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DYNAMICS BETWEEN CONTRACT MANUFACTURING AND OPERATIONAL PERFORMANCES: AN EMPIRICAL STUDY OF THE U.S. MANUFACTURING INDUSTRIES

Liang-Chieh (Victor) Cheng*

Department of Information & Logistics Technology
College of Technology

230A Technology Building
University of Houston
Houston, Texas 77204-6020, USA
Tel: 713 7431524
Fax: 713 743 4032
E-mail: lcheng6@uh.edu

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*Corresponding author

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ABSTRACT

Recently, the U.S. manufacturers have been facing increasing pressure of cost reduction and customization from both domestic and global markets. One crucial response to these competitive pressures is the prevalent outsourcing strategies. While sporadic case studies have investigated the cost reduction potentials of outsourcing, cross-industry, empirical analyses examining outsourcing operational performance are lacking in the operations management literature. This paper investigates the trends and impacts of outsourcing for the U.S. manufacturing sectors. The theoretical framework hypothesizes that higher level of outsourcing is associated with higher industry-level financial and operational performance. The 1997 & 2002 Economic Census of the U.S. Census Bureau serve as the main data sources, including entire 473 manufacturing industries. Regression runs suggest that outsourcing is positively associated with ROI and ROA, but negatively associated with product specialization. The findings offer critical insights to the potentials of outsourcing strategies for researchers, practitioners, and policy makers.

Keywords: Contract manufacturing, ROI, ROA, product specialization, capacity utilization, outsourcing performance

1. Introduction

Over the past two decades, supply chain management has become increasingly important in the efforts of firms to remain competitive. Supply chain management is a growing area that consists of interrelated components including global logistics operations, production scheduling and distribution and intelligent systems for decision support (Chopra & Meindl, 2007). U.S. Original Equipment Manufacturers (OEMs) have been facing increasing pressure of customization from both domestic and global markets. One crucial response to this pressure is the prevalent outsourcing strategies utilized by the U.S. OEMs, i.e. using Contract Manufacturers (CMs) to account for production as well as supply chain operations (Cavinato, 1989). In industries with shortening product life cycles, such as the electronics and automobile industries, commitment to adopting the flexibility strategy is a strategic-long term decision (Sturgeon, 2002).

Current developments in the integration of the CMs into the OEMs supply chain are made possible by rapid advancements in communication and computer technology (Chopra & Meindl, 2007). As firms increasingly outsource their non-core activities, the suppliers or CMs assume a greater role in the firm's supply chain, from product development, finished goods inventory management, to ultimate physical distribution (Cavinato, 1989). As a result, integrating the CMs' activities with its own has become critical for the OEMs, given the need to minimize logistics costs, such as inventory carrying costs, and to be able to deliver customer orders on time (Fine, 2000; Fine, Golany, & Naseraldin, 2005). While this OEM-CM networks and outsourcing strategies exhibit higher level of flexibility, they also require greater endeavor for the OEM operations to be balanced with supply and distribution tiers of the supply chain.

The primary challenge in using contract manufacturing is to identify performance indicators for this flexible strategy. While outsourcing has the potential to obtain customization, extant empirical research on outsourcing only focused on the cost reduction aspect on this innovative organizational strategy. Additionally, matrices to investigate contract manufacturing strategies is also lacking in the outsourcing literature. Few outsourcing works address which operational performances supply chain should be aware of as indicators of the effectivenesses of contract manufacturing strategies (Daft & Lewin, 1993).

Moreover, despite the abundant academic discussions and evidences on the increasing number of outsourcing, empirical studies that explicitly investigate outsourcing at the industry level are merely on an ad hoc basis (Daft & Lewin, 1993; Schilling & Steensma, 2001). These issues have not been adequately addressed in published research in that the developed models are limited in scope and not covered the entire supply chain or manufacturing sectors, thereby preventing in-depth analysis of contract manufacturing decision-making scenarios. Hence, there is a critical need to extend the outsourcing research toward the dynamic between outsourcing and the pertinent performance outcomes over time. In brief, the preceding observations motivate this research to conduct an industry-level investigation as to the performance outcomes of the contract manufacturing strategies.

The goal of this paper is to contributions the knowledge as to the dynamics between OEMs' outsourcing strategies and the financial and operational performance indicators. Specifically, critical indicators of outsourcing effectiveness are return on investment, return on asset, product specialization, and capacity utilization. Industrial economics researchers have conducted industry-level studies to analyze critical manufacturing strategies (Balakrishnan & Wernerfelt, 1986; D'Aveni & Ravenscraft, 1994; Levy, 1985; MacDonald, 1985; Porter, 1998; Ravenscraft, 1983; Schilling & Steensma, 2001). In the spirit of this stream of literature, we expect the industry level analysis can contribute to the knowledge of industry-level of outsourcing strategy.

This study contributes the operations management literature by determining the value of contract manufacturing as a flexible supply chain design strategy through elaboration of statistical analyses, supplemented by managerial implications. The remaining sections are arranged as follows: section 2 defines and explores pertinent operational outcomes of the outsourcing strategy. A set of hypotheses is also developed based on operations management literature. Section 3 details a method to operationalize relevant variables and statistical procedures for hypotheses testing. I section 4; the results of statistical method are reported and discussed. The last section of this paper concludes with discussion on managerial implications and future research directions.

2. Theory and Development of Hypotheses

This section presents a theoretical framework assessing contract manufacturing strategies and develops testable hypotheses. Specifically, key indicators of outsourcing implications are return on investment (ROI), return on asset (ROA), product specialization, and strategic capacity utilization. A body of literature has shown that outsourcing strategy entails substantial inter-organizational investment and joint sharing of assets (Cavinato, 1989; Chopra & Meindl, 2007; Sturgeon, 2002). Additionally, outsourcing will affect the product design and use of production capacities (Fine, 2000; Hayes, 2002; Randall & Ulrich, 2001). As a result, examinations of the links between contract manufacturing and ROI, ROA, product specialization, and capacity utilization are imperative. As well, confirming the links will establish the matrices evaluating the effectiveness of contract manufacturing.

ROI is defined as the ratio of money gained or lost on an investment relative to the amount of money invested (Banker, Chang, & Majumdar, 1996; Frigo & Ciecka, 1995; Kousenidis, Negakis, & Floropoulos, 1998). In this article, the measure of ROI indicates an *annual rate of return*, unless otherwise noted. Furthermore, this research defined ROA as the percentage shows how profitable a company's assets are in generating revenue per year, as ROI is measured (Bettis, 1981). Thirdly, product specialization is defined as the primary product dollar value as a percentage of the total production output values (Brush & Karnani, 1996). Finally, one of the most used definitions of the capacity utilization rate is the ratio of actual output to the potential output (Banker et al., 1996).

2.1 Contract Manufacturing vs. ROI

In OEM-CMs networks, firms can jointly allocate the resources to respective supply chain stages (Gulati, 1998; Gulati, Nohria, & Zaheer, 2000). Investments are additional resources added into supply chain in addition to the expenses on existing facilities, equipments for inter-firm operations. Due to the increasing awareness of supply chain management and the requirement of strategic change, it is important that OEMs are able to streamline the supply chain operations by investing the latest logistics technologies and supply chain solutions (Sturgeon, 2002). In order to do so, many OEMs re-configure their business processes with CMs to achieve e-business integration (Chopra & Meindl, 2007).

Supply chain management requires constant, substantial investment for OEM-CM partners to coordinate. In a supply chain setting, information technologies enabling supply chain coordination, such as Electronic Data Interchange (EDI), Bar Code systems, Enterprise Resource Planning (ERP), Radio Frequency Identification (RFID), and other e-commerce technologies, are oftentimes substantial investments between firms (Chopra & Meindl, 2007). Furthermore, a growing number of OEMs are integrating their legacy systems with Internet-enabled applications. Integrative IT has been proven to achieve coordination efficiencies similar or superior to vertical integration (Fine, 2000).

Along with the investments in the logistics solutions, OEMs, for instance, Motorola and Dell Computers, have utilized the outsourcing strategy to leverage CMs' strength in R&D and production processes (Magretta, 1998; Sturgeon, 2002). OEM and CM can form joint investment in more R&D endeavors. Furthermore, standardization and technological developments between OEMs and CMs also further reduce the joint requirements by supply chain partners. As such, technological investments in R&D and production can be relatively easily tailored to fit the needs for OEM & CM relationships (Fine, 2000). Investment burdens are shared between supply chain partners, and same resources can be utilized by multiple supply chain partners. The weight of investment from OEMs, therefore, can be drastically reduced. The investment return for the OEM-CM supply chain as a whole may grow faster than the collection of originally separate supply chain entities (Sturgeon, 2002).

Moreover, resources can be combined and exchanged to achieve collaborative gains (Gulati, 1998). OEMs and CMs combine richer resources originally lodged separately across the supply chain. Initially scattered investments can now be consolidated and exploited to generate synergetic developments. Additionally, by outsourcing R&D and production to contract manufacturers, OEMs can focus on the strengths of their supply chain functions, thus reaching even higher effectiveness and efficiencies for their own investments (Gulati et al., 2000).

A vertically integrated firm not only needs to account for all the expenditures on its own but also has to accommodate all the procured investment for its specific requirements. Since the investments are exclusively for vertical integration, high switching costs prevent resource utilization for other purposes. In an environment of high uncertainty, integrative inter-firms investments are less likely to be recovered soon or not easy to achieve higher level of returns (Sturgeon, 2002).

Based on prior reasoning, the impact of contract manufacturing on ROI is proposed as follows:

Hypothesis 1: The higher level of the use of contract manufacturing, the higher ROI for the OEM industry.

2.2 Contract Manufacturing vs. ROA

Commitment to adopting the flexible uses of assets is a strategic, long term decision (Sanchez & Mahoney, 1996). Assets are existing facilities, equipments for supply chain operations. OEMs increasingly outsource their non-core activities to the suppliers with a goal of the removal of redundant assets and, in the meantime, capitalize CMs' assets when using outsourcing strategies. Integrating the supplier's activities with its own, rather than increasing asset expenses, has hence become critical for the firm, given the need to minimize physical, fixed costs (Sturgeon, 2002). As well, the objective of combining OEM and CM core resources is to minimize or reduce the overall required physical assets in the enlarge OEM-CM production network.

OEMs are operating on a non-asset oriented strategies. Current developments in the integration of the supplier into the supply chain of the firm are made possible by rapid advancements in communication and computer technology (Fine, 2000; Fine et al., 2005). Instead of investing new assets independently to the internal facilities, members in global networks can perform cooperative projects and take away redundant facilities. Meanwhile, contract manufacturers assume a greater role not only in performing actual supply chain processes, but also in deploying and structuring the entire network facilities (Sanchez & Mahoney, 1996). According to the Square Root Law, since the assets, i.e. land, machinery, lease, facilities, buildings, etc., are consolidated by the contract manufacturers, the overall collection of assets will be reduced (Evers & Beier, 1998). Refined deployment of physical assets in, for instance, factories, marketing channels, and logistics, can be minimized and the operations can be optimized.

Certainly, the impacts of outsourcing on ROA will vary widely across different industries (Bettis, 1981). Specifically, capital-intensive industries, e.g., automobile and semiconductor manufacturing with lower initial ROA, will likely benefit more by integrated OEM-CM systems. In contrast, industries relying less on capitals might exhibit less impacts from outsourcing. However, overall, using integrated CMs will potentially reduce the assets required by the whole value system. This, in turn, will lead to higher ROA. Therefore, this research concludes the preceding discussion with the following hypothesis:

Hypothesis 2: The higher level of the use of contract manufacturing, the higher ROA for the OEM industry.

2.3 Contract Manufacturing vs. Product Specialization

Contract manufacturers assume a greater role in the firm's supply chain for product development (Sturgeon, 2002). Manufacturers face uncertain demand for quantity and variety of products. The flexibilities created through outsourcing have contributed to higher level of customization capabilities (Fine, 2000). Utilizing contract manufacturing to achieve product, process, and supply chain flexibility is an often-considered strategy to deal with uncertainty and enlarge production volumes at a low cost. As well, product design process can achieve higher level of variety because of combined resources and workforce between OEM and CMs as suggested in aforementioned discussions (Fine et al., 2005). In contrast, integration leads to more rigid supply chain arrangements which allow fewer product categories because of the consideration for scale economies.

Richer resources combined by OEMs and supply chain members can lead to even stronger innovation outcomes. Consistent with the ROI arguments, wider resource bases can potentially incorporate more design and product activities (Gulati, 1998). Specifically, OEMs and CMs can exploit the advancement in computer-enabled communication to modularize production processes and product designs, which translate to higher the supply chain flexibilities and increase product varieties. Since OEMs in this context are more capable to diversify product lines rather than to offer narrower product scopes, outsourcing leads to greater innovations and less production concentration (Sturgeon, 2002).

Successful examples of leveraging outsourcing to achieve high level of customization include: Motorola in the electronics industry, Nike and Reebok in the footwear industry, Dell in the computer industry, among others. Since firms no longer concentrate on limited product categories, OEMs can achieve higher diversification or product variety (Sanchez & Mahoney, 1996; Sturgeon, 2002). The product specialization hence decreases as higher outsourcing and pertinent modularity is utilized. So, the relationship between contract manufacturing and product specialization is hypothesized as follows:

Hypothesis 3: The higher level of the use of contract manufacturing, the lower product specialization for the OEM industry.

2.4 Contract Manufacturing vs. Capacity Utilization

In the conventional vertically integrated system, OEMs are more likely to set capacity utilization high with a goal to attain production economies of scale (Banker et al., 1996). Higher utilization of capacity is highly associated with the push supply chain strategy. In a push system, manufacturers tend to exploit its manufacturing capacity for volume production, so they can achieve scale economies. The inventories are accumulated and in turn pushed to the marketplace (Chopra & Meindl, 2007). Capacity utilization in this case, will be higher. However, evidence indicates that many industries in the developed capitalist economies suffer from excess capacity on the pursuit of scale economies (Porter, 1998).

Contrastingly, contract manufacturing strategies are often used in a pull system. Compared to the push system, the pull system's capacity is held off until orders arrive (Chopra & Meindl, 2007). Most productions are utilized for customized products. Specifically, manufacturers adopt higher level of outsourcing, aiming at higher efficiencies for the total supply chain rather than manufacturing alone. Contract manufacturer productions are triggered by incoming orders instead of forecasting (Hayes, 2002). The manufacturing capacities thus will be used on an as-needed basis. Since the participating manufacturers, both OEMs and CMs no longer need to operate manufacturing facilities to the full extent. The pull strategy will thus lead to lower capacity utilization.

Nowadays, OEMs outsource entire or parts of production to CMs (Cavinato, 1989). Specifically, by concentrating on the logistics, manufacturing, or marketing processes, OEMs and CMs can reach scale economies in respective supply chain processes and better utilize capacities. Furthermore, the efficiency of production may change over time due to new technologies (Sturgeon, 2002). That is, firms can still achieve acceptable unit cost on production even when operating at low capacity utilization. In line with the ROA argument, capacities in the manufacturing networks will be utilized in a more effective, if not more efficient, manner. Consequently, the capacity utilization will be likely lower with higher level of contract manufacturing. The foregoing discussion regarding capacity utilization is summarized as the following hypothesis:

Hypothesis 4: The higher level of the use of contract manufacturing, the higher capacity utilization for the OEM industry.

3. Data and Methods

3.1 Sample

The unit of analysis of this research is a U.S. manufacturing industry (U.S. Census Bureau., 2004a). Manufacturing industries have been the main focus of the industrial economies literature (Baldwin & Clark, 1997; Langlois & Robertson, 1995; Schilling & Steensma, 2001; Sturgeon, 2002). The 1997 version of the 6-digit North American Industry Classification System (NAICS) established by the U.S. Census Bureau (U.S. Census Bureau., 1998) is applied to define a manufacturing industry.

The 1997 & 2002 Economic Census of the U.S. Census Bureau serve as the main data sources, which include entire 473 manufacturing industries in the North American Industrial Classification System. This study collect the latest data for entire 473 manufacturing industries from multiple online data sets established in the 1997 & 2002 Economic Census. While 473 industries are included in the complete population of the 6-digit NAICS manufacturing industries, the final sample used for this research comprises over four hundred industries for which data can be obtained for all variables in the regression models.

3.2 Operationalizations of Variables

<u>Dependent variables</u>

Return on Investment (ROI): ROI is the ratio of profit gained on an investment relative to the amount of investment invested. ROI is most often stated as an annual rate of return, and it is most often stated for a calendar or fiscal year (Frigo & Ciecka, 1995; Kousenidis et al., 1998). In this article, "ROI" indicates the return on an investment over a one-year period, i.e. 1997 and 2002.

Return on Assets (ROA): ROA is the ratio of total profit to total assets. Return on assets is an indicator of how profitable a company is (Bettis, 1981). Once again, this paper uses this ratio annually to compare performances over industries.

Product specialization: the degree of production specialization is the ratio of annual primary product dollar values to dollar values of entire production outputs. The data sources are 1997 & 2002 Economic Census (Brush & Karnani, 1996).

Capacity Utilization. The operationalization of capacity utilization is the (weighted) average of the ratio between the actual output of firms to the maximum that could be produced per unit of time, with existing plant and equipment (Banker et al., 1996). The results are presented as an average percentage rate by industry and economy-wide, where 100% denotes full capacity. The data sources are 1997 & 2002 Annual Surveys of Manufactures in the respective Economic Census surveys.

<u>Independent and control variables</u>

Contract manufacturing: this paper utilizes Schilling and Steensma's (2001) operationalization to measure the degree for the use of contract manufacturing. Contract manufacturing is computed by a manufacturing industry's expenditure on contract work as a percentage of the total cost of materials. The data source is the Census of Manufacturers in the 1997 Economic Census (Schilling & Steensma, 2001).

Capital intensity: the level of capital intensity is measured by the ratio of capital expenditure to the total number of employees in an industry each year (Brush and Karnani, 1996). We use the "implicit price deflators for gross domestic product" reported by BEA to convert the capital expenditure dollar values into real 1997 terms (Dewan and Min, 1997, p. 1666). Capital intensive industries may need fewer inventories to buffer uncertainties because of the greater automation.

Labor intensity. Labor intensity is measured by dividing total number of employees by the dollar value of industry outputs each year (Schilling and Steensma, 2001). GDP price deflator is employed to convert industry outputs dollar vale into real 1997 terms (Dewan and Min, 1997). Labor intensive can probably lead to higher inventory because of the longer production leadtime.

Vertical integration. Since we are interested in a focal firm's use of outsourcing, it is imperative to hold the degree of vertical integration constant. Economics and management literature has used the ratio of value added over sales as an proxy for vertical integration (Balakrishnan and Wernerfelt, 1986; Brush and Karnani, 1996; Levy, 1985; Jacobsen, 1988). Two measures, value added and dollar value of output, obtained from the 1997 Economic Census to operationalize the focal industry's vertical integration (U.S. Census Bureau, 1997). We derive the focal industry's degree of vertical integration by dividing the industry's value added by the total value of shipments.

3.3 Statistical Procedures for Testing Hypotheses

The following model specifies the regression on overall contract manufacturing:

Industry Performance Indicator = β_0 + β_1 *Contract Manufacturing* + β_2 *Capital Intensity* + β_3 *Labor Intensity* + β_4 *Vertical Integration* + *error terms*

Based on our hypotheses, we anticipate that the coefficient of contract manufacturing variable (β_1) will be positive and significant in the regression models for ROI and ROA, whereas β_1 will be negative and significant in the regression models for product specialization and capacity utilization regressions, respectively.

4. Results

Table 1 presents the descriptive statistics and the correlation coefficients for the values of all variable measures. Several correlation coefficients, e.g. the coefficient between capital intensity and labor intensity, are close to .50. The high correlation could signify multicollinearity and result in imprecise regression results (Greene, 2000). The variance inflation factor (VIF) for each independent variable is thus investigated (Bae & Gargiulo, 2004; Neter, Wasserman, & Kutner, 1990). Management literature indicates that the accepted threshold for a VIF is 10. In the tests, all VIF scores are within the range 1.156 to 1.575, implying multicollinearity is not a serious problem for regression analyses.

[Insert Table 1 about here]

Statistical methods documented in the econometrics and industrial organizations literature are utilized to test the hypotheses (Greene, 2000; Johnston & DiNardo, 1997).

Ordinary least squares (OLS) serve as a baseline model for contract manufacturing. Since the regressions are based on time series data sets, the Durbin-Watson (DW) test is conducted to test the autocorrelation of error terms. Table 2 reports the OLS results. The DW statistic values in all regression models are all less than 2, indicating positive autocorrelation between 1997 and 2002 error terms (Johnston & DiNardo, 1997). Hence, this study utilizes Maximum Likelihood Estimation (MLE) techniques to account for the autoregressive problems (Greene, 2000). All regression runs are performed using SPSS software. The regression results reported below and in Table 3 are MLE outcomes.

[Insert Table 2 about here]

[Insert Table 3 about here]

Hypothesis 1: ROI

Hypotheses 1 suggest that higher level of contract manufacturing is associated with higher levels of ROI. With reference to the ROI regression outcomes in Table 3, the coefficient for contract manufacturing is positive and significant ($\beta_1 = 18.999$, $p < .05$); hence, Hypothesis 1 is supported.

Hypothesis 2: ROA

Hypothesis 2 suggests that the contract manufacturing should be positively associated with ROA. According to the ROA regression outcomes in Table 3, the coefficient for contract manufacturing is positive and significant ($\beta_1 = 1.877$, $p < .01$), suggesting that Hypothesis 2 is supported.

Hypothesis 3: Product specialization

In terms of product specialization, Hypothesis 3 proposes that higher contract manufacturing is associated with lower product specialization. The coefficient for contract manufacturing is negative and significant ($\beta_1 = -28.656$, $p < .001$), showing support for Hypothesis 3.

Hypothesis 4: Capacity utilization

The far right regression in Table 3 displays the regression coefficients regarding to capacity utilization. Surprising, the coefficient for contract manufacturing is not significant, not as predicted in Hypothesis 4. Hypotheses 4, hence, is not supported.

Finally, the results for our control variables suggest that vertical integration and labor intensity are both associated with greater modularity.

5. Discussion and Conclusion

5.1 Summary and Managerial Implications

A great deal of attention is being focused on the role of the contract manufacturers in the supply chain (Fine, 2000; Fine et al., 2005; Schilling & Steensma, 2001; Sturgeon, 2002). As the level of demand heterogeneity grows higher, manufacturing systems specializing in a narrow product range may no longer gain competitive advantages over more versatile systems with higher customization level (Schilling & Steensma, 2001). Outsourcing literature has yet determined the impacts of outsourcing or provided the basis for assessing this flexible manufacturing strategy. This research proposes various operations indicators examining outsourcing's effectiveness: ROI, ROA, product specialization, and capacity utilization.

This paper develops a set of hypotheses pertaining to the links between contract manufacturing and the foregoing four operations indicators. The method collects a large-scale archival data set and employs regression analyses to test the hypotheses. Statistics outcomes suggest that higher level of contract manufacturing is likely to lead to higher level of ROI and ROA. In contrast, higher degree of contract manufacturing is associated with lower degree product specialization. Overall, this study has displayed that outsourcing strategies are effective in achieving gains from assets and investment. Outsourcing has also resulted in higher product diversification, as displayed in the lower product specialization coefficients.

5.1 Managerial Implications

This study confirms that the preceding indices, with the exception of capacity utilization, should be incorporated to the metrics for assessing outsourcing strategies. The contract manufacturing strategy can significantly contribute to higher degree of ROI, ROA, and production diversification for OEMs. Given the significant impacts of contract manufacturing on these operational performances, future OEM must use these indicators to evaluate the effectiveness of individual contract manufacturers and the outsourcing strategy as a whole. Relationships with CMs that achieve higher ROI, ROA, and production variety may lead to sustainable competitive advantages for the OEMs.

In the current globalization contexts, commitments to reengineer a new format of supply chain are very critical for OEM successes. Role of CMs in expanding product offerings and increasing gains from existing assets and investments cannot be underestimated. Furthermore, manufacturing industries can obtain greater flexibilities by developing OEM-CM networks. On the product level, CMs help OEMs achieve product-mix flexibility and design flexibility. In terms of process or operations levels, outsourcing strategies helps OEMs achieve process flexibility by augmenting resource bases in technology, production, and logistics systems. On the network level, the OEM-CM networks can provide with more alternatives to configure supply chains, a strong flexibility which cannot be easily achieved by vertically integrated manufacturers.

5.2 Contributions

This paper is the first empirical research examines the impacts of contract manufacturing on product development and critical manufacturing system outcomes. Outsourcing literature has conceptually identified that using CMs can enhance supply chain flexibility in uncertain environments. The statistics analyses of this paper offers proof that utilizing CMs can be valuable for OEMs in terms of enhancing ROI, ROA, and product diversification. As such, this paper fills the gap in the outsourcing literature by conducting an empirical study, using extensive objective data sets. The findings will offer crucial insights into the potential impacts of outsourcing.

The findings of this paper help determine which decision-making criteria influence the use of contract manufacturers and robustness of the OEM-CM supply chains. The knowledge conveyed by this paper is valuable for policy makers and professionals working in manufacturing, supply industries, and services and investment institutions for OEMs and CMs. It is also able to further knowledge and research, as well as theory and practice, in the field of manufacturing technology and management.

5.3 Future research

Several limitations also call for future research. The recent global, large contract manufacturers have consolidated the manufacturing requirements from their global clients, and the square root law suggests that the consolidation can lead to lower echelon inventories. On the other hand, the distant communication between OEM and CMs and intermittent coordination can lead to bullwhip effects. Impact of the bullwhip effect in the OEM and CM network has yet been examined.

The long-term goal of the study is a longitudinal research stream regarding the outsourcing strategies for all U.S. manufacturing industries in both domestic and international contexts. The scope of this paper is limited to investigate the impacts of outsourcing for the entire U.S. manufacturing sectors, across years 1997 and 2002. Future research will be based on upcoming release of the Census data (e.g., Census 2007) which will lead to future development of the contract manufacturing practices.

Furthermore, firm-level study or industry specific research should be applied to examine flexible systems. On the business-to-business setting, OEMs and CMs are engaged in complex contracting processes. Aspects of supply contracts for effective outsourcing should be investigated to provide roadmaps for potential outsourcing manufacturers. Lastly, future research should aim at developing additional matrices and measurements pertaining to outsourcing strategies so that OEMs and CMs can more comprehensively determine the impacts of this emerging strategy.

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TABLE 1. DESCRIPTIVE COEFFICIENTS AND CORRELATION COEFFICIENTS

Variables	Mean	Standard Deviation	Min	Max	ROI	ROA	Product Specialization	Capacity Utilization	Contract Manufacturing	Capital Intensity	Labor Intensity	Vertical Integration
ROI	19.773	13.729	2.94	151.270	1							
ROA	1.677	1.080	.230	12.270	.700**	1						
Product Specialization	92.141	5.809	56.000	100.000	-.146**	-.174**	1					
Capacity Utilization	.706	.117	.230	.990	-.176**	-.090**	-.098**	1				
Contract Manufacturing	.034	.048	.000	.621	.254**	-.333**	-.231**	-.059	1			
Capital Intensity	9.195	10.985	.389	122.779	-.365**	-.348**	-.065*	.307**	-.154**	1		
Labor Intensity	.006	.003	.000	.037	.240**	.357**	.056	-.128**	.334**	-.464**	1	
Vertical Integration	.511	.124	.117	.881	.213**	.263**	.009	-.165**	.279**	-.161**	.420**	1

** $p < .01$; * $p < .05$ (2 tailed tests).

TABLE 2. ORDINARY LEAST SQUARE (OLS) REGRESSION RESULTS

	Dependent Variables			
	ROI	ROA	Product Specialization	Capacity Utilization
Constant	15.744 (1.900)***	1.025 (.143)***	91.945 (.882)***	.731 (.017)***
Contract Manufacturing	49.587 (9.130)***	4.817 (.389)***	-33.410 (4.172)***	-.006 (.082)
Capacity Intensity	-.392 (.042)***	-.022 (.003)***	-.031 (.020)	.003 (.000)***
Labor Intensity	-12.246 (153.624)	47.061 (11.595)***	184.576 (70.678)**	3.886 (1.399)**
Vertical Integration	11.446 (3.772)**	.833 (.285)**	1.229 (1.771)	-.157 (.034)***
R^2	.179	.233	.074	.107
Adjusted R^2	.175	.230	.070	.103
F	48.982***	67.001***	17.649***	26.759***
Durbin-Watson	1.333	1.091	1.638	1.280
Number of Observations	897	897	868	891

*** p< .001; ** p < .01; * p < .05; + p < .10 (2 tailed tests). Standard errors in parentheses.

TABLE 3. MAXIMUM LIKELIHOOD ESTIMATION (MLE) REGRESSION RESULTS

	Dependent Variables			
	ROI	ROA	Product Specialization	Capacity Utilization
Constant	11.460 (2.007)***	.746 (.146)***	92.600 (.933)***	.695 (.018)***
Contract Manufacturing	18.999 (9.220)*	1.877 (.643)**	-28.656 (4.331)***	.004 (.082)
Capacity Intensity	-.354 (.041)***	-.017 (.003)***	-.035 (.020)+	.003 (.000)***
Labor Intensity	-410.005 (160.065)*	-2.159 (11.298)	178.261 (74.463)*	-.748 (1.456)
Vertical Integration	25.576 (2.007)***	2.016 (.273)***	-.257 (1.868)	-.034 (.035)
Log-Likelihood	-3452.985	-1073.958	-2700.776	784.364
Number of Observations	897	897	868	891

*** p< .001; ** p < .01; * p < .05; + p < .10 (2 tailed tests). Standard errors in parentheses