

The Impact of Resource Commitment, Product Route Efficiency on Supply Chain Performance and Profitability: An Empirical Case Analysis

Kelly Weeks*, Joan Mileski

Department of Maritime Administration, Texas A&M University at Galveston, Galveston, Texas
*Corresponding author: weeksk@tamug.edu

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Abstract This study examines the impact of resource commitment and product route efficiency on supply chain performance of the firm through operations management. The firm's profitability is impacted by the commitment made by its management on resources and also by product route efficiency of transporting goods to its customers. Sixteen hundred survey instruments were mailed to the scrap steel industry with 277 of the 307 returned being useable. Structural equation modeling (SEM) was utilized to test each related hypothesis.

Keywords: *supply chain & logistics, operations management, resource commitment, product route efficiency, profitability*

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1. Introduction

A supply chain consists of various entities involved in the flow of material [1]. The entities are suppliers/vendors, manufacturers/distributors, and retailers/wholesalers linked by a transportation, information, and financial involvement in the flow of materials [2]. Materials in the form of goods and services flow "down" the supply chain from the miner of raw materials to end users while funds and information flow at the same time in the opposite direction. Decisions concerning sourcing and supply management influence the cost and characteristics of the products or materials [3].

Supply chain management (SCM) allows suppliers, manufacturers, distributors, and customers to integrate their operations in order to reduce costs and increase response time to the customer. Lambert, Stock and Ellram [4] stated SCM is the integration of key business processes including the customary logistics activities of warehousing, inventory control, transportation management, and the non-traditional logistics activities including procurement, production support, packaging, and the processing of orders [5]. SCM assesses the operational strategies that impact the purchasing, production, logistics management, and also analyzes the entire flow of goods and services in the supply chain. Efficiencies developed by the firm and integrated into the operational methods being utilized are considered ways to improve profitability. Two approaches to the management of the supply chain have been identified: the top-down approach, which is a high-level centralized strategic approach and the bottom-up approach, which uses

individual elements of the supply chain from each supplier [6]. Methods where efficiencies can be developed are procurement, logistics, production, and facility operations.

One potential problem concerning SCM [7] is that a lack of a formal policy may inhibit reverse logistics' effectiveness. This is particularly apt when talking about commitment of resources, whether it is managerial (such as day-to-day decision-making) or financial, such as an investment in training personnel on the new technology, and information at all levels on what needs to be done [8]. Information support is important to both resource commitment and product routing, which engages in the transportation of goods to customers. Authorizing, tracking, and handling returns can positively affect both economic and service quality-related performance [8]. Logistics systems management in distribution channels is a complex process. Integration of the logistics system is needed on all levels to insure channel efficiency and maintain high levels of customer service [9]. Logistics routes utilized can determine whether shipments are on time or late, and can also impact profitability by resulting in a potentially non-optimizing route schedule. A non-optimizing route schedule demonstrates the need for proper resource positioning.

A good example of product routing is from Gottinger [10], who modeled a regional solid waste management problem as a network flow problem. The regional management system is concerned with selecting the number and locations of the transfer points, processing facilities and landfill sites; their capacities; and the routing of material through the network. Inputs include potential locations of the processing points and landfill sites, and the cost of transporting and processing the quantities of

waste generated at the supply points. The results of cost minimization linear model indicated which facilities should be operated and how the materials are routed, processed and disposed. The results of Gottinger [10] showed that there was an effect on profits by increasing the efficiency of the supply chain routes used to transport goods. However, Gottinger [10] did not analyze resource commitment at each facility. There are several researches in the literature that studied the impact of resource commitment on information technology and business performance [11-17], but the impact of resource commitment and product route efficiency on profitability has not been adequately investigated.

This research examines the impact of resource commitment and product route efficiency on firm's profitability. Specifically, the study investigates the impact, from supply chain standpoint of view, of resource commitment and product route efficiency on profitability through operations management. The following sections provide a brief literature review followed by hypothesis development, empirical results, conclusions and future research.

2. Literature Review

2.1. Resource Commitment

Resource commitment is defined as the willingness to provide needed materials and support to achieve the stated goals of the firm. There are two types of resource commitments: managerial and financial. The development of SCM relies upon a combination of intangible and tangible resource commitments. Intangible resource commitments are managerial and temporal in nature while tangible resource commitments are more financial [12].

This research analyzes resource commitment from a facility perspective. Increasingly, logistics managers are recognizing the cost saving and waste reduction benefits of SCM, and in order to realize these benefits, technology must be implemented [18,19]. With a well-rounded SCM system, it is possible to generate a cost savings by improved efficiency. Andel [20] noted that, to get the most out of a supply channel, you need excellent information management systems. Reese [21] added that SCM is a very information technology intensive business. These two researchers, Andel and Reese, showed how the commitment of resources to facilities, whether in terms of capital, equipment, or technology, was important for the operation of the organization. Resource commitment requires not only financial resources for facility purchases, but also an investment in training personnel on the new technology and information that will be used at all levels [8].

Because of the uneven and unpredictable - but almost always critical - nature of SCM demands, research should examine the role of relationship commitment [13]. These authors identified a very important point in organizational operations. A well-polished logistics system should not only work in ideal situations but also in those situations that are not easily predictable.

2.2. Product Route Efficiency

Product or transportation routing can be defined as the method of moving goods from one point in the supply

chain to the next step in the supply chain [14]. The direction in which materials move will determine whether a company is using forward or reverse logistics. For example, after producing an item, a manufacturer then must ship it to retailers. The transportation director of the producer must determine the most efficient method for shipment of the goods. The method utilized may differ depending upon the location of the retailer. This process is called forward logistics. When the same material needs to come back to a previous point in the supply chain, this is reverse logistics.

In situations where vehicle routing poses a problem, *Alshamrani [22] states that one way to solve this dilemma is to use a three stage heuristics. The first step involves the clustering of customers into groups. The second step involves the assignment of a vehicle/driver to each of the clusters. The third step requires finding a vehicle route for each cluster of customers. This process improves the logistics process. By improving efficiency and effectiveness, this will help reduce the number of vehicles required.*

2.3. Operations Management

Operations management is concerned with all areas related with producing goods and services that affect the company on a daily basis, such as the maintenance, control, and improvement of organizational activities. One of the chief aims of operations management is to maximize the profit [23]. There are many factors that can contribute to achieving this goal, such as production mix efficiency, product route efficiency, and resource commitment.

Anderson [24] states that product quality, production efficiency, and productivity indexes are most crucial for operations management. Several previous studies [25,26,27,28] of operations management have included analyses of both quality and efficiency, but none has included the productivity indexes as Anderson [24] states they should. Furthermore, none of the literature has viewed operations management in the steel industry from solely a supply chain aspect. This study further breaks down operations management constructs into two constructs of production commitment and production efficiency. As Anderson [24] describes, these constructs of operations management work in either the forward or backward direction. Therefore, these constructs are applicable to this study and have been included.

2.5. Profitability

The main goal of firms is to maximize the profit regardless of what service or product they offer [29]. His study uses return on equity (ROE) as a measure of profitability. He notes that others such as return on assets (ROA) and net income can also be used. Jaggi and Freedman [23] add net income, and return on sales to analyze a firm's profitability.

Managers of many firms ignore the efficient return and refurbishment of products and as matter a fact, return on investment is a very important variable for measuring profitability. Andel [20] states that utilizing the supply chain as a method for maximizing the value of returned assets can make a significant difference between

companies. Efficient use of the resources can increase the return on assets in supply chain.

Previous literature states that resource commitment makes SCM programs more efficient and more effective. However, the resources must be used in such a manner as to develop innovative capabilities/approaches to handling returns [16]. If an organization uses a system in a manner that it was not intended for, as described previously, very little efficiency, if any, can be gained. This study will attempt to provide insight into the actual empirical effects resource commitment plays in company profitability. Furthermore, no comprehensive study in the literature has been found to investigate the impact of resource commitment and product route efficiency together on firm profitability. This research will provide an empirical analysis of the relationship of resource commitment, product route efficiency, operations management, and profitability in the U.S. scrap steel industry.

3. Research Questions and Hypotheses

While some previous studies of operations management have included analyses of both quality and efficiency, none has included the productivity indexes as Anderson [24] states they should. In addition, prior studies analyzing profitability typically only looked at return on assets or return on equity. This study looks at profitability from a comprehensive literature perspective and has four measurement indicators. The supply chain strategy of production route efficiency has typically been narrowly analyzed from a single dimension. This study defines it within a comprehensive literature approach as detailed by Faulin, Sarobe, and Simal [30]. Lastly, resource commitment is analyzed from a facility aspect and not a broad, general perspective. To address the gap, the following research questions are raised in the study:

1. Does operations management impact profitability?
2. How does operations management relate to the supply chain strategy of product route efficiency in the pursuit of profitability?
3. How does operations management relate to the supply chain strategy of resource commitment in the pursuit of profitability?

From the research questions previously listed, five hypotheses were developed to assist managers with supply-chain related decisions that can potentially increase profitability. The first research question asked is whether operations management has an impact on the profitability of these steel companies. Jaggi and Freedman [23] offer a good overview of profitability in firms and describes the common techniques, which are used to measure this factor. The literature showed many different ways to measure profitability. However, according to Jaggi and Freedman [23], the four most important and necessary are return on assets (ROA), return on equity (ROE), net income (NI), and return on sales (ROS). All four of these measures will be used in this study.

Many researchers have studied operations management (OM). Anderson [24] gives an excellent guide for measures used to analyze this item of OM. She says that the most crucial constructs to be studied are product quality, production efficiency, and productivity indexes, each of which is composed of several variables. This study incorporates Anderson’s recommendations and includes variables such as average training, education level, machine hours, expected output, and hours of machine downtime. Figure 1 shows the theoretical model proposed by this study. Hypothesis 1 addresses the first research question.

H1: Increased levels of Operation Management factors cause an increase in profitability.

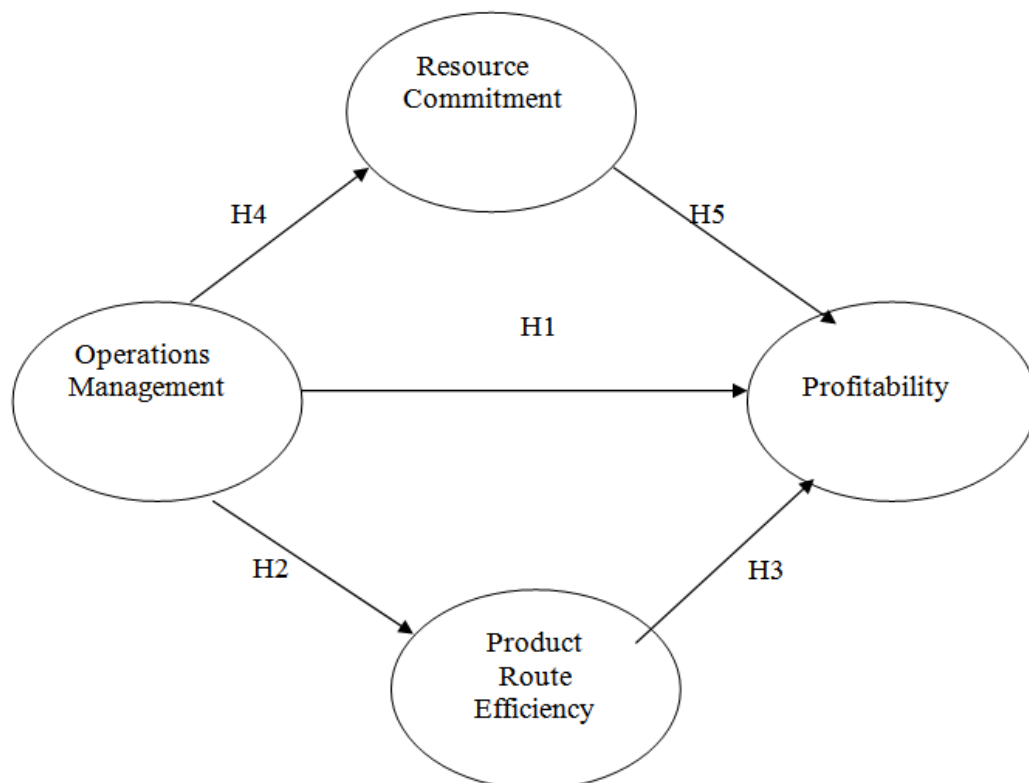


Figure 1. THEORETICAL MODEL

The second research question addresses the relationship between operations management and the strategy of product route efficiency. Literature has indicated several variables used to measure product route efficiencies. Faulin, Sarobe, and Simal [30] suggest that some of these indicator items are fleet size, vehicle load limits, and time to cover the route. For the purpose of this study, product route efficiency is defined as the path and mode of transportation chosen to move goods from one point to another while trying to maximize profits. Hypotheses 2 and 3 address the second research question.

H2: Increased levels of operation management factors cause an increase in product route efficiency.

H3: Increased levels of production route efficiency factors cause an increase in profitability.

The third research question addresses the relationship between operations management and the strategy of resource commitment. Daugherty, Autry, and Ellinger [12] describe how a commitment of resources is crucial to firm performance. Their study defines performance by profitability for the ability to statistically analyze all relationships. Hypotheses 4 and 5 address the third research question.

H4: Increased levels of operation management factors cause an increase in resource commitment.

H5: Increased levels of resource commitment factors cause an increase in profitability.

4. Empirical Results

4.1. Population Sample

The literature has illustrated that the decision of the resource commitment and product route efficiency are made by a supply chain organization, and their effective utilization is based on the participation and perception of managerial decision makers. As the literature shows -- because a large portion of the steel content of appliances and cars is recycled -- supply chain and reverse logistics management is extremely important in the scrap steel industry. Therefore, the research targets the U. S. steel scrap industry. Recycling scrap steel conserves virgin materials, energy, and landfill space. The remelting of scrap requires much less energy than the energy required for the production of iron and steel products from iron ore. Consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment [31].

Scrap steel is a vital raw material for the production of new steel and cast-iron products. The steel industry has been recycling steel scrap for more than 150 years. In 2004, about 105 mini-mills consuming ferrous scrap in electric arc furnaces (EAF) accounted for about 52% of the total raw steel produced in the United States [31]. The steelmaking and foundry industries in the United States are highly dependent upon the ready availability of scrap from manufacturing operations and from the recovery of products that are no longer used nor needed [31]. The domestic steel industry recycles millions of metric tons per year of steel cans, automobiles, appliances, construction materials, and other steel products [32].

The primary source of obsolete steel is the automobile [32]. In 2004, the domestic steel industry recycled about

68 million metric tons (Mt) of appliances, automobiles, cans, construction materials, and other steel products [31]. This resulted in an overall recycling rate of nearly 71%. Approximately 44% of a typical 2003 U.S. family vehicle was made from recycled ferrous metals.

4.1. Questionnaire

Data was collected from mailed questionnaires. A total population of 1600 firms was sampled, from which 307 (19.2%) questionnaires were returned. Thirty of these were found to be unusable due to missing data. Two hundred and seventy-seven of the returned surveys (90.2%) were valid for analysis. The survey instrument for use in this study was designed to obtain the perceptions of plant manager respondents about the influence of operations management on profitability strategies of resource commitment and product route efficiency. The instrument consisted of five sections plus a demographic section. Items in Sections 1 and 2 pertained to the operations management where the respondent was employed. Section 3 related to the construct of production route efficiency. Section 4 analyzed the construct of resource commitment. Lastly, Section 5 analyzed profitability. Individual items were valued on a 7-point Likert scale.

Factor analysis and internal consistency tests were conducted on the constructs to ensure reliability and validity. Confirmatory factor analysis (CFA) was chosen since it provides a more rigorous testing of theory compared to that of exploratory factor analysis (EFA). In addition, CFA allows the researcher to evaluate a priori relationships whereas EFA does not require a priori specifications for theorized relationships prior to model testing. CFA permits the indicators to load only on certain pre-selected factors, while EFA permits the data and statistical technique to determine the measurement model [33].

The internal consistency of the questionnaire was tested by examining the item-to-total correlation and Cronbach's Alpha value. This study determines an item-to-total correlations of > 0.60 as acceptable. An Alpha level of .70 is generally considered the low end of an acceptable scale, but Hair [33] states for an exploratory study the acceptable level is .60 or higher. Table 1 also shows the item-to-total correlation, which is each item's correlation with the sum of the other items in its category.

All Cronbach's Alpha values exceeded the established requirement and they validated that the survey instrument possessed excellent reliability. The item-to-total correlations were consistently higher than the required 0.60, with the exception of OM3 (Education Level of Employees), OM5 (Machine Hours Consumed), PR1 (Actual # of Vehicles), and PR8 (Total Quantity Transported). In order to ensure that the validity of each measurement scale was considered satisfactory, these four items were eliminated from the study.

4.2. Analysis and Discussion

Structural equation modeling was used together with CFA to analyze and evaluate the proposed model and hypotheses. Structural equation modeling is a multivariate statistical technique that defines and estimates the relationships among endogenous and exogenous variables simultaneously [33,34,35,36]. The analysis was tested using LISREL version 8.54 [37]. In the proposed model

(Figure 2), operations management was considered an exogenous variable, and profitability was considered an endogenous variable. Product route efficiency and resource commitment form both exogenous variables (to operations management) and endogenous variables (to profitability).

Table 1. INTERNAL CONSISTENCY VALUES FOR THE QUESTIONNAIRE

Factors	Descriptions	Item-to-Total Correlations	Cronbach's α
OM1	Average Training	0.635	0.769
OM2	Tenure of Employees	0.681	0.815
OM3	Education Level of Employees	0.543*	0.878
OM4	% Goods Meet Expectations	0.788	0.724
OM5	Machine Hours Consumed	0.534*	0.867
OM6	Expected Machine Hours	0.632	0.829
OM7	Expected Output	0.751	0.728
OM8	Hours of Downtime	0.601	0.793
PR1	Actual # of Vehicles	0.545*	0.896
PR2	Needed # of Vehicles	0.730	0.786
PR3	Average Load Limit / Vehicle	0.793	0.737
PR4	Time to Transport Load	0.854	0.724
PR5	Expected Time to Transport	0.772	0.763
PR6	Miles / Vehicle	0.770	0.796
PR7	Amount of Vehicle Expenses	0.760	0.790
PR8	Total Quantity Transported	0.543*	0.847
RC1	Total # of Quality Inspectors	0.765	0.867
RC2	Total Time a Machine is Down	0.789	0.846
RC3	Actual # of Machines Used	0.733	0.843
RC4	Needed # of Machines	0.813	0.824
RC5	Level of Technology	0.876	0.813
PF1	Average 3 yrs Net Income	0.794	0.781
PF2	Average 3 yrs Return on Assets	0.924	0.918
PF3	Average 3 yrs Return on Equity	0.727	0.701
PF4	Average 3 yrs Return on Net Sales	0.863	0.864

Note: * unacceptable; OM: Operations Management; PR: Product Route Efficiency; RC: Resource Commitment; and PF: Profitability.

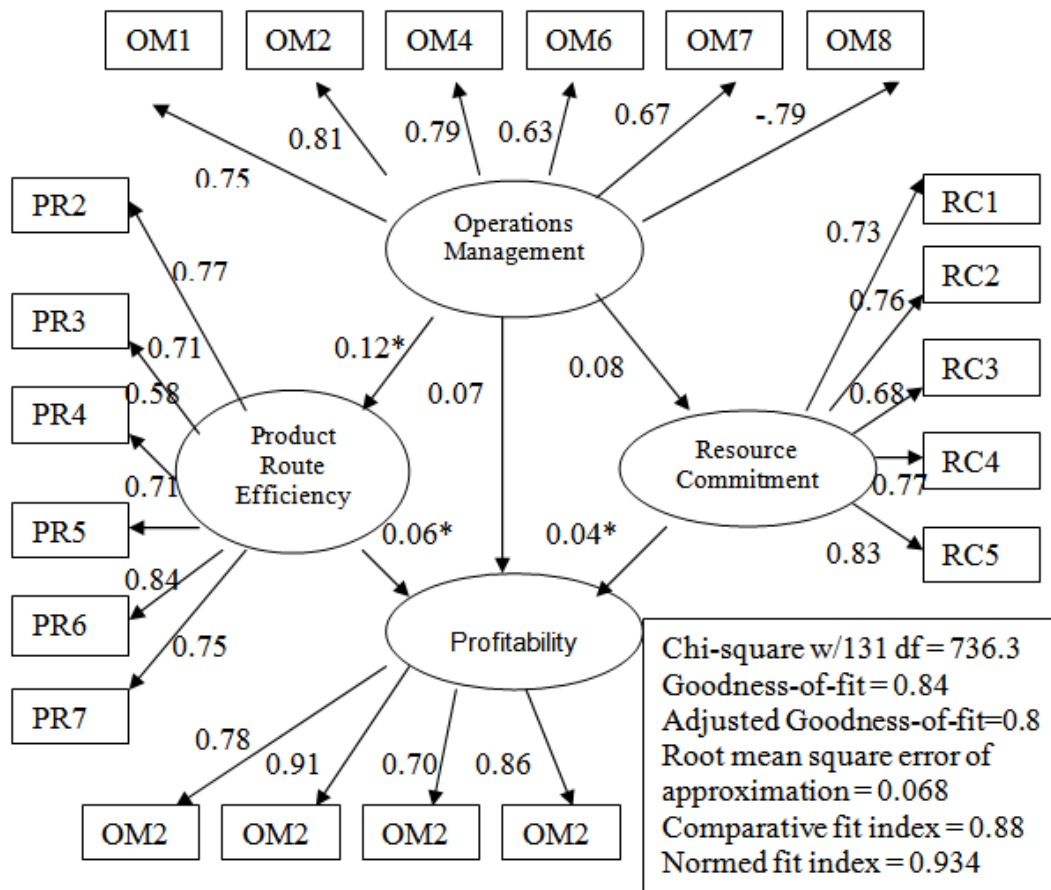


Figure 2. RESULTS OF SEM ANALYSIS (Note: * p < 0.05)

The GFI score was a good fit at 0.84. The RMSEA was 0.068, which falls within acceptable parameters. The NFI value was .934, while the CFI score was 0.88. Both of these are fair to good fits. The Chi-square values for the structural model shown in Figure 2 were shown to be significant. However, the Chi-square value was a direct result of its sensitivity to the large sample. Therefore, Chi-square does not provide conclusive and sufficient

evidence to be useful to this research [38]. These combinations of indices, all of which are within acceptable parameters, taken together validate overall fit. Based on Figure 2, three of the five hypothesized (H2, H3, and H5) relationships showed statistically significance. The summarized results of the analysis are presented in Table 2.

Table 2. SUMMARIZED OBSERVATIONS FROM MODEL ANALYSIS

Hypothesis	Path	P-value
H1	Operations Management -> Profitability	0.470
H2	Operations Management ->Product Route Efficiency	0.000*
H3	Product Route Efficiency -> Profitability	0.000*
H4	Operations Management -> Resource Commitment	0.398
H5	Resource Commitment -> Profitability	0.000*

Note: * $p < 0.05$

Since the measurement model was now established, relationships among the latent variables can be analyzed through the path coefficients of the model. Hypothesis 1 stated that increased levels of operation management (OM) factors caused an increase on profitability (PF). The path between OM and PF was found to be not significant for this study ($p=0.470$). Therefore, the data provides strong evidence to reject Hypothesis 1. Hypothesis 2 stated increased levels of operations management (OM) factors caused an increase on product route (PR) efficiency. The path between OM and PR was found to be significant for the research ($p=0.000$). Therefore, the data provides strong evidence to support Hypothesis 2.

Hypothesis 3 stated that increased levels of product route efficiency (PR) factors caused an increase in profitability (PF). The path between PR and PF was found to be significant for the research ($p=0.000$). Therefore, the data provides strong evidence to support Hypothesis 3. Hypothesis 4 stated the following: Increased levels of operation management (OM) factors caused an increase on resource commitment (RC). The path between OM and RC was found to be non-significant for the research ($p=0.398$). Therefore, the data provides strong evidence to reject Hypothesis 4. Hypothesis 5 stated that increased levels of resource commitment factors caused an increase in profitability. The path between resource commitment and profitability was found to be significant for the study ($p=0.000$). Therefore, the data provides strong evidence to support Hypothesis 5.

5. Conclusion, Limitations, and Future Research

This study has focused the impact of resource commitment and product route efficiency on firm's profitability. Specifically, the study investigates the impact, from a supply chain standpoint of view, of resource commitment and product route efficiency on profitability through operations management. Three of five hypotheses in this study were supported by the data collected from the steel scrap industry within the United States. Hypothesis 1 stated that increased levels of operation management factors caused an increase on profitability. Support was not found for Hypothesis 1. Hypothesis 2 stated increased levels of operations

management factors caused an increase on product route efficiency. Hypothesis 3 stated that increased levels of product route efficiency factors caused an increase in profitability. Supports were found for Hypothesis 2 and Hypothesis 3. Hypothesis 4 stated the following: Increased levels of operation management factors caused an increase on resource commitment. Support was not found for Hypothesis 4. Hypothesis 5 stated that increased levels of resource commitment factors caused an increase in profitability. Support was found for Hypothesis 5. Managerial decision makers can use the information found and proven by this research as a strategic tool to increase profitability within their supply chain.

The constructs of operations management and production route efficiency analyzed in this research is diverse in nature. There is much inconsistent research on what should be included in order to help increase a firm's financial profitability. This study attempted to do a comprehensive analysis of many different potential variables in the strategy. However, there is always the possibility of some items being overlooked or neglected. Another limitation of this study is that the data was collected only from the U.S. based firms. This may limit applications to any international or global firms.

Future research needs to scour new sources and literature and add new variables to each construct to potentially adjust or re-analyze this study's findings or compare differentiations. In addition, future research should add different strategies and analyze them. There are other strategies in addition to the ones provided of production route efficiency and resource commitment, and there are a number of possible combinations among them. Lastly, future research should look from a global perspective. This would not only provide new information, but also a means of comparison between individual countries.

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