with a task force of experts in the construction industry – These individuals provided feedback on research findings and valuable information from their experience and industry involvement.
  3. An industry-wide survey – The surveys were administered to 1,000 members of the electrical, mechanical, sheet metal, and air conditioning industries.
  4. Interviews with 50 companies representing various segments of the procurement chain. Project owners, GCs, architects, engineering firms, SCs, distributors, and manufacturers were all included in one-on-one interviews.

### **3.3 Research Validation**

The task force of industry experts and leaders supports both the methodology and the conclusions of the research. The guidance and information they provided were instrumental in completing this research. The task force met monthly to review the progress and provide feedback on the research findings. Their experience and involvement in the industry were invaluable to the research.

In addition, an academic review board was assembled to validate the final results of this research project. Overall academic review board supports the neutrality and approach of this research. The individuals in the academic review board, however, recommend that a longer and more in-depth study is needed to validate the long-term impact of various procurement models.



#### 4.0 Industry Interviews

A wide range of companies was interviewed to gain the perspective of the entire supply chain. Every member of the supply chain from both the electrical and mechanical industries is represented in this research. The procurement chain members include

- ∞ Architects
- ∞ Engineers
- ∞ Project owners
- ∞ GCs
- ∞ SCs
- ∞ Distributors
- ∞ Manufacturers

The interviewed companies span the United States and are based across the country in locations such as Seattle, Detroit, Miami, Dallas, St. Louis, Los Angeles, Atlanta, and Washington, DC. The sales volume ranges from a few million dollars per year to billions of dollars per year.

In each interview, approximately two hours were spent with the company's decision-makers and managers with confidentiality promised to the interviewed executives. All the companies received the project objectives and an interview agenda specific to their industry in advance.

Over the course of this research, the following companies were interviewed:

1. Baker Electric, Inc.: Electrical Contractor, Escondido, CA
2. Brasfield & Gorrie: General Contractor, Atlanta, GA
3. Bruce & Merrilees Electric Company: Electrical Contractor, New Castle, PA
4. Butler Supply Company: Electrical/Plumbing Distributor, Fenton, MO
5. C & R Mechanical Company: Mechanical Contractor, St. Louis, MO
6. Capital Electric Construction Company: Electrical Contractor, Kansas City, MO

7. Capital Lighting & Supply: Electrical Distributor, Alexandria, VA
8. City Electric Supply: Electrical Distributor, Boston, MA
9. Cleveland Electric Company: Electrical Contractor, Atlanta, GA
10. Cogburn Bros, Inc.: Electrical Contractor, Jacksonville, FL
11. Collins Electrical Company, Inc.: Electrical Contractor, Stockton, CA
12. Cutler-Hammer: Electrical Product Manufacturer, Coraopolis, PA
13. Dee Cramer, Inc.: Mechanical Contractor, Flint, MI
14. Denier Electric Company, Inc.: Electrical Contractor, Ross, OH
15. DTE Energy: Energy and Energy Technology Provider, Detroit, MI
16. Dynaletric Company, Inc.: Electrical Contractor, Dulles, VI
17. Elk Electric, Inc.: Electrical Contractor., Austin, TX
18. Elliott Electric Supply Company: Electrical Distributor, Nacogdoches,  
TX
19. Ferguson Electric: Electrical Contractor, Buffalo, NY
20. Ferguson Enterprises: Mechanical Distributor, Newport News, VI
21. GE Industrial Systems: Electrical Product Manufacturer, Southfield,  
MI
22. General Motors: Automotive Manufacturer, Pontiac, MI
23. Graybar: Electrical Distributor, Flint, MI
24. Graybar: Electrical Distributor, Clayton, MO
25. Henderson Electric Company: Electrical Contractor, Stone Mountain,  
GA
26. Holder Construction Company: General Contractor, Atlanta, GA
27. Home Depot: Home Improvement Retailer, Atlanta, GA
28. Kyle Electric: Electrical Contractor, North Bend, OR
29. Lithonia Lighting: Lighting Manufacturer, Conyers, GA
30. MacDonald-Miller Facility Solutions, Inc.: Mechanical Contractor,  
Seattle, WA
31. McKinstry Company: Mechanical Contractor, Seattle, WA
32. Mills Electrical Contractors: Electrical Contractor, Dallas, TX
33. Newcomb and Boyd: Engineering Design Firm, Atlanta, GA

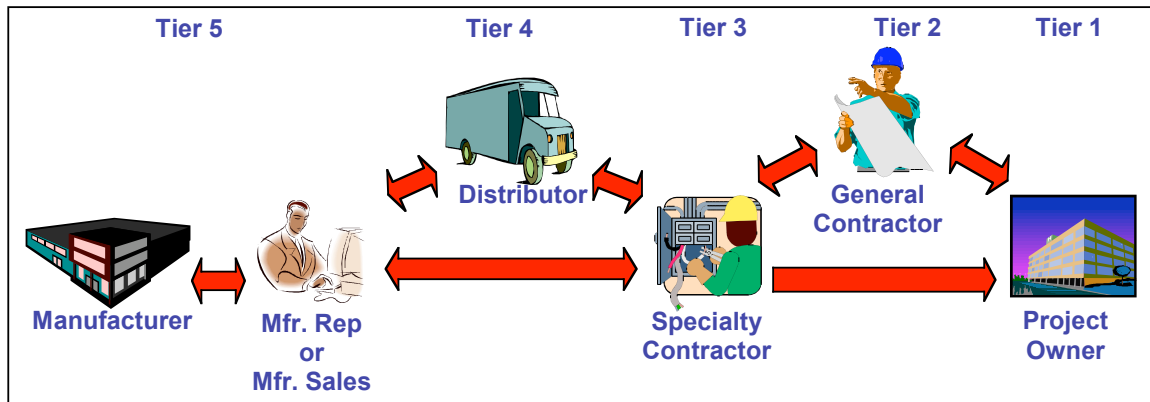
34. Newkirk Electric Associates, Inc.: Electrical Contractor, Muskegon, MI
35. Ozz Energy Corporation: Electrical Contractor, Toronto, Ontario
36. Parsons: Electrical Contractor, Minneapolis, MN
37. Southwire Company: Wire and Cable Manufacturer, Carrollton, GA
38. Square D: Electrical Product Manufacturer, Nashville, TN
39. State Electric Supply Company: Electrical Distributor, Huntington, WV
40. Tore Electric Company: Electrical Contractor, Belleville, NJ
41. Trane Corporation: HVAC Manufacturer, Lacrosse, WI
42. Tucker Mechanical, an EMCORP Company: Mechanical Contractor, Meriden, CT
43. Turner Properties: Property Manager for Turner Broadcasting System, Atlanta, GA
44. United Parcel Service (UPS): Courier Service
45. Universal Systems: Electrical Contractor, Flint, MI
46. University Mechanical Contractors, Inc.: Mechanical Contractor, Mukilteo, WA
47. WA Botting Company: Mechanical Contractor, Woodinville, WA
48. Wheatland Tube Company: Tube Manufacturer, Collingswood, NJ
49. Wiedenbach-Brown Company: Electrical Distributor, Norwood, MA
50. Winter Construction Company: General Contractor, Atlanta, GA

## 5.0 Construction Procurement Models

Construction is a complex industry where the needs of the project owner change over the duration of the project. The project owner relies on a network of manufacturers, manufacturing representatives, GCs, subcontractors, distributors, engineers, and architects to provide a high-quality product at the lowest possible price in a timely manner. In a construction project, material and equipment procurement has been targeted by owners as a place where they can lower the price of construction. Today, project owners employ a variety of methods to achieve perceived cost savings on material and equipment. The procurement methods prevalent in the construction industry are categorized into three different models. These models are

1. Specialty Contractor Procurement Model (SCPM)
2. Owner Procurement Model (OPM)
3. General Contractor Procurement Model (GCPM)

On a construction project, there are typically six major parties that are involved in procuring equipment and material. In each procurement chain model, the participation level of each party varies. Figure 2 shows the participants and their position in the supply chain for the SCPM. Historically, procurement in construction has been centered on the SCPM. The other two models, GCPM and OPM, bypass tiers within the supply chain in an effort to reduce the cost and time at each tier. For instance, in the OPM model, owners will bypass tiers 2, 3, and 4 and purchase equipment and material directly from the manufacturer. Both the GCPM and OPM remove major components of the supply chain, thereby affecting the path that products, money, service, and knowledge historically traversed.



**Figure 2. Basic procurement flow in the Specialty Contractor Procurement Model.**

When altering an existing model, a certain amount of risk is involved for the participating members of the model. Because SCPM has been the primary avenue for material and equipment procurement, members of the supply chain must review their operations and make the necessary adjustments when considering using a different supply chain model. Sometimes these adjustments require a major investment, and the business must determine whether the investment is in its best interest. In order to make this decision, a business must examine its current operations in the following areas:

- ∞ Internal business processes
- ∞ Supply chain integration
- ∞ Information technology.

This research examined the impact of these changes to determine the effects on the project owner and the other members of the supply chain.

Each supply chain model is defined by the method in which transfers are handled. The transfers between each tier can be categorized into three major groups:

- ∞ Tangible
- ∞ Service
- ∞ Knowledge.

The tangible transfers consist of physical items such as material, equipment, and money. These tangible items are the core of the supply chain. Knowledge and service transfers supplement the core exchange of products for

money. Product knowledge, safety knowledge, and experience ensure that installation is correct and efficient. Services are provided by members of the procurement chain to add value to the product. Knowledge and service transfers are important for quality, safety, reliability, application, time savings, and cost reduction. The combination of these three transfers provides value to the owner. The value that SCPM, GCPM, and OPM provide the owner is subject to question because the level of service and knowledge in each model has not been thoroughly studied. In Section 6.0, a detailed evaluation of both the GCPM and the SCPM is presented. OPM was also included in this research, but it was not the major focus of this study; therefore, an in-depth analysis of this model is not included in Section 6.0. The evaluation of each supply chain model yielded important knowledge that was considered when developing the preferred supply chain model presented in Section 7.0.

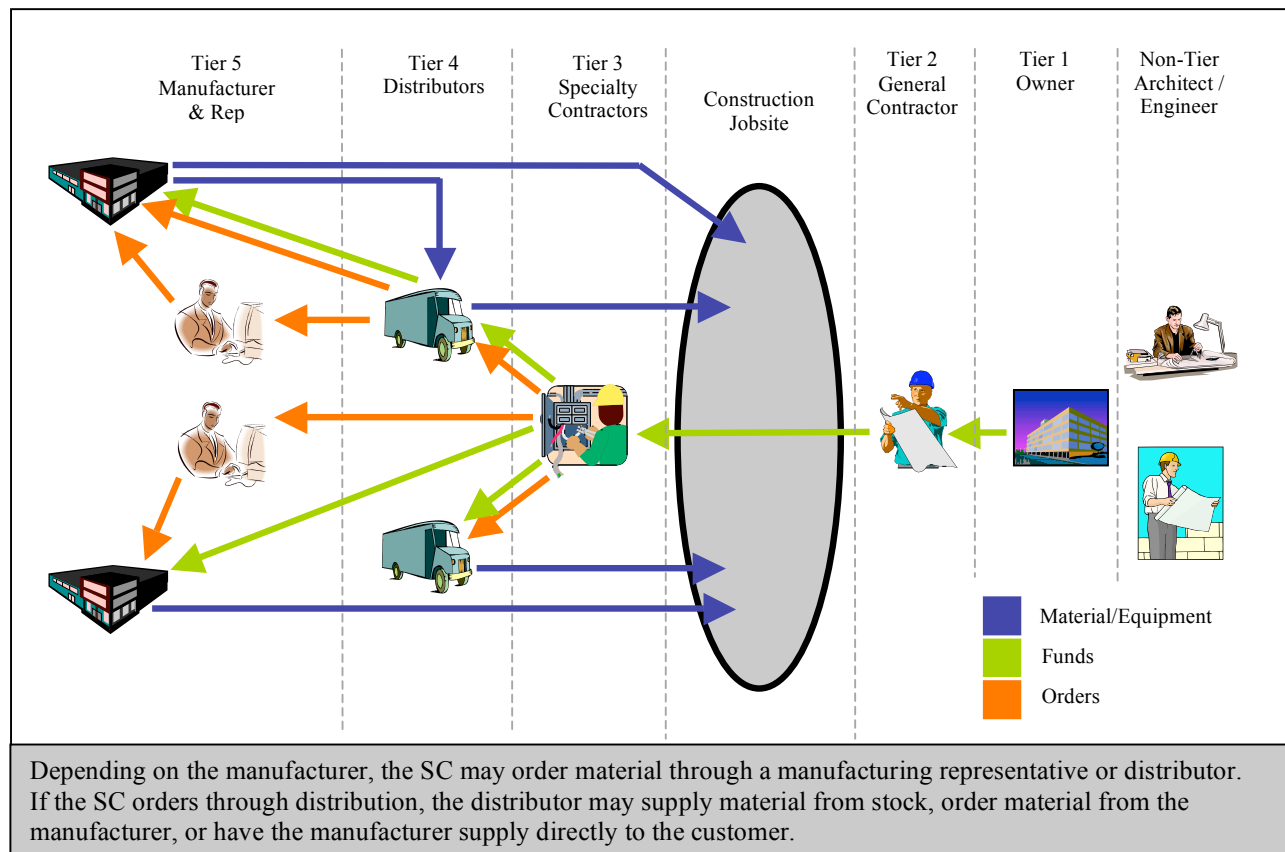
### **5.1 Specialty Contractor Procurement Model (SCPM)**

Today's construction industry predominantly uses the SCPM because material procurement has historically been the function of the SC. In this model, the owner and GC rely on the SC to procure all the equipment and material for the project. Today, owners use the SCPM model to procure build-to-order equipment over 80% of the time and use the SCPM over 90% of the time to procure commodity material.<sup>2</sup>

The majority of tangible material transfers occur between manufacturers, manufacturing representatives, distributors, and SCs. In the SCPM model, the SC has the opportunity to review the design specifications and notify the owner or GC of equipment or material incompatibility issues, design change recommendations, or lower cost equipment and material substitutions. Once the design is finalized, material orders flow from the SC to both the distributor and manufacturer. The material and equipment then flow back to the SC at the jobsite. The transfer of tangible items in the SCPM model is shown in Figure 3.

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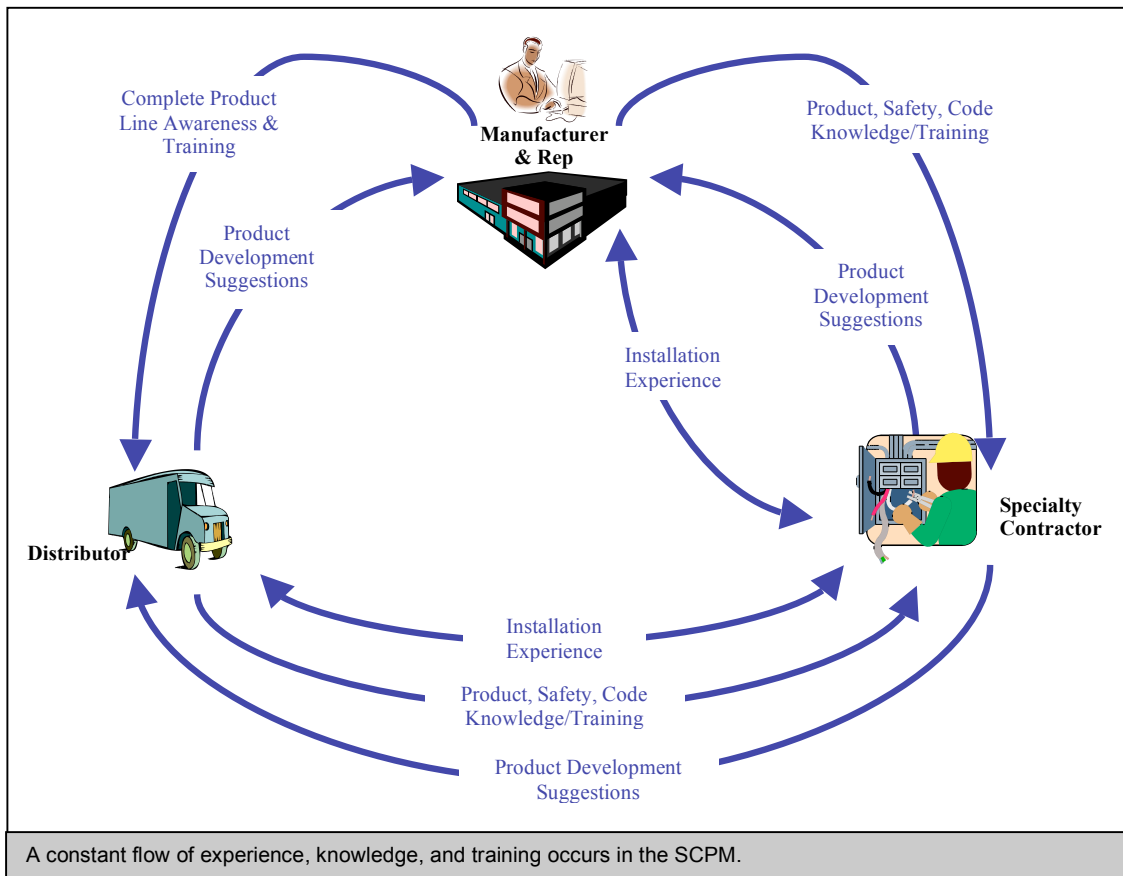
<sup>2</sup> Daneshgari, P., and Harbin, S. J. (2003). [Procurement practices in the construction industry]. Unpublished raw data.



**Figure 3. Basic flow of material/equipment, funds, and orders in SCPM with a single specialty contractor.**

The knowledge and service transfer in the SCPM model are also primarily between the manufacturers, distributors, and SCs. The knowledge transfer in this procurement chain model is shown in Figure 4. Many manufacturers rely on the distributor to provide product knowledge, safety knowledge, and general support to their customers and will invest in training their distributors. Other manufacturers who primarily sell directly to customers will provide knowledge and support to their customers themselves. The product knowledge and training of distributors and manufacturers, coupled with the SCs' project experience, results in opportunities for the SC to offer design options to the owner that may reduce cost and save time. The knowledge acquired through experience in this network is not limited to each individual SC performing the work, but instead

branches out to include the experience of competitors and peers in each tier. Specialty contractors have many forums to discuss best practices.



**Figure 4. Knowledge transfer that takes place in the SCPM.**

The service provided in the SCPM is supported by the SC and distributor. SCs can provide design review and optimization, material management, and labor/material coordination to lower labor costs and save time for the owner. Distributors offer services that make material readily available to the SC and offer customer support on warranties, product information, returns, and installation.

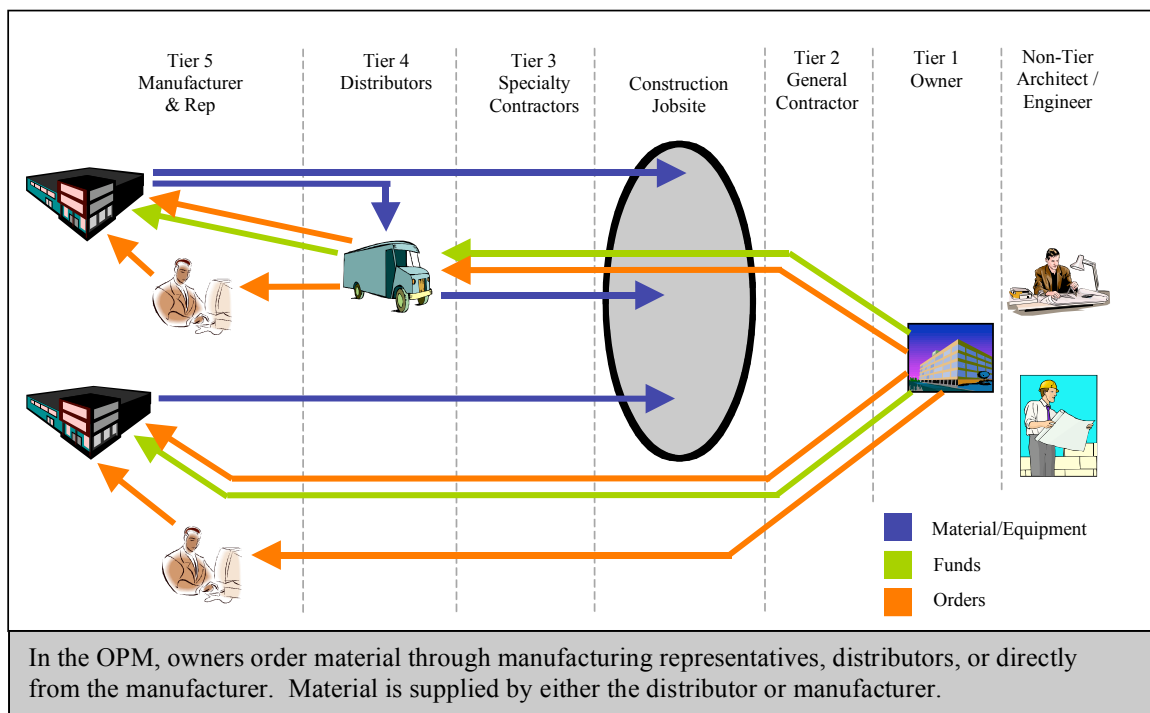
## 5.2 Owner Procurement Model (OPM)

The OPM is less common than the SCPM model in the construction industry, but it has been growing over the last 15 years. In this model, owners procure material and equipment directly from the manufacturer or from a



distributor. Typically the owner and manufacturer have developed processes that remove transactional costs from the supply chain. Today, owners utilize this model about 10% of the time for the entirety of their equipment and material purchases. This model is used more commonly for procurement of build-to-order materials than it is for commodity materials.

The tangible transfers in this model are directly between the owner and manufacturer. The owner typically relies on the design specifications created by the engineering firm and his or her own expertise to determine the correct material and equipment to procure. Input from the SC varies. Often, the owner has a standing relationship with individual SCs, and in these instances the SC may give input about materials to the owner. In the OPM model, once the material is ordered from the manufacturer, it is shipped directly to the jobsite and stored until installation by the SC. Most manufacturers are not structured to handle this type of relationship, but they will adjust if the owner can deliver a substantial amount of sales. The flow of tangible items for the OPM model is shown in Figure 5.



**Figure 5. Basic flow of material/equipment, funds, and orders in the OPM.**

The knowledge and service transfers in this model are very limited. SCs find it more difficult to obtain knowledge and service from manufacturers and distributors because the owner places the order in OPM. Knowledge is primarily acquired through the owner's past experience and through the design specifications that were developed for previous projects. OPM is primarily practiced by companies that have a good understanding of materials for their projects.

The OPM model is common in the construction of similar, repetitive structures such as chain stores and "big box" retailers. When constructing similar structures, the design specifications are comparable and improved over time. Equipment and material are usually standardized across a number of projects to ensure each structure is uniform.

Electrical utility companies are an example of owners who regularly practice the OPM model. The utility companies typically have a good understanding of electrical material due to their involvement in an electrical construction related industry. In addition, utility companies often have multiple electrical contractors performing similar work. It is advantageous for the utility company to procure a high volume of equipment themselves; compared to 9 or 10 ECs procuring the same equipment individually. The high volume usually gives the utility company better pricing on material and standardizes the brand of products installed on all their projects. Owners who employ the OPM believe that their own expertise, their relationships with manufacturers and SCs, and their buying power is sufficient to warrant buying directly from the manufacturer while simultaneously ensuring the desired level of quality for their construction projects.

### **5.3 General Contractor Procurement Model (GCPM)**

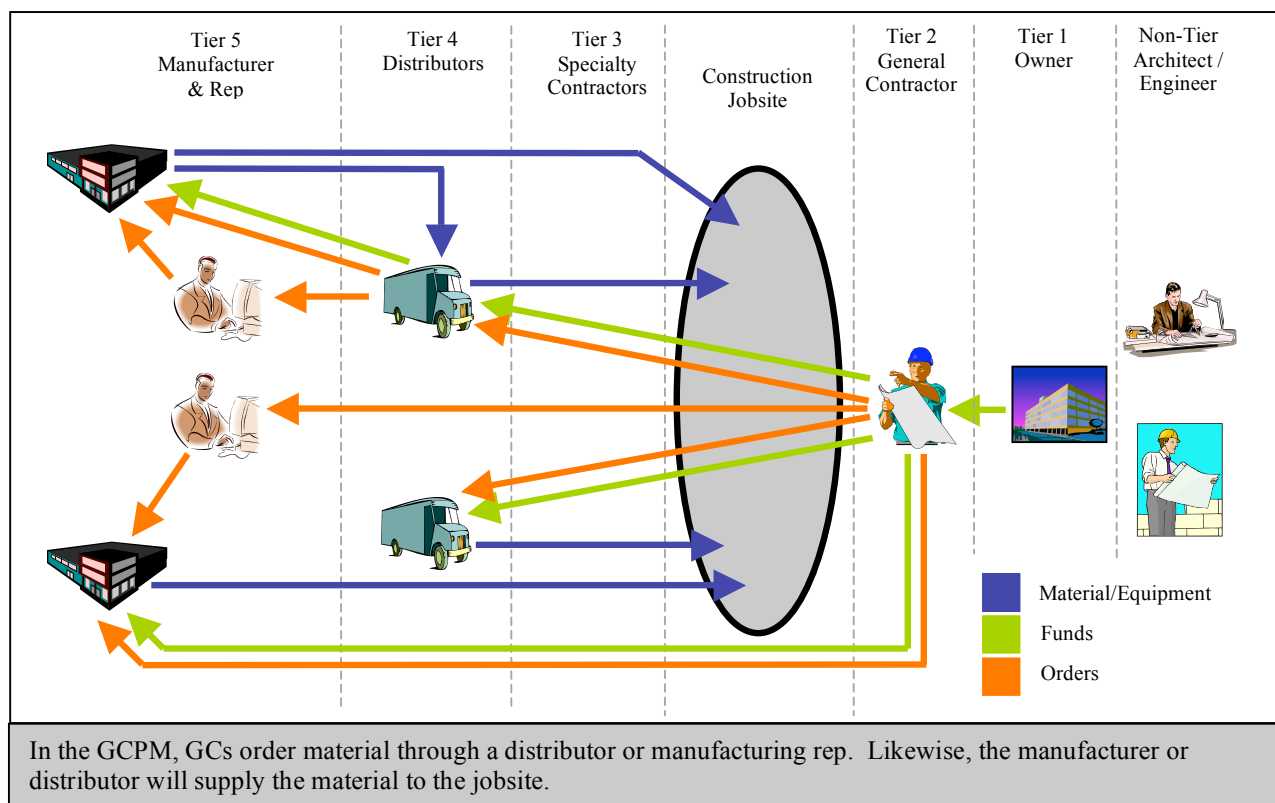
The GCPM is the least common purchasing model in the construction industry. This model was attempted throughout the 1990s and has been revived by GCs over the last 4 years. In this model, owners commission the GC to procure material and equipment. Often, the GC seeks to purchase all the

equipment and material directly from the manufacturers. However, most manufacturers are not set up to sell their products directly to customers, and they therefore require the GC to go through regular distribution channels. Today, owners utilize this model about 2% of the time for the majority of their equipment and material purchases.<sup>3</sup>

The tangible transfers in this model occur between the GC, distributor, and manufacturer or directly between the GC and manufacturer. Once the contract is given to the GC by the owner, the GC will purchase equipment and material without input from the SC. Typically, the GC either procures the equipment and material exactly as defined in the specifications or the GC may search for lower priced substitutions. Once the SC is selected, the GC may assign the purchase order to the SC. The SC then must assume responsibility for receiving the material on the jobsite, resolving inaccurate orders, returning products under warranty and resolving product incompatibilities. The tangible transfers within the GCPM model are shown in Figure 6.

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<sup>3</sup> Daneshgari, P., and Harbin, S. J. (2003). [Procurement practices in the construction industry]. Unpublished raw data.



**Figure 6. Basic flow of material/equipment, funds, and orders in the GCPM.**

The knowledge and service transfers in this model are similar to the knowledge and service transfers in the OPM model. The GC must depend on his or her own experience, as well as on details from the manufacturer and/or distributor in order to purchase the proper material. In the GCPM model, knowledge from installation experience does not exist because the specialty contractor who physically completes the material installation is absent from the material procurement process. The GC does not utilize the experience and knowledge of the SC because, in order to shorten procurement time, the GC purchases material and equipment before or during the SC selection process. As in the case of OPM, this model also attempts to bypass distribution in order to lower the material cost.

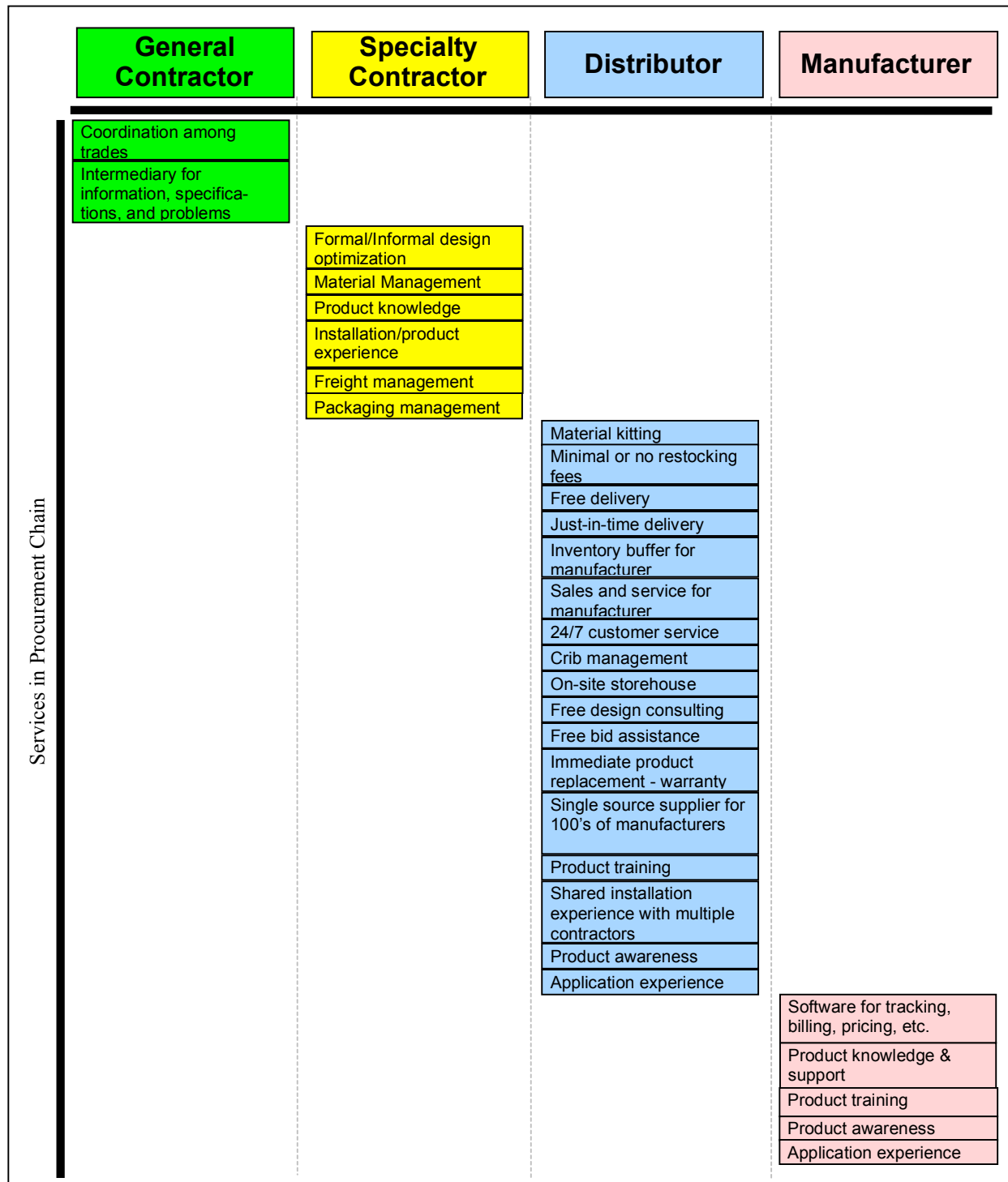
## 6.0 Model Evaluation

The main purpose of evaluating the procurement chain models was to determine how each model benefits the owner. The conclusions formulated through these comparisons were used to reach the final goal of establishing the value provided to the project owner in each procurement chain model. The comparisons focused on three main elements of a construction project that are important to the satisfaction of the owner:

1. Time
2. Cost
3. Quality

SCPM and GCPM each embrace a different approach towards each of these goals, both with the intention of achieving the best value for the owner.

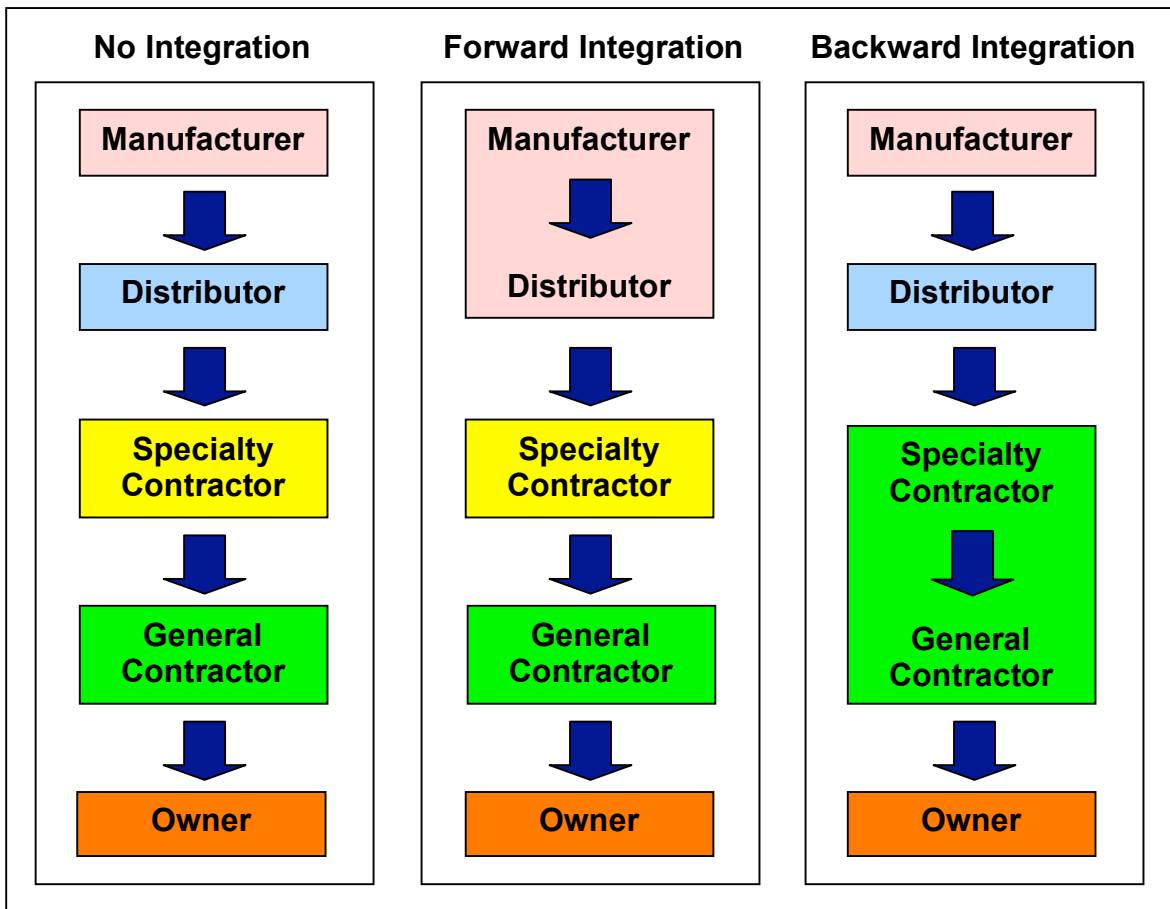
In the SCPM, time savings, cost reduction and quality are pursued without implementing vertical integration (See Appendix A) as in the case of GCPM. Each member of the procurement chain focuses on his or her core competencies to try and become more efficient at those competencies. For example, the core competency of the manufacturer is developing quality products that are demanded by the market, while the core competency of the distributor is establishing the correct combination of services and products to satisfy the demands of various customers. Depending on the nature of the product, the members of the SCPM are utilized to varying degrees to achieve maximum value for the owner. Some of the services provided by each member are shown in Figure 7. In the SCPM, service and knowledge of manufacturers, distributors and specialty contractors are the driving forces that provide maximum value to the owner.



**Figure 7. Services available from each member of the procurement chain in the SCPM.**

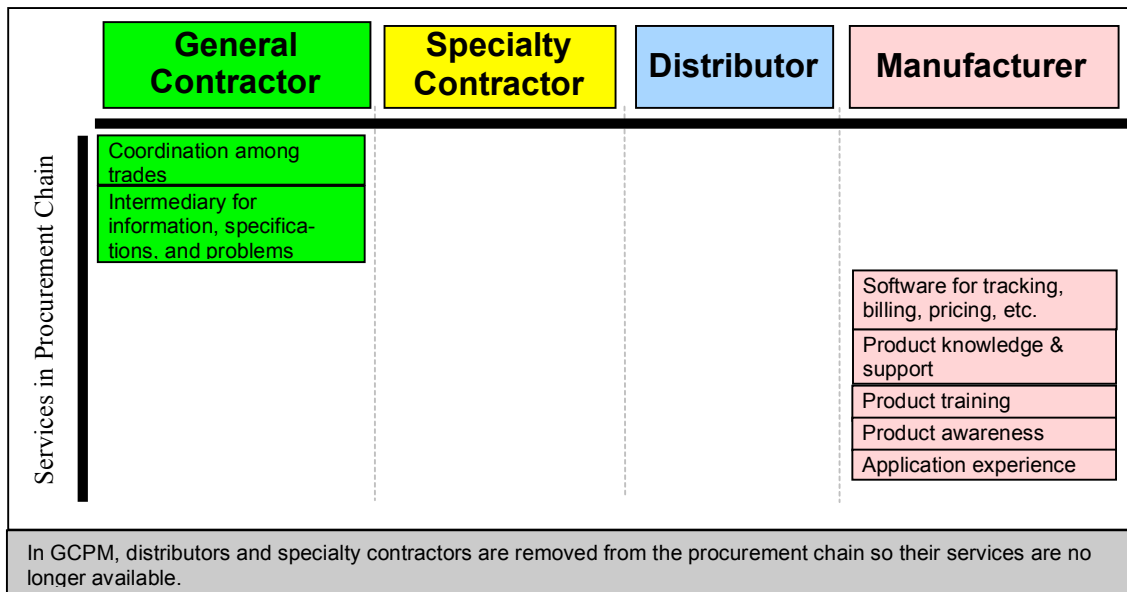
The GCPM promotes a model that varies greatly from the SCPM. In the GCPM, the procurement chain is a form of vertical integration (See Appendix A).

In vertical integration, the roles of supply chain members are forwardly integrated or backwardly integrated to compress the supply chain. Forward integration is when a member of the supply chain assumes the role of his or her immediate customer. In the GCPM, the GC desires the manufacturer to forwardly integrate their distributors and incorporate distribution into their business model as shown in Figure 8. Backward integration is when a member of the supply chain assumes the role of his or her supplier. The GC applies backward integration to the supply chain by taking on the procurement functions of the specialty contractors as shown in Figure 8. This attempt to vertically integrate the procurement chain causes the services of the specialty contractor and distributor to be lost in exchange for a presumed lower material price and time savings for the owner. The new service structure proposed in the GCPM is shown in Figure 9.



**Figure 8. Two types of vertical integration (1) Forward Integration  
(2) Backward Integration.**





**Figure 9. Services available from each member of the procurement chain in the GCPM.**

Opposition from manufacturers has arisen from the fact that they would be forced to provide some of the services that had previously been provided by their distributors. Figure 7 demonstrates that distributors provide a number of services to the manufacturer. Many manufacturers who rely on distribution have decided not to adapt to the GCPM and have required GCs to procure through distribution. These manufacturers force all products to go through distribution to avoid additional cost that would be incurred by their adoption of some of the distributors' services. The assumption in the GCPM is that eliminating the SC and distributor from the supply chain would avoid the markup and the extra time required to pass through these levels. This time and cost savings could be passed to the owner.

The owner receives the best value from the supply chain when there is a balance between service and cost. This balance varies according to the needs of the owner. The key factors that were considered in the evaluation of the GCPM and the SCPM affecting time, cost and quality are

- ∞ Product Savings
- ∞ Product Selection

- ∞ Material Management
- ∞ Design Optimization.

## 6.1 Product Savings

Some GCs suggest that the owner can save between 7% and 15%<sup>4</sup> on material and equipment by using the GCPM instead of the traditional SCPM. Figure 10 shows the theoretical calculation used by some GCs as their marketing tool to convince manufacturers to supply direct.

	Low	High	
Manufacturer Volume Discount	2%	5%	
Distributor Markup Reduction	7%	20%	
Specialty Contractor Markup Reduction	5%	15%	+
<b>Cost Reduction in GCPM</b>	<b>14%</b>	<b>40%</b>	
Cost Reduction in GCPM	14%	40%	
GC Markup	7%	25%	-
<b>Proposed Savings in GCPM</b>	<b>7%</b>	<b>15%</b>	

This calculation is a marketing tool used by some GCs to convince manufacturers to supply direct. Three main variables in this calculation are manufacturer volume discount, distributor markup and specialty contractor

**Figure 10. Theoretical material and equipment savings for the project owner using GCPM when compared to SCPM.<sup>4</sup>**

This calculation was provided by various manufacturers during the interview process. Some of the figures such as distributor markup<sup>5</sup> and manufacturer volume discount<sup>6</sup> were verified, however, this calculation only represents GCs' way of justifying pricing and it is not supported by this investigation. The savings is derived from a volume discount from manufacturers and removal of the SC and distributor markup from the procurement chain. Three assumptions are made in order to substantiate the proposed savings.

1. The manufacturer is willing to work directly with the GC.

<sup>4</sup> Savings presented by Turner Logistics to manufacturers, 2003.

<sup>5</sup> Profit Planning Group. (2003). NAED 2003 Performance Analysis Report. Boulder, CO: Author.

<sup>6</sup> Daneshgari, P., and Harbin, S. J. (2003). [Procurement practices in the construction industry]. Unpublished raw data.

2. The GC supports enough volume to receive a volume discount.
3. The SCs do not increase their prices to compensate for a much riskier labor only contract.

These three factors are obstacles in reaching the savings suggested in the GCPM. The actual savings between the GCPM and the SCPM was investigated and compared. In order to compare the markup between the GCPM and the SCPM, the two major purchasing practices supported by manufacturers were investigated: direct sales and distribution. In the following sections, GCs calculation is dissected and evaluated based on actual procurement practices in the construction industry.

#### **6.1.1 Savings from Direct Sales**

Some manufacturers, especially in the mechanical construction industry, support direct sales as their primary supply model because much of the equipment they sell is build-to-order. For example, heating, ventilation, and air conditioning (HVAC) manufacturers of large build-to-order equipment often sell directly to any customer because 90% to 95% of their sales are build-to-order.<sup>7</sup> Manufacturers in this situation have developed the infrastructure to provide sales to their customers without the support of distribution. Because these manufacturers bypass distribution and sell directly to any customer, the equipment is not subject to the 3% to 20% markup from distributors in either the SCPM or the GCPM. Furthermore, according to the Robinson-Patman Act, suppliers are required to sell products to competing entities for the same price; therefore, the manufacturer's selling price is the same for both the SC and the GC when competing. In special cases, the GC may be able to achieve better pricing through volume discounts, but this is also true for the SCs. Because the distributor markup is not included in this procurement practice, the formula presented in the GCPM has to be recalculated as shown in Figure 11. Based on this formula, the owner actually can save up to 10% more by using SCPM.

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<sup>7</sup> Daneshgari, P., and Harbin, S.J. (2003). [Procurement practices in the construction industry]. Unpublished raw data.

Proposed Savings			Actual Savings		
	Low	High		Low	High
Manufacturer Volume Discount	2%	5%	Manufacturer Volume Discount	0%	0%
Distributor Markup Reduction	7%	20%	Distributor Markup Reduction	0%	0%
Specialty Contractor Markup Reduction	5%	15%	Specialty Contractor Markup Reduction	5%	15%
		+			+
Cost Reduction in GCPM	14%	40%	Cost Reduction in GCPM	5%	15%
Cost Reduction in GCPM	14%	40%	Cost Reduction in GCPM	5%	15%
GC Markup	7%	25% -	GC Markup	7%	25% -
<b>Proposed Savings in GCPM</b>	<b>7%</b>	<b>15%</b>	<b>Actual Savings in GCPM-2%</b>	<b>-10%</b>	

Both specialty contractors and general contractors can procure direct from manufacturers who support direct sales. Therefore, both entities can bypass distribution. Furthermore, the majority of sales are not subject to better pricing from the manufacturer.

**Figure 11. Actual savings in the GCPM when compared to the SCPM when procuring directly from the manufacturer.**

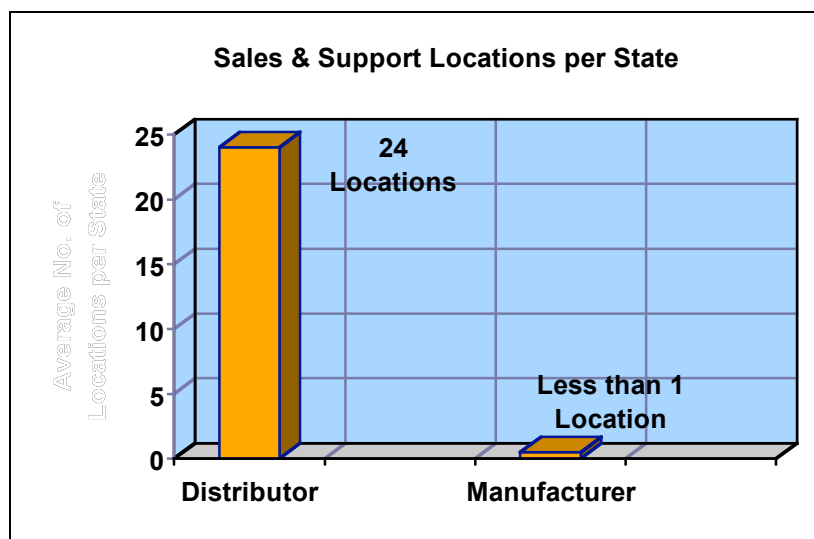
### 6.1.2 Savings from Distribution

Distribution is the other main supply model used by manufacturers. Manufacturers, especially in the electrical construction industry, use distributors to supply their material and equipment to customers. The manufacturers depend on the distributor for sales, customer support, delivery, credit services for customers, inventory, and training. Without the support of distribution, manufacturers would have to increase their selling price to provide the services normally handled by distributors. The additional service and production requirements that manufacturers would have to assume without distribution were investigated:

1. Sales and Support: Many manufacturers rely on distribution for sales and support. Electrical distributors' sales expenses for 2003 accounted for 9.3% of net sales.<sup>8</sup> This contributes to almost half of the average distributor's markup. Manufacturers would have to compensate for a loss in sales support from their distributors if the

<sup>8</sup> Profit Planning Group (2003). NAED 2003 Performance Analysis Report. Boulder, CO: Author

GCPM becomes prevalent. Also, the number of sales and support locations of both the distributor and the manufacturer were compared in the electrical construction industry and the results are shown in Figure 12. These locations are essential to provide local sales and support to customers for the manufacturer. Without distribution, manufacturers would have to compensate for this loss, create their own sales and support departments, increase their staff, add processes and procedures – and thereby increase the selling price of their products.



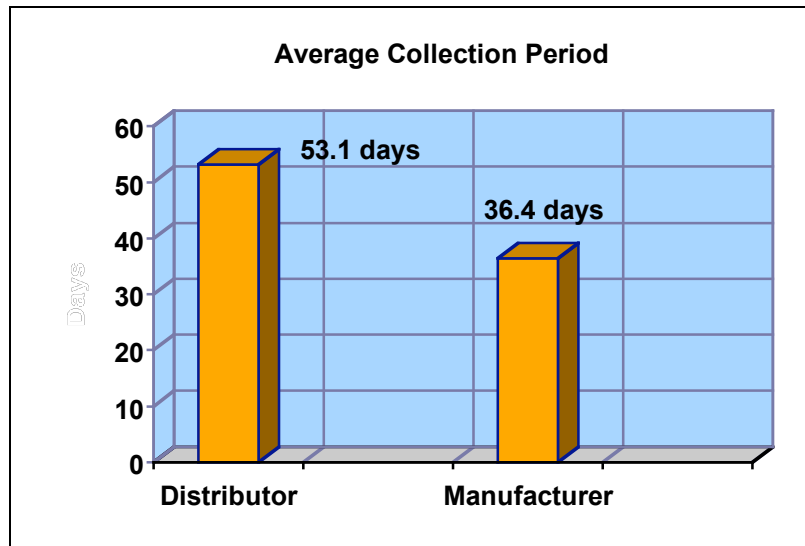
**Figure 12. Distributor and manufacturer comparison of sales and service locations per state.**

2. **Delivery:** Local distribution centers are also important to maintain timely delivery to the contractor. Many contractors rely on fast delivery in the case of emergencies, starvation, and other circumstances. Local distribution allows manufacturers to keep their products close to their customers. The average delivery period for products in stock by distributor and manufacturer is shown in Figure 13. The manufacturer would have to build a faster delivery structure into their business model in order to support the delivery times maintained by distribution.



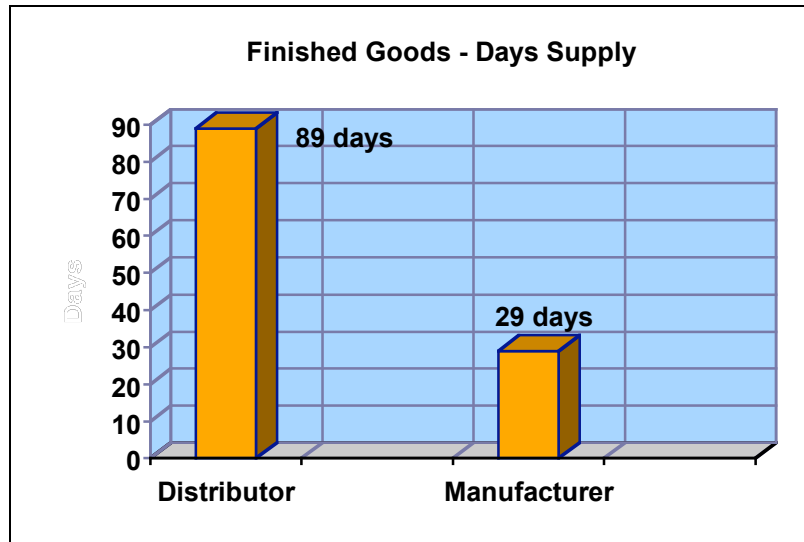
**Figure 13. Distributor and manufacturer comparison of delivery times for standard distributor stock items.**

3. Credit Service: Distributors create a credit buffer between the contractor and manufacturer. The manufacturer generally requires shorter payment terms from distributors than distributors require from their customers. In many circumstances, contractors do not get paid until they complete a percentage of the work. Distributors extend contractors the credit they need at the beginning of a project in order to buy the necessary materials for the project. Most manufacturers have a minimal collections department because distributors generally make payments within the specified terms. If manufacturers increase direct sales, they may have to increase their collections effort and manage the extended payment terms. These requirements could raise the manufacturers' cost. The average collection period of both distributors and manufacturers is shown in Figure 14.



**Figure 14. Distributor and manufacturer comparison of average collection time period.**

4. Inventory: Manufacturers strive to reduce their inventory and, in turn, rely on the distributor to act as the inventory buffer between production and product demand. Figure 15 shows the comparison of inventory sustained by the manufacturer and the inventory sustained by the distributor. The chart shows the inventory level in terms of “days’ supply.” Days’ supply is the number of days before inventory would be depleted without restocking. If distributors are removed from the supply chain, manufacturers will have to increase warehousing and manage a larger amount of inventory. These changes would increase the cost of their products to cover the larger expense.



**Figure 15. Distributor and manufacturer comparison of finished goods days' supply.**

The increased service and production cost is one reason many manufacturers have required non-distributor customers to procure equipment and material strictly through distribution. The GCPM suggests that GCs are able to bypass distribution to achieve savings, but most manufacturers have required GCs to procure through distributors as well. When determining the savings of GCPM, the savings must be re-evaluated to figure in the cost of distribution for a large percentage of the products. The actual savings, when procuring through distribution, is shown for both the SCPM and the GCPM in Figure 16. If the GC were able to bypass distribution, distributor markup could be removed but manufacturer selling price would increase. The actual increase in manufacturing pricing could not be adequately determined during this research and is therefore not included in the calculation in Figure 16.



Proposed Savings			Actual Savings		
	Low	High		Low	High
Manufacturer Volume Discount	2%	5%	Manufacturer Volume Discount	0%	0%
Distributor Markup Reduction	7%	20%	Distributor Markup Reduction	0%	0%
Specialty Contractor Markup Reduction	5%	15%	Specialty Contractor Markup Reduction	5%	15%
		+			+
Cost Reduction in GCPM	14%	40%	Cost Reduction in GCPM	5%	15%
Cost Reduction in GCPM	14%	40%	Cost Reduction in GCPM	5%	15%
GC Markup	7%	25%	GC Markup	7%	25%
		-			-
<b>Proposed Savings in GCPM</b>	<b>7%</b>	<b>15%</b>	<b>Actual Savings in GCPM-2%</b>	<b>-10%</b>	

Since many manufacturers require sales go through distribution, the distributor markup can typically not be reduced in GCPM when procuring commodity material and other products sold through distribution.

**Figure 16. Actual savings in the GCPM when compared to the SCPM when procuring through distributors.**

### 6.1.3 Risk on Labor-Only Contracts

The two main components of direct cost for a specialty contractor are labor and material. For electrical contractors, the split is almost even with 35.3% allocated to material and 35.0% allocated to labor.<sup>9</sup> Material is a very low risk element of a construction project that ensures the SC a set profit. Labor, on the other hand, is a very risky element of any construction project. Two major sources of risk that must be considered when estimating the cost of labor are

1. Human Characteristics
2. Worksite Conditions.

Workers are human, and they perform work at different productivity levels. Factors that affect this are age, experience, and skill. Worker motivation is another human factor that is difficult to control and predict including absenteeism, starting work late, ending work early, or extended break periods. The level of output produced by workers is affected by these human characteristics and cannot be fully predicted when estimating labor cost.

The conditions on the worksite can also increase labor cost. Weather such as rain, snow, humidity, extreme temperatures, and other debilitating weather

<sup>9</sup> Industry Insights, Inc. (2000). Electrical Contractors' Financial Performance Report. Columbus, OH: Author

conditions can have a dramatic affect on labor. These factors are very difficult to gauge and have a volatile impact on labor cost. Furthermore, labor output declines in overcrowded work areas and when overtime is required over long periods of time. SCs have control over their own labor force and are responsible for preventing these conditions or compensating for them in the estimate if unavoidable. Many times, however, overcrowding and overtime result from unforeseen circumstances outside the control of the SC, such as manufacturing delays, conflicts between trades, labor shortages, or one of many possible circumstances. These worksite conditions can cause major fluctuations in labor cost and increase the risk of estimating the cost of labor.

If material contracts are taken away from SCs, they are left with very risky labor-only contracts. When handling a labor-only contract, many contractors include a sufficient cushion to avoid the risk factors associated with these contracts. The additional markup added to a labor-only contract varies between contractors,<sup>10</sup> but it is a common practice and necessary to prevent potentially major losses.

## **6.2 Product Selection**

A wider product selection gives the owner better control over installation time, product price, and product standardization. When many manufacturers are available, the owner can shop for the best price, delivery time, and brand of choice. The GCPM and the SCPM were compared to determine which model offers the best product selection for the owner.

The theory of the GCPM has GCs purchasing products directly from manufacturers instead of from distributors. This limits the choices available to the GC for three main reasons:

1. Many manufacturers do not sell directly to GCs or owners because their business model is to supply their products through distribution.<sup>11</sup>

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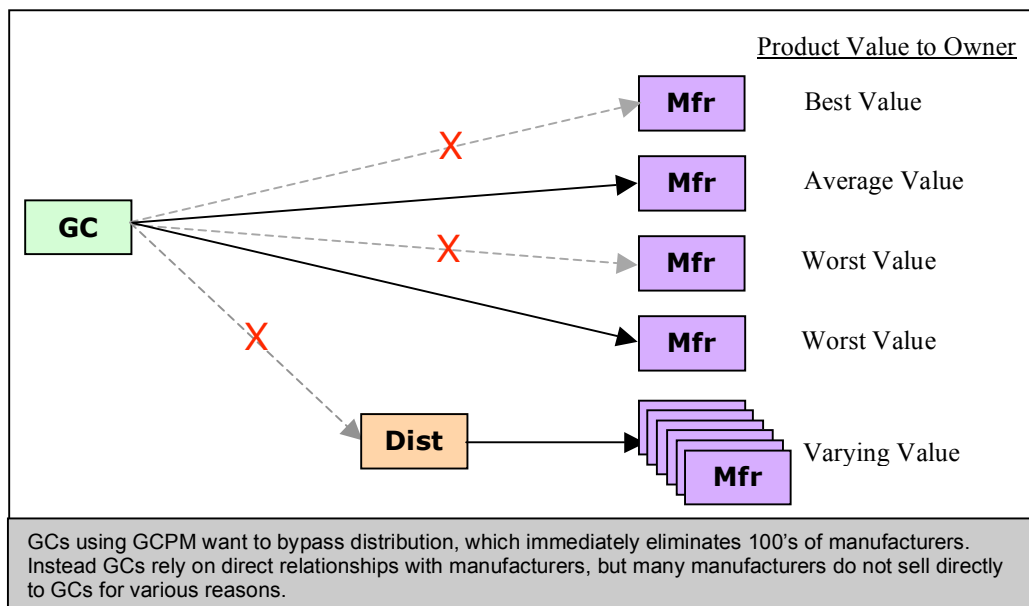
<sup>10</sup> Daneshgari, P., and Harbin, S. J. (2003). [Labor-only contract management in the construction industry]. Unpublished raw data.

<sup>11</sup> Daneshgari, P., and Harbin, S. J. (2003). [Procurement practices in the construction industry]. Unpublished raw data.

These manufacturers depend on distributors for sales, customer support, credit handling, inventory, and other functions. This limits the access of GCs to many manufacturers.

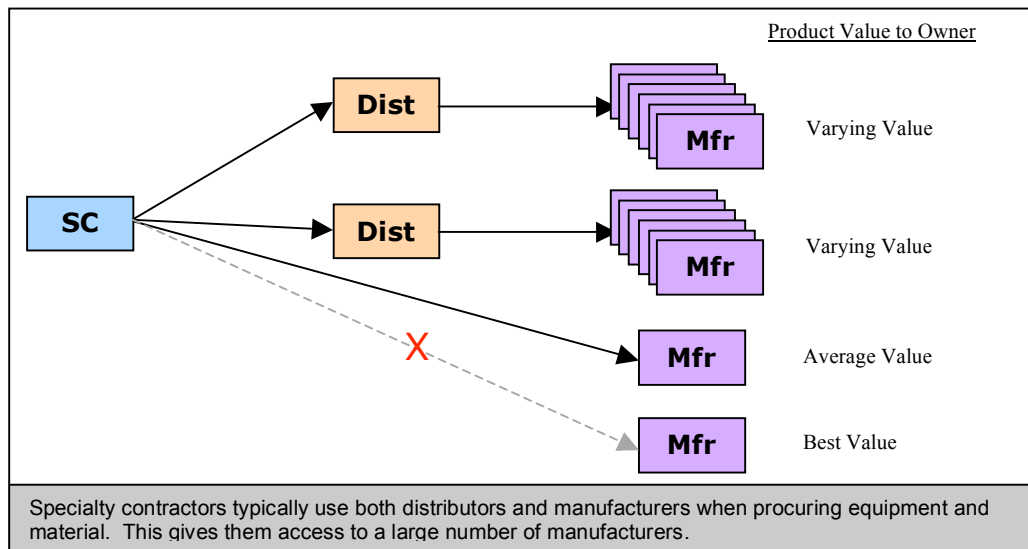
2. The GCs' decision to bypass distribution has limited their access to many manufacturers. Distributors offer quick access to hundreds of manufacturers. The GCPM theory is based on the premise that GCs will have to spend a significant amount of time and money establishing relationships with hundreds of manufacturers to offer the same product selection that is available in the SCPM.
3. Some distributors have a sales and service structure that caters to a certain market such as Original Equipment Manufacturers (OEM), Maintenance Repair and Operations (MRO), SCs, or other owners – and these distributors will not adjust their infrastructures to service GCs because it has proven to be less profitable. Therefore, these distributors may avoid selling to GCs.

These factors have resulted in poor access to products for GCs, as shown in Figure 17.



**Figure 17. Product selection in the GCPM.**

The SCPM gives the owner more options because SCs primarily use distribution for procurement whereas GCs primarily pursue direct purchasing from manufacturers. Distributors provide the SC with access to hundreds of manufacturers. SCs, also, have the same access as GCs to all the manufacturers that supply direct. Figure 18 shows the SCs' access to manufacturers.



**Figure 18. Product selection in the SCPM.**

## 6.3 Material Management

Managing material procurement can have a significant impact on the time and cost of a project. Material management is important for ensuring timely delivery of long-lead items, labor productivity, and manpower coordination. Both the SCPM and the GCPM were evaluated to determine which model provides the best value through management of commodity material and build-to-order equipment.

### 6.3.1 Managing Product Flow

In the SCPM, material management is often inefficient. This inefficiency has resulted in inflated material cost and an unproductive workforce. SCs primarily order commodity material in large quantities and have it stored on the jobsite or in their warehouse. Whatever material and equipment isn't installed is

usually returned to the SC's warehouse and stored for future projects. This material management practice has increased the cost of material and the cost of labor for SCs, and this problem has not been adequately addressed by most SCs.

Many SCs have money locked away in unused material that is stored from previous projects. Sometimes the material and equipment stored in the warehouse may never be used again. Also, since funds may be allocated to leftover material and equipment stock, the SC could have limited access to money, which may lead to additional cost such as credit expenses. Another costly issue in the SCPM is labor productivity. The average time spent on handling material and other associated material management by electrical contractor's labor is 40%.

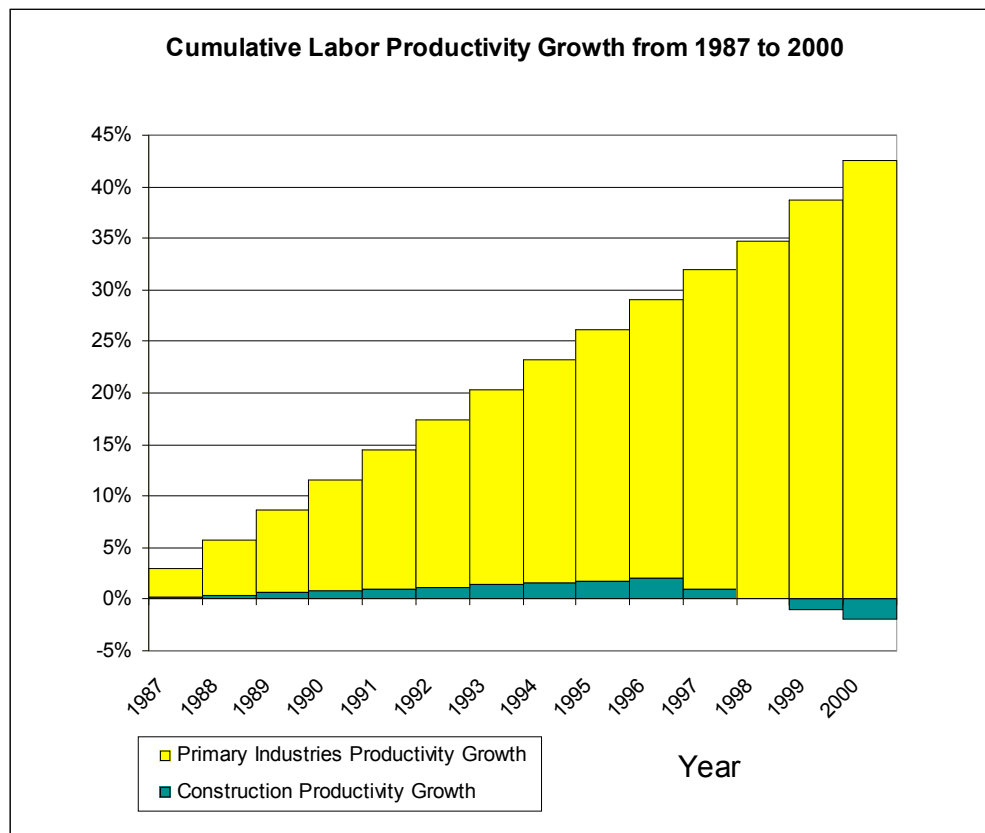
Furthermore, over the period from 1973 to 1997 construction labor productivity declined a total of approximately 5.2%.<sup>12</sup> During this period, an average of only 47.7% of the labor's time was spent directly working on the project.<sup>12</sup> Figure 19 shows the change in labor productivity from 1973 to 1997.



**Figure 19. The trend of construction labor productivity from 1973 to 1997.<sup>12</sup>**

<sup>12</sup> Haas, C. T.; Borchering, J. D.; Allmon E.; Goodrum, P. M. (1999). U.S. Construction Labor Productivity Trends, 1970-1998, Austin, TX: Center for Construction Industry Studies, The University of Texas at Austin.

Another study has shown that productivity growth in the construction industry lags far behind other industries. Construction productivity growth increased 0.2% annually from 1987 to 1996 and -1.0% annually from 1996 to 2000.<sup>13</sup> On the other hand, other primary industries have experienced productivity growth of 2.7% annually from 1987 to 1996 and 3.9% annually from 1996 to 2000.<sup>14</sup> This comparison of productivity growth is shown in Figure 20. Material management has not been properly addressed in the SCPM and must be considered when developing the preferred procurement chain model.



**Figure 20. Cumulative labor productivity growth from 1987 to 2000.<sup>14</sup>**

GCPM is an attempt to improve the construction supply chain, but the same material management issues arise in this model. GCs store commodity

<sup>13</sup> Faruqui, U.; Gu, W.; Kaci, M.; Laroche, M.; and Maynard, J. (2003). Differences in productivity growth: Canadian-U.S. business sectors, 1987-2000. Monthly Labor Review April 2003, 16-28.

<sup>14</sup> Faruqui, U.; Gu, W.; Kaci, M.; Laroche, M., and Maynard, J. (2003). Differences in productivity growth: Canadian-U.S. business sectors, 1987-2000. Monthly Labor Review April 2003, 16-28.

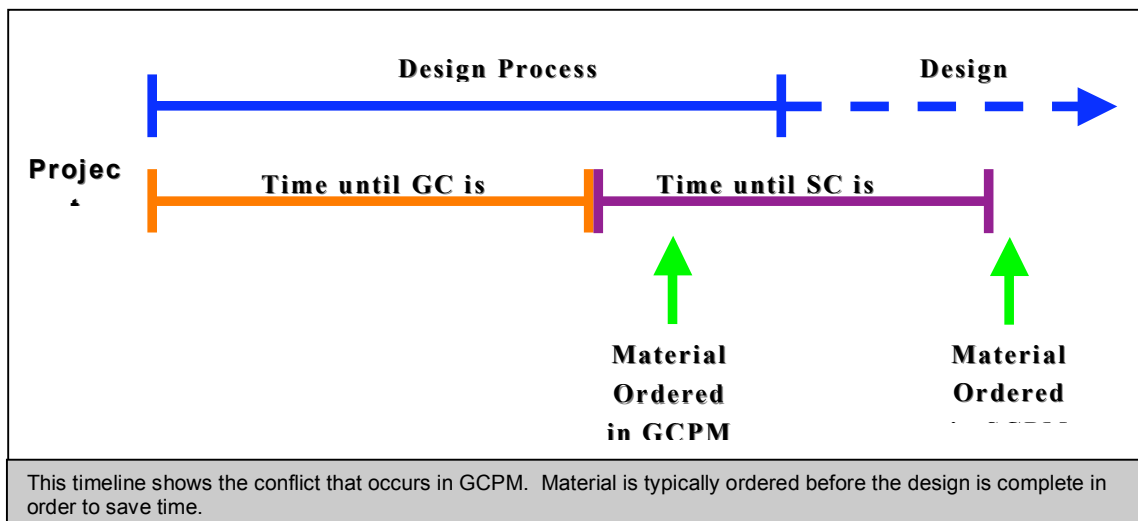
material on the jobsite in bulk as in SCPM. Sometimes material and equipment management is even more difficult in GCPM because the SC and distributor are excluded from the delivery and storage process. This may result in excess time spent handling material and equipment because of poorly chosen storage locations, inefficient material organization, or shipping issues with build-to-order equipment. The excess time creates problems with labor productivity and increases material cost, both of which are often more serious than the issues that arise in the SCPM. In most cases, both the SCPM and the GCPM suffer from inefficient material management strategies, which generate waste in the construction process. There is a substantial need for material management improvement in the supply chain.

### **6.3.2 Managing Details of Build-to-Order Equipment**

Build-to-order equipment can require extensive time for manufacturing and delivery. This required time period can potentially delay the project beyond the owner's desired completion time. The two procurement models approach this issue differently. Both methods intend to provide the owner with the fastest occupancy. The GCPM proposes that, if the GC procures equipment early in the project, before the SC is selected; long-lead items can be delivered to the jobsite earlier – thus reducing the time span of the project. The SCPM proposes that, if the SC procures equipment, the ordered equipment will be more accurate and reduce time-consuming rework and returns later in the project – even though the equipment will be purchased later in the project schedule.

The premise of the GCPM is that the GC is in a better position than the SC to procure long-lead items because the GC is selected before the SC and is therefore involved in the project earlier. Since the SC is selected later in the project, the GCPM can provide time savings to the owner. Yet, some problems are more likely to arise in the GCPM – and one reason why problems often occur in the GCPM is because the GC procures equipment before the design is complete. In the GCPM, where the owner secures the services of a GC before the design specifications are complete, the GC often procures equipment shortly after

he or she is selected in order to save time in the procurement process. This scenario is shown in Figure 21.



**Figure 21. Timeline for design process, contract selection, and procurement**

GCs rely heavily on the design specifications for ordering equipment because they do not have the same knowledge and experience SCs possess. Therefore, since the design is not complete and the GC does not have the experience to analyze it fully, more time may be spent correcting problems with the build-to-order equipment after it is ordered. When procuring specialized equipment, there are many factors that must be considered during order placement, such as accurate specifications, shipping requirements, equipment option selection, and jobsite delivery coordination.

1. Accurate specifications: SCs have extensive installation experience and may notice inaccurate specifications or compatibility issues that the GC may overlook. The architect and engineering firm are not always 100% accurate in their design specifications, and sometimes they do not account for problematic installation requirements that are more apparent to someone with installation experience such as the SC. If a build-to-order product is ordered incorrectly, extra time is required to re-build or return the item. For example, on the West Coast, a GC



ordered an HVAC system that was specified incorrectly. The HVAC system had to be modified, which lead to over \$300,000 in additional expenses.<sup>15</sup>

2. Equipment option selection: SCPM is also beneficial to the owner because the SC can eliminate unnecessary options that may add time to the manufacturing process. This may also reduce the cost of equipment.
3. Shipping requirements: Some equipment requires special shipping conditions. This is becoming more prevalent, especially as the government and safety organizations press for more environmental regulations. Special shipping conditions are often necessary in the HVAC industry where concerns of dangerous mold are present. When shipping or storing certain HVAC equipment, moisture control must be administered to the unit before shipping in order to prevent mold or other damage. It is the purchaser's responsibility to ensure that all shipping requirements are specified before the equipment is shipped. For example, a general contractor in the Washington area procured an HVAC system without specifying the proper moisture regulations that were required for the project owner. This error resulted in a delay and additional cost so that the HVAC equipment could be tested once it arrived on the jobsite.<sup>16</sup>
4. Jobsite delivery coordination: On the jobsite there are many obstacles to avoid when moving equipment to its designated location. Depending on its size, equipment may need to be delivered in multiple pieces to pass through doorways or other obstacles. Appropriate machinery such as cranes or forklifts may need to be coordinated with delivery. Without proper installation experience, this coordination could result in lengthy and costly delays.

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<sup>15</sup> Daneshgari, P., and Harbin, S. J. (2003). [Study of mechanical contractor on the West Coast of the U.S.]. Unpublished raw data.

<sup>16</sup> Daneshgari, P., and Harbin, S. J. (2003). [Study of mechanical contractor on the West Coast of the U.S.]. Unpublished raw data.

While researching various projects, major problems occurred in all four of these categories of equipment management in the GCPM. The underlying cause of these problems was the GCs' lack of installation experience and product knowledge. However, if projects are repetitive and the design is optimized and verified, then the GCPM is an option for procuring build-to-order equipment earlier in the project.

In SCPM, procurement is delayed until the SC is selected. This delay allows time for the design to be completed. Once the SC is selected, the SC inspects the design specifications and notifies the GC or owner of any discrepancies. The SC may also provide suggestions to optimize the design. This is a planning measure that results in substantially fewer procurement problems later in the construction project. The reduction in procurement errors is a result of the more extensive knowledge transfer existing in the SCPM. SCs often share their collective installation experience within peer group settings – and this installation information is also shared with distributors and manufacturers. This method of knowledge transfer is highly effective because SCs are the only members of the procurement chain who are directly involved with material installation. This direct involvement provides them with the most application experience of anyone in the procurement chain.

## **6.4 Design Optimization**

An advantage of the SCPM that is not available in the GCPM is the design optimization offered by specialty contractors. The GCPM does not use this advantage because, in order to save time, equipment is procured before the specialty contractor is selected. After equipment is ordered, the design can no longer be revised without incurring major expenses if equipment has to be returned or rebuilt. Since the architect and engineering design firm do not have the installation experience of specialty contractors, SCs may find ways to optimize the design or detect design flaws that have been overlooked.

The design optimization provided by specialty contractors can occur informally during the specialty contractor's procurement process or formally

through a design optimization method referred to as value engineering. Value engineering is a strategy used by owners to give SCs the opportunity to evaluate the proposed design for the project and offer money saving revisions. A project on the West Coast was studied to determine the savings achieved with value engineering. The results of this study show that the owner was able to save 13% on a \$58 million project<sup>17</sup>. This saved the project owner more than \$7 million. If this design optimization were applied to a GCPM, there would no longer be a time savings component. The SC would already be involved in the project, design specifications would have been set – and equipment would have been purchased under the premise that time can be saved by procuring equipment before the SC is selected. Design optimization can provide a major cost and time savings to a project owner, so the owner must weigh the benefits of design optimization for his or her design specifications when deciding which procurement model to choose.

## **6.5 Summary**

The evaluation of GCPM and SCPM provided evidence that SCPM is favorable over GCPM, but that the supply chain in general is still fragmented and inefficient. GCPM was an attempt to resolve waste in the supply chain, but it has proven to be even more inefficient than the predominant model, SCPM. GCPM promotes the practice of vertical integration (See Appendix A) in order to address the fragmented nature of the supply chain. The vertical integration strategy employed in the GCPM has resulted in restricted product selection, minimal or nonexistent price savings, and risky time-saving strategies when compared to the SCPM. On the other hand, supply chain members of the SCPM are isolated in nature and are not integrated, which is also inefficient. There are some exceptions as manufacturers and distributors become integrated through electronic data interchange (EDI), but the majority of relationships are governed by adversarial relationships in which each company focuses on its bottom line. Both GCPM and

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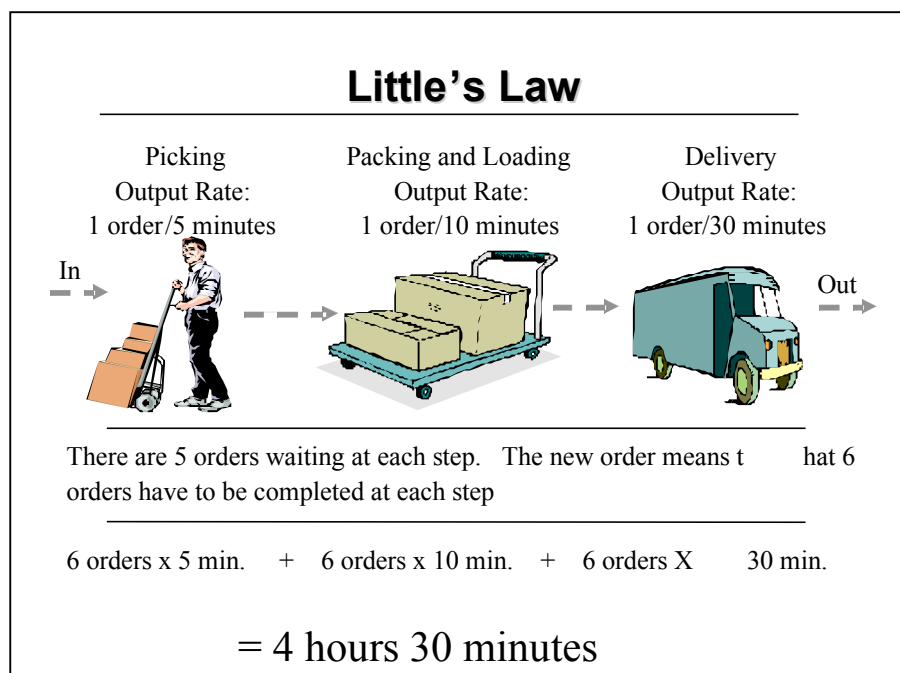
<sup>17</sup> Daneshgari, P., and Harbin, S. J. (2003). [Study of mechanical contractor on the West Coast of the U.S.]. Unpublished raw data.

SCPM primarily focus on the direct cost and availability of product and neglect the benefits of properly managing the product and labor. The lack of proper management is not intentional but is instead a lack of horizontal integration (See Appendix A).

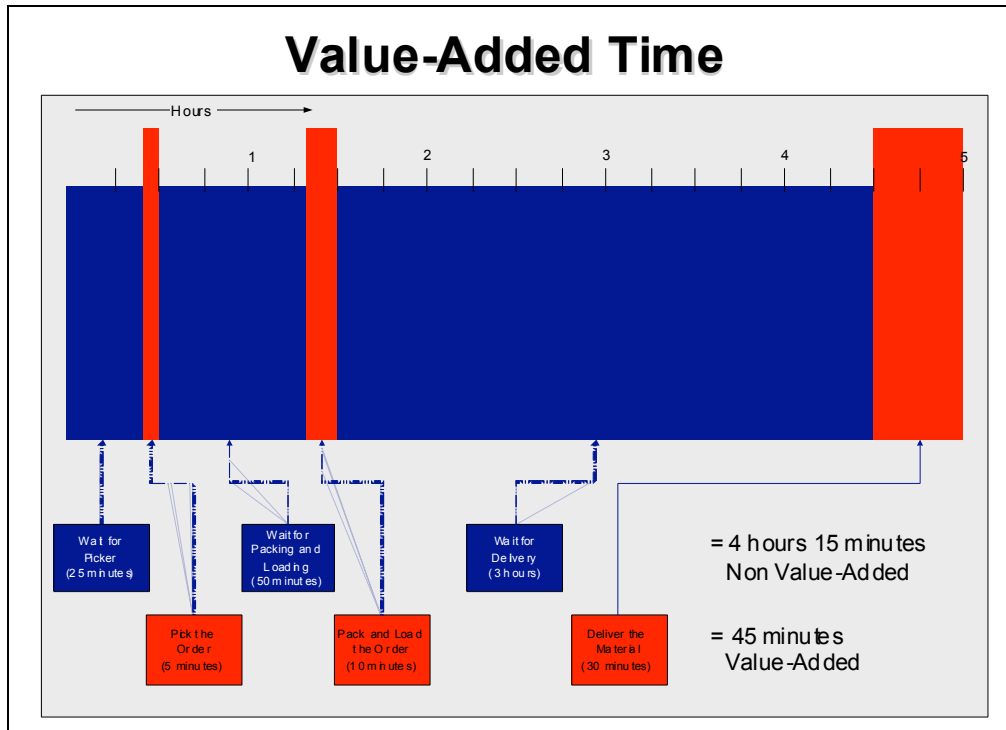
Horizontal integration is essentially achieved by exploring the needs of customers and suppliers and then restructuring the operational model to meet these needs. Many times companies focus only on the price of a product. Sometimes, companies will take support and customer service into account when choosing a supplier as well. While these issues are important, collaboration between supply chain members can yield savings that surpass the factors directly associated with the product. In horizontal integration, supply chain members come together to discuss their needs beyond the scope of product. When this occurs, the customer-supplier relationship can be utilized to address issues such as labor productivity, billings, material management, and other factors that are usually foregone in favor of securing the best price on material and equipment. The proposed procurement chain model is presented in Section 7.0. This model can potentially impact the construction industry by improving labor productivity, reducing cost, and improving delivery and quality of construction projects.

## 7.0 Alternative Procurement Chain Model

Horizontal integration is defined as a collaborative reduction of cost among the stakeholders of any activity chain. The horizontal integration model is best practiced in the automotive industry, specifically Toyota. When applying horizontal integration, all the participants in the supply chain use their expertise to reduce non-value-added activities and reduce the work in process (WIP). The practice of reducing WIP is an application of Little's Law, illustrated in Figure 22. Little's Law is a principle of system design and governs nearly all batch and queue work flow. For example, when a supplier processes an in-stock order, it takes five minutes to pick each order. If there are five orders in the queue, it will take 30 minutes to pick the new order. If the process then takes ten minutes per order to pack and load onto the truck, the packing and loading step will take one hour total. Assuming that delivery takes 30 minutes per order, the delivery step will take a total of 3 hours. The total time to deliver the material took four hours and 30 minutes – even though only 45 minutes were dedicated to the specific order. The breakdown of value-added versus non-value-added time is shown in Figure 23.



**Figure 22. Little's Law example of a simplified order fulfillment process.**



**Figure 23. Timeline diagram representing the value- and non-value-added time in a simplified order fulfillment process.**

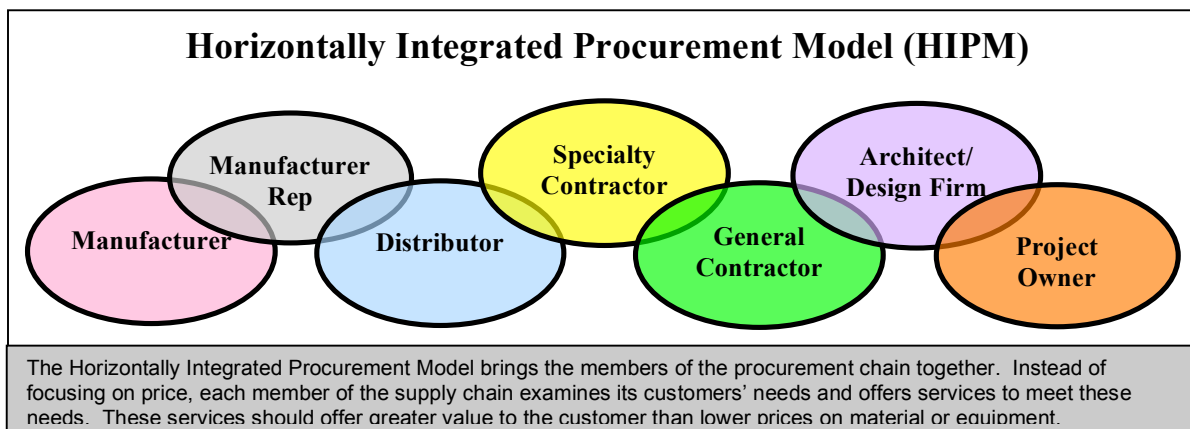
While price and availability of product will always be important, there are other pressing issues that have a much greater impact on the bottom line for supply chain members. The supply chain practices in the construction industry have resulted in poor productivity. Electricians spend 40% of their time handling material and equipment. Productivity of construction labor has declined 2.0% from 1987 to 2000 while productivity growth in other primary industries increased 44.4% over the same time period.<sup>18</sup> Order placement is still handled with hundreds or thousands of individual purchase orders.<sup>19</sup> Equipment and material is shipped to the jobsite in a manner that prevents agile movement around the construction site. Many contractors still store material in bulk on the jobsite for labor to mill through and then carry to the installation location. There

<sup>18</sup> Faruqui, U.; Gu, W.; Kaci, M.; Laroche, M.; and Maynard, J. (2003). Differences in productivity growth: Canadian-U.S. business sectors, 1987-2000. Monthly Labor Review April 2003, 16-28.

<sup>19</sup> Daneshgari, P. (1996-2003). [Accounting practices of contractors in the construction industry]. Unpublished raw data.

are many more prominent issues with the procurement chain which need to be addressed, but are not. For the right price, material is sold while productivity is overlooked. This is a result of a fragmented construction supply chain where members don't fully understand their customers' needs. If these issues are addressed, the project owner and other supply chain members will experience profitability that exceeds the savings obtained by beating each other into price submission.

The alternative model, shown in Figure 24, is one of horizontal integration (See Appendix A). Collaboration is the key when attacking cost throughout the supply chain. While each member of the supply chain is attacking the surface of the problem, cost – the real source of the problem – lies underneath. As members fight for lower prices, the real problem underneath grows larger, causing prices to go even higher. The heart of the problem is productivity. If all members of the supply chain work together as a unit instead of as individuals, each member of the supply chain will become more profitable.



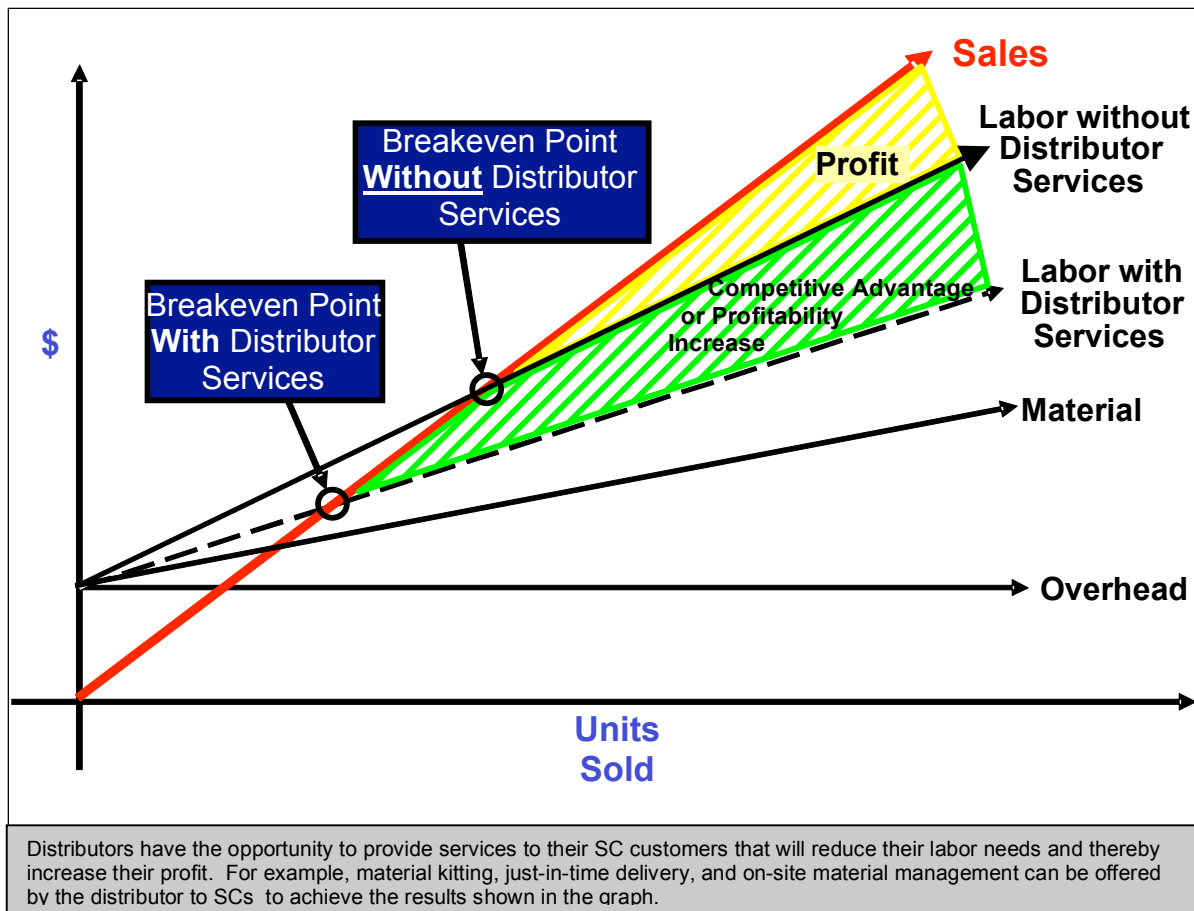
**Figure 24. The Horizontally Integrated Procurement Chain.**

Horizontal integration (See Appendix A) has already been tested between distributors and SCs. Material management strategies have been implemented through distributor-SC relationships including material kitting, just-in-time (JIT) delivery, on-site inventory management, and blanket purchase orders.

1. Kitting: Kitting is the method of bundling material into a unique package for different jobsite locations or different components of the job. For example, on some projects, all the material that is being installed in a specific room is kitted and delivered to the designated room. Previously, material would be delivered in a stockpile on the jobsite and the workers would have to search through the stockpile for specific material or equipment.
2. Just-in-time (JIT): JIT is the method of delivering material and equipment as it is needed. JIT reduces the amount of material and equipment on the jobsite, which in turn saves time searching through stockpiles. An added benefit is that a JIT system prevents material damage from prolonged exposure to the construction environment.
3. On-site inventory management: Some distributors will support a jobsite trailer, which functions as a remote jobsite distributor. This trailer will house the material needed for the project. Generally, the on-site inventory provides a buffer of material for emergency warranty fulfillment and change orders.
4. Blanket purchase orders (POs): Instead of the SC writing a PO for each order, some distributors have established monthly billing to account for all the purchases made during a specific timeframe. The time-based or project-based PO has improved the efficiency of labor on the jobsite because POPOs no longer have to be created for each order, allowing material needs to be fulfilled faster.

These measures can lower project cost and can shorten the project schedule by reducing the amount of labor required for material handling. The labor reduction for the specialty contractor is shown in Figure 25. This labor reduction gives the specialty contractor an opportunity to offer the project owner a lower price.





**Figure 25. Labor reduction through horizontal integration of distributor and specialty contractor.**

Several obstacles must be overcome to achieve this unity between members of the supply chain. One obstacle that must be overcome is the established ideologies that every member of the supply chain has built up over time. Most people act according to principles they have learned. These principles may have been instilled by company culture, leadership, personal experience, or other defining circumstances. This has prevented companies from pursuing uncharacteristic relationships with each other. Furthermore, antagonistic relationships between entities in the supply chain could cause these companies never to consider the possibility of becoming a team. Another issue that arises is that companies do not have a complete understanding of the needs of their customers. Therefore, an exclusive or semi-exclusive relationship with each other would not be beneficial

to the customer, since he or she could go elsewhere for the same product or service. Trust and loyalty are important issues when pursuing horizontal integration (See Appendix A).

The project owner will experience the best value when horizontal integration is implemented throughout the procurement chain. Instead of procurement chain members concentrating on price, they will be able to develop exchanges that benefit both parties involved beyond the issue of price. Over the last 10 years the construction industry has fallen dramatically behind the nationwide increase in productivity. Therefore, there are wide-open opportunities for members of the construction industry to embrace new methods for improvement and become more profitable.

## **8.0 Conclusion**

Depending on the situation the project owner is facing, each model provides a certain level of value. Overall, the SCPM and the OPM generally provide the highest value to the owner. GCPM does have some positive features, but it does not provide the same value as SCPM or OPM. Each model can be summarized as follows:

### **∞ Specialty Contractor Procurement Model**

The traditional subcontractor purchasing model (SCPM) in which material transfers from manufacturer to distributor to subcontractor offers the most value for the owner for the majority of projects. Subcontractors, via their distributors, have access to the largest number of manufacturers – thereby having access to the greatest product selection. GCs often run into problems with manufacturers due to the refusal of these manufacturers to bypass distributors and sell material directly.

### **∞ General Contractor Procurement Model**

The GCPM can potentially offer a greater time savings if the design specifications are correct and “time until occupancy” is at a minimum.

Problems arise when “time until occupancy” is a pressing concern and projects begin with incomplete or incorrect design specifications due to the rushed nature of the project. Cost savings and product selection did not provide better value than the SCPM to the owner.

#### ∞ **Owner Procurement Model**

The OPM appears to be viable for repetitive projects with little variation in design, but the scope of this research did not provide the details necessary to draw a conclusion on this model’s value to the owner. The key to the OPM is that the owner must have an in-depth knowledge of the work that the SC performs. The OPM model has been successful for big-box retailers, chain stores, and utility companies. Big-box retailers and chain stores typically reuse design plans for many of their stores – having perfected the design and equipment specifications on earlier projects. Electrical utility companies often have the expertise, through years of purchasing electrical equipment, to purchase equipment for electrical contractors. In addition, utility companies often have long-term partnerships with electrical contractors. The contractor can then influence the purchasing patterns of the utility company.

#### ∞ **Horizontally Integrated Procurement Model**

The project owner will achieve the best value by utilizing a procurement chain that is horizontally integrated. The savings attained through increased productivity can substantially outweigh the direct cost of material or equipment. This is the desired future state of the procurement chain.

The prevailing, existing, and alternative procurement chain models are not satisfying the needs of most project owners. In order to improve procurement chain management in the construction industry, a new model should be instituted which utilizes the benefits of horizontal integration. Through horizontal

integration of the procurement chain, the project owner and each member of the procurement chain will be able to complete a construction project at lower cost for everyone involved.

Every owner must look at how each of the three categories is impacted by the model he or she selects. The advantages that each model offers a project owner depends greatly upon the type of project, as well as the actions of the parties involved in the project. As procurement chain members begin adopting the horizontally integrated structure, the project owner will find that the best value can be achieved through the Horizontally Integrated Procurement Model.

## **Appendix A: Vertical Integration vs. Horizontal Integration**

### *Vertical Integration*

Vertical integration is the practice of incorporating a firm's upstream suppliers or downstream buyers into their own business model. This means a firm practicing vertical integration would perform the functions of their suppliers or buyers, thereby removing them from the supply chain. This method of integration focuses on reducing cost by eliminating the transaction cost (markup, shipping, coordination, etc.) between members of the supply chain. There are two types of vertical integration:

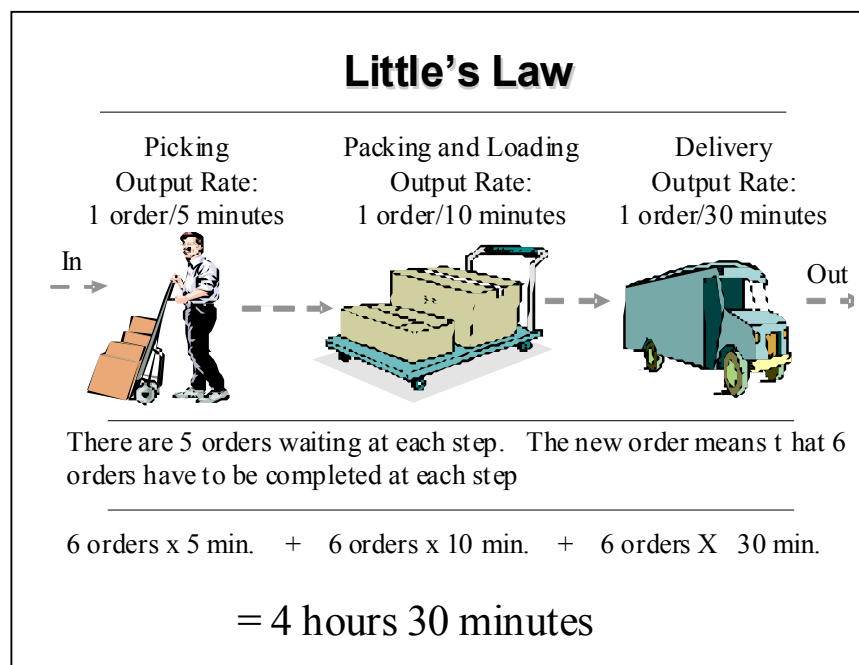
- ∞ Backward Integration – Backward integration is when a firm assumes the role of their supplier. An example of this would be an automotive manufacturer that decides to acquire the raw materials to make the vehicles. By taking on this responsibility, the automotive manufacturer would be assuming the role of their suppliers who provide raw materials.
- ∞ Forward Integration – Forward integration is when a firm assumes the role of their buyer. Many manufacturers use distributors or retail stores to supply their products to the end customer. If the manufacturer decided to distribute their products directly to the customer, this would be a form of forward integration. The manufacturer would be taking on the function of their buyers: distributors or retail stores.

### *Horizontal Integration*

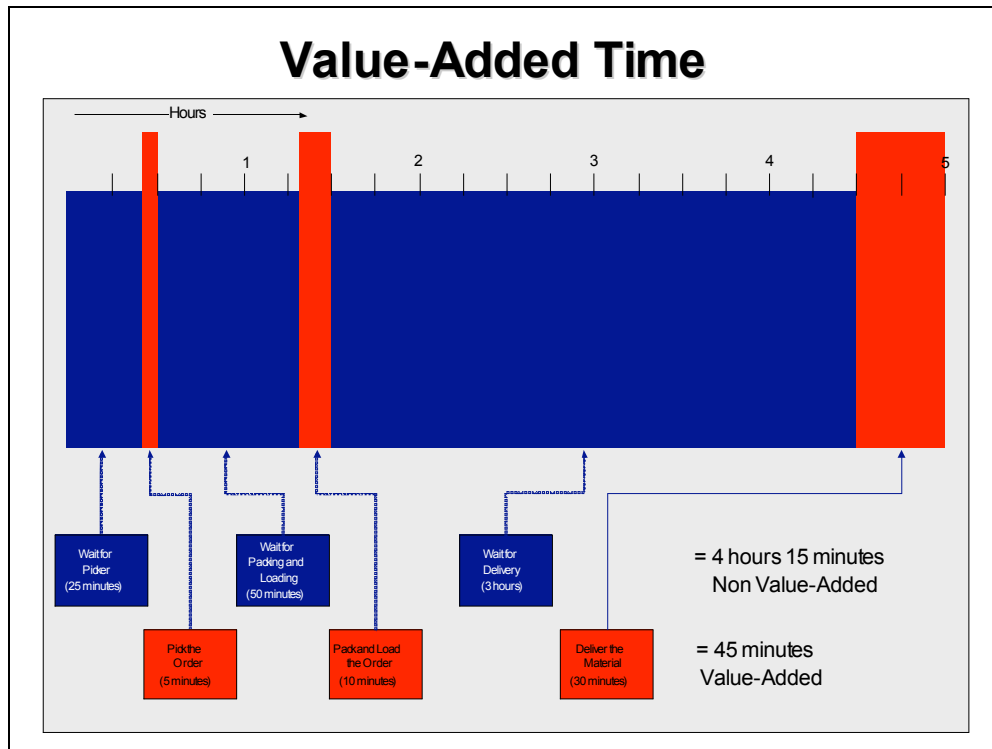
Horizontal integration is when a firm expands its core competencies to meet its customer's needs. Horizontal integration occurs when a firm forms a close relationship with its upstream suppliers or downstream buyers to identify each other's needs. This method of integration helps members of the supply chain determine what products and services are important to their customers. An example of this would be a retail store expanding its services to provide financial

support to its customers through loans or credit plans. This integration tactic avoids bypassing members of the supply chain and instead promotes evolution of the supply chain members to better suit each other's needs.

The horizontal integration model is best practiced in the automotive industry, specifically Toyota. When applying horizontal integration, all the participants in the supply chain use their expertise to reduce non-value-added activities and reduce the WIP. The practice of reducing work in process is an application of Little's Law, shown in Figure 26. Little's Law is a principle of system design and governs nearly all batch and queue work flow. For example, when a supplier processes an in-stock order, it takes five minutes to pick each order. If there are five orders in the queue, it will take 30 minutes to pick the new order. If the process then takes ten minutes per order to pack and load onto the truck, the packing and loading step will take one hour total. Assuming that delivery takes 30 minutes per order, the delivery step will take a total of 3 hours. The total time to deliver the material took 4 hours and 30 minutes – even though only 45 minutes were dedicated to the specific order. The breakdown of value-added versus non-value-added time is shown in Figure 27.



**Figure 26. Little's Law example of a simplified order fulfillment process**



**Figure 27. Timeline diagram representing the value- and non-value-added time in a simplified order fulfillment process.**

## Appendix B: Measuring Construction Productivity

**Productivity is the measure of total system output versus total system input.** More specifically, productivity compares the amount of goods and services produced with the inputs used in production. By measuring productivity, economic efficiency is made visible. It shows how effective the economy is performing when converting economic inputs into output. The formula for measuring productivity is

$$\text{Productivity} = \frac{\text{Output (unit of products)}}{\text{Input (resources)}}$$

There are two ways to measure productivity. These two measurements are labor productivity and multifactor productivity.

**Labor productivity** is the most commonly used measurement. Labor productivity is the ratio of the output of goods and services produced to the input of labor hours dedicated to making the output. With this measure it is easy to see that, as labor productivity grows, the economy is capable of producing more with fewer or same amount of workers.

**Multifactor productivity** compares output to a combined set of inputs, not strictly labor. This measurement reflects the impact of many factors such as new technologies, managerial skills, economies of scale, and organizational restructuring.

In this report two studies were cited that provide measurements of productivity. Each study measures productivity in a different way, but both use the labor productivity method. One study was performed by the Center for Construction Industry Studies (CCIS). The other study was performed by the Bureau of Labor Statistics (BLS).



CCIS measured productivity by work sampling. Work sampling is a system that measures how the labor force utilizes its time. Observations of the work performed by each worker are recorded at specified instances during a project. This system measures the total hours of productive work of a worker and then compares that to the total work performed by the worker. This is done on a large scale in order to sample many different workers. The formula used to determine productivity by CCIS is

$$\text{Productivity} = \frac{\text{Hours of direct work (productive actions progressing the project)}}{\text{Total working hours}}$$

The BLS also provided unofficial construction productivity figures. In the construction industry as in other industries, the BLS takes the gross product of the industry and compares it to the total hours of work performed. The BLS measures both labor productivity and multifactor productivity, although the figures cited by BLS in this report use the labor productivity method. The formula used by BLS is

$$\text{Productivity} = \frac{\text{Gross product of construction}}{\text{Total hours worked by employees in the construction industry}}$$

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