INTRODUCTION

The use of vending machines in industrial settings has become an increasingly important aspect of day-to-day operations for many organizations (Manrique and Manrique, 2015). These computerized systems (commonly referred to as industrial vending, point-of-use vending or line-side vending machines) are used by organizations to stock different items such as maintenance, repair and operations (MRO) items and consumables, safety equipment, tools, as well as controlled substances. The machines keep track of inventory levels, record what is being dispensed and to whom, and generate different reports on how and when items are being used (Melcer, 2000). This information is exchanged between the customer and the vendor, or supplier, who is responsible for replenishment.

One impetus for the emergence of this technology stems from the growing need of organizations to monitor specific inventory items. For example, increased control in the case of MRO items and consumables is of critical importance for organizations since expenditures in those areas can exceed 20 percent of a firm's annual spend and account for more than 50 percent of an organization's indirect purchases (Goodwin, 2011). Another reason for the development of industrial vending systems is the fact that the majority of organizations do not have systems in place that enable them to restrict access to stockrooms where inventory items are housed or to monitor the usage of those items. These issues can lead to stock outs of critical items, unnecessary downtime as well as lost customers (Goodwin, 2011).

Industrial vending systems represent a specific form of vendor-managed inventory (VMI). VMI has been defined as a collaborative agreement between a buyer and a vendor to optimize the availability of products and minimize cost to the two entities. In a VMI system the vendor is responsible for the management of the inventory within an agreed framework of targets

which are constantly monitored to continuously improve performance (Hines et al., 2000). Industrial vending is unique in that it blends the benefits inherent to traditional consumer vending systems with the benefits of VMI (Goodwin, 2011).

Overall, different benefits associated with industrial vending solutions have been identified in specific trade journals that advocate the use of these systems. However, the field of industrial vending has been largely ignored by the academic community. The purpose of this paper is to develop a model to empirically investigate the relationships between different enablers, user (or buyer) perceived industrial vending system success and a series of performance outcomes. To accomplish the stated research objective, a survey instrument was designed and data was obtained from 171 current industrial vending system users. A structural equation model was developed and the AMOS software package was used to test the model. The proposed model is grounded in transaction cost theory and represents a modified version of the VMI model developed by Claassen et al. (2008).

The rest of the paper is organized as follows: The study begins with an overview of the transaction cost theory literature and the field of VMI which provide theoretical support for this research. The authors then discuss the development of the research hypotheses before transitioning to the methodology and results sections. Conclusions, implications, and directions for future research are also discussed.

THEORETICAL BACKGROUND

Transaction Cost Theory

Transaction cost theory (TCT) is a complex economic theory that has been successfully applied to different supply chain management problems (Luzzini et al., 2012, Scherrer-Rathje et

al., 2014). At its core, TCT proposes that there is a cost associated with all business transactions that must be accounted for, and that companies attempt to minimize those costs while balancing the risks associated with each potential outcome (Williamson, 1985). TCT differs from other economic theories because it recognizes that certain situations require parties to engage in an ongoing relationship to complete a transaction (Grover and Malhotra, 2003).

There are two key assumptions that underlie TCT: bounded rationality and opportunism (Grover and Malhotra, 2003). The assumption of bounded rationality suggests that decision makers possess finite limits in regard to their ability to receive, store, retrieve and communicate information without error (Simon, 1957). Bounded rationality thus limits the extent to which decision makers can be expected to act in a rational manner in times of uncertainty. In instances where the level of uncertainty increases, firms react by adopting governance mechanisms which enable them to minimize transaction costs. The second assumption underlying TCT, opportunism, suggests that decision makers will act in their own self-interest. Opportunism results in increased transaction costs due to the added expenses associated with monitoring the relationship and the other partner's actions as well as the need to safeguard company assets (Grover and Malhotra, 2003). Firms may thus seek new inventory solutions and focus on buyer-seller relationships to mitigate transaction costs. Transaction costs can be viewed in terms of their two major components: coordination costs and transaction risks. The relationship between the different components is presented below (Clemons et al., 1993).

Transaction Costs = Coordination Costs + Transaction Risks

Coordination costs generally include, but are not limited to, the costs associated with the exchange of information in the buyer-seller relationship. Typically, these costs include product specifications, pricing, warranties, ancillary costs, and the terms and conditions of the sale (Tadelis, 2010). The buyer-seller relationship of a transaction is also related to asset specificity. Asset specificity is defined as the extent to which investments made to support a transaction have a higher value to that transaction than those investments would have if redeployed elsewhere. In certain situations, asset specificity can help reduce coordination costs by creating a dependency between the buyer and the seller (Riordan and Williamson, 1985). An increased dependency can lead to numerous benefits such as cost reductions or increased levels of customer service (Williamson, 1985).

On the other hand, transaction risks stem from the risk resulting from either party (the buyer or the vendor) either willingly or unwillingly failing to fulfill their contractual obligations. In this respect, industrial vending solutions can make a vast amount of real time information available to both the buyer and the vendor. The information generated by industrial vending systems and the subsequent exchange of information can help increase the level of information symmetry and make the relationship more transparent. As a consequence of this increased information symmetry and transparency, industrial vending systems can help reduce the possibility of buyer or supplier opportunism, improve the quality of the buyer seller relationship, and ultimately help moderate both transaction costs and risks.

VMI and Collaborative Relationships

The concept of VMI was developed and popularized in the late 1980s by Wal-Mart and Proctor & Gamble and is presently one of the most thoroughly researched partnering initiatives

used to improve multi-firm supply chain efficiency (Niranjan et al., 2012). Past research indicates that VMI can create different opportunities for channel partners, help firms reduce costs, and improve service levels (Niranjan et al., 2012). Many buying firms report that VMI systems have enabled them to receive higher levels of service and reduce overall inventory costs (Tang, 2006). Alternatively, various suppliers have found that the successful implementation of VMI initiatives has allowed them to reduce production, inventory and transportation costs by helping them smooth peaks and valleys in the flow of goods (Kaipia and Tanskanen, 2003, Tang, 2006).

Buyers and suppliers engage in VMI as a collaborative strategy to improve inventory availability at the most efficient cost (Hines et al., 2000). These collaborative relationships can create competitive advantage and improve firm performance (Fawcett et al., 2008). The exchange of critical resources such as information, technology, and expertise characterizes these relationships.

In most VMI agreements, a supplier takes full responsibility for managing the inventory of certain agreed upon products and in exchange a supplier is given access to demand information. In turn, suppliers are responsible for developing replenishment plans for the customer based on their actual usage patterns and monitoring the buyer's inventory levels (Waller et al., 1999). One of the key aspects related to VMI success is that the responsibility for purchase decisions is transferred from the buying firm to the supplier (Tang, 2006, Dong et al., 2007). The transfer of responsibility can allow suppliers to respond to demand volatility proactively instead of reactively (Marques et al., 2010).

The successful implementation of VMI has ultimately been found to promote higher levels of collaboration between channel partners, resulting in improved cost, improved inventory

control, and improved service performance for both parties (Cetinkaya and Lee, 2000, Dong et al., 2007, Waller et al., 1999). In addition, successful VMI has also been found to reduce the negative impacts associated with the distortion of demand information transferred from the buyer to the supplier known as the bullwhip effect (Disney and Towill, 2003).

Enablers and Outcomes of Perceived VMI Success

Claassen et al. (2008) identified a series of enablers of managerial perception of VMI success such as the degree of information quality, the quality of the buyer-supplier relationship and the degree of information sharing between buyers and suppliers. These enablers can help firms become more strategically aligned with suppliers through improved collaboration and information exchange.

A decision maker's contingent response to the environment is linked to outcomes (Fawcett et al., 2008). Bounded rationality, which creates barriers to predict outcomes of stronger collaboration, becomes economized in the minds of managers when certain outcomes (such as lower inventory costs) are realized (Chiles and McMackin, 1996). The research by Claassen et al. (2008) investigated the outcomes of VMI systems. These outcomes or benefits included cost reductions and service improvements.

Enablers thus influence managers' perceptions of success while outcomes are the manifestation of this buyer-perceived success and can help managers decide whether the commitment to vendor managed solutions (in this case, industrial vending systems) should be continued (Dong et al., 2007). Perceived success is looked at from the perspective of users who describe the implementation of those specific vendor managed solutions as "a good idea" and who consider that the agreements have "more advantages than disadvantages" and will most

likely improve performance over time (Claassen et al., 2008, p. 410). Therefore, perceived industrial vending system success measures cognitive feelings about both observed performance and future potential.

In this study, three enablers (*information exchange, information quality* and *relationship quality*) and two of the outcomes (*cost benefits and service benefits*) are adapted from Claassen et al. (2008). An additional outcome (*inventory benefits*) not studied by Claassen et al. (2008) is included based on the literature review and a series of interviews with industry professionals. As a result, the proposed theoretical model (shown in Figure 1) links three enablers and three outcomes or benefits of buyer-perceived industrial vending system success.

Insert Figure 1
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The original model developed by Claassen et al. (2008) resulted in some unexpected findings that are reexamined in this study. First, Claassen et al. (2008) had originally found that the coefficient of the path between information quality and perceived VMI success was not significant. This finding, from a TCT perspective, seems to be unexpected since more accurate, reliable and timely information (i.e., higher quality information) should help reduce the level of uncertainty and enhance a decision maker's ability to make more informed decisions. Second, the outcome results presented by Claassen et al. (2008) were also somewhat unexpected. The authors' model explained only nine percent of the variance in cost benefits and, compared to the other outcomes included in their analysis, the relationship between VMI success and cost benefits had the lowest standardized coefficient. This finding does not seem to correspond with what TCT proposes regarding asset specificity. As previously explained, specialized industrial

vending machines can create a strong bilateral dependency between buyers and vendors that should ultimately lead to significant cost benefits. All these different issues are investigated in this study by testing a series of hypothesized relationships. The following two sections develop the model's hypotheses.

ENABLERS OF PERCEIVED INDUSTRIAL VENDING SYSTEM SUCCESS

Information Quality Impact on Perceived Success

The first hypothesis is related to the link between information quality and buyer-perceived industrial vending implementation success. The hypothesis was developed based on the idea that improved information quality should result in increased perceptions of vending solution implementation success. This study employs four items (information accuracy, adequacy, reliability and timeliness) originally included in the measurement instrument for studying supply chain management practices developed and validated by Li et al. (2005). Those four items are used to measure the quality of the information provided by the industrial vending system.

Support for this hypothesis is provided by Frohlich and Westbrook (2002), who established that information quality positively affects perceptions of operational success. This is especially true in cases where buyers are dependent on suppliers due to high environmental and demand uncertainty (Yigitbasioglu, 2010). Information quality can be linked to the TCT concepts of bounded rationality, uncertainty and opportunism. While bounded rationality and uncertainty limit a decision maker's ability to make informed decisions, fears of opportunism can exacerbate perceptions of knowledge scarcity (Grover and Malhotra, 2003). In this respect, the more accurate, reliable and timely information generated by an industrial vending system should

help mitigate opportunism, reduce the level of uncertainty, and enhance a decision maker's ability to make informed decisions. Improved information quality should then help reduce transaction costs (Dyer and Chu, 2003) and lead to higher perceptions of operational success (Yigitbasioglu, 2010).

Monczka et al. (1998) established that successful supply chain alliances are associated with high levels of information quality. Similarly, Petersen et al. (2005) (who also recognized that information quality has multiple dimensions such as accuracy, completeness, ease of use and timeliness) analyzed firms involved in collaborative supply chain agreements such as VMI, and found that effective collaborative initiatives depend on the quality of the information that is exchanged between supply chain partners. The following hypothesis is therefore proposed.

H_1: The higher the quality of the information generated by the industrial vending system, the higher the buyer-perceived industrial vending system success.

Information Exchange Impact on Perceived Success

The second research hypothesis deals with the relationship between information exchange and buyer-perceived industrial vending system implementation success. Information exchange can be defined as the extent to which critical, proprietary information is communicated between buyers and suppliers (Monczka et al., 1998). It has been established that a key to collaborative supplier initiatives is the exchange of information (Dong et al., 2007). For example, the exchange of information about usage and inventory levels can lead to better forecasting and play an important role in VMI initiatives (Claassen et al., 2008).

The hypothesis was developed based on the idea that an increased level of information exchange should lead to increased perceptions of vending solution implementation success. For this purpose, our study adapts items originally used by Claassen et al. (2008) which are, in turn,

based on the specific types of information exchanged between buyers and suppliers researched by Lee and Whang (2000). The items included in our study are specifically aimed at determining the degree to which industrial vending systems provide both buyers and vendors with access to actual usage and inventory data, and whether the information exchanged allows the organizations to operate more efficiently.

The supply chain management and logistics literature has long acknowledged the importance of exchanging information between supply chain partners (Williams and Waller, 2010). Past research has identified the exchange of information as a necessary condition to the success of buyer-seller alliances (Hofer et al., 2012). Thatte et al. (2013) reported that more responsive channel partners tend to exchange more information, while Thomas and Esper (2010) identified collaborative behaviors such as information sharing, idiosyncratic investments and effective governance as sources of competitive advantage. Boon-Itt and Wong (2011) also found that higher levels of integration lead to increased information exchange and more successful relationships in all areas.

Further support for the proposed hypothesis is provided by TCT, which suggests that the asset specificity of specialized machines designed to assist with inventory management can result in increased channel transparency and improved information flows. Transparency in the vendor–buyer relationship has been identified as an important factor to realize the benefits of a VMI initiatives (Tyan and Wee, 2003). TCT has also been used to characterize inter-organizational information exchange. In this line of research, Yigitbasioglu (2010) found that information exchange can result in improved buyers' performance with respect to resource usage, output, and flexibility. Therefore, it is posited that the increased exchange of information resulting from the

implementation of industrial vending solutions can be an important enabler of perceived industrial vending system success.

The work by Claassen et al. (2008) also established that sharing information represents an important factor in the success of VMI initiatives and provides further theoretical support for the relationship between information exchange and the perceived success of an industrial vending initiative. Based on the discussion above, the following hypothesis is then proposed.

H_2: The more extensive the exchange of information between buyer and vendor, the higher the buyer-perceived industrial vending system success.

Relationship Quality Impact on Perceived Success

The third hypothesis is related to the link between buyer-vendor relationship quality and buyer-perceived vending solution implementation success. This hypothesis was developed based on the belief that higher levels of relationship quality should lead to increased perceptions of industrial vending system implementation success. In this study, items employed by Claassen et al. (2008) are used to measure the buyer-vendor relationship, including questions such as: "We can count on the supplier's support when it comes to important needs and requirements" and "We are convinced that this supplier will live up to all the deals and agreements." The items included in Claassen et al. (2008) are, in turn, based on the measurement instrument for studying industrial supplier relationships and their impact on relationship quality originally developed and validated by Walter et al. (2003).

Transaction cost theory suggests that firms that successfully match supplier specific assets with long lasting relationships should observe a positive effect on performance (Heide and Stump, 1995). In this respect, Jones and Hill (1988) established that, because of their specialized nature, transaction specific assets tend to not only be highly productive but also foster improved

relationship quality as well as relationship continuity. Research by Dyer and Chu (2003) established that relationships characterized by multiple buyer-seller interactions help build transaction history and can, in turn, help reduce uncertainty and transaction costs. Mentzer et al. (2000) established that buyer-supplier relationships significantly impact how efficiently and effectively supply chains are managed. These relationships, when deemed to be of high quality, have been shown to improve flexibility, increase efficiencies, and when maintained over time, have the potential to create sustainable competitive advantage (Nyaga et al., 2010).

Finally, the quality of the buyer-seller relationship has also been established as a key factor in successful VMI implementations (Claassen et al., 2008). As a result, the following hypothesis is proposed.

H_3: The higher the quality of the buyer-vendor relationship, the higher the buyer-perceived industrial vending system success.

OUTCOME FACTORS OF PERCEIVED INDUSTRIAL VENDING SUCCESS

Claassen et al. (2008) establish that outcomes are the manifestation of perceived success. In the case of industrial vending systems, beneficial outcomes encompass cost reductions, service improvements, and inventory improvements.

Cost Reductions as an Outcome of Industrial Vending System Success

The fourth research hypothesis deals with the relationship between perceived vending solution implementation success and cost benefits. The hypothesis was developed based on the belief that higher levels of buyer-perceived vending solution implementation success should lead to increased perceptions of cost benefits. For this purpose, measures developed and tested by Claassen et al. (2008) are adapted to inquire about different potential cost benefits, including

questions focused on the reduction in total inventory costs, hoarding and pilferage costs, and stock out costs.

Support for this hypothesis is provided by Tang (2006), who found that VMI systems enable buying firms to reduce overall inventory costs. Williams and Waller (2010) established that buyers and sellers tend to form alliances and partnerships in order to minimize costs, while Yao et al. (2007) noted the potential inventory cost savings afforded by VMI solutions. Similarly, other authors have established that vendor managed inventory agreements are an effective means of reducing different types of costs (Kauremaa et al., 2009, Niranjan et al., 2012, Waller et al., 1999).

Additional support for this hypothesis is provided by TCT, which suggests that asset specificity can help reduce transaction and coordination costs. In this respect, previous research has linked asset specificity to VMI success and cost reductions due to greater efficiencies (Grover and Malhotra, 2003, Tadelis, 2010). The following hypothesis is therefore proposed.

H_4: The higher the buyer-perceived industrial vending system success, the more cost reductions are achieved.

Service Improvements as an Outcome of Industrial Vending System Success

The fifth hypothesis is related to the link between perceived vending solution implementation success and improvements in customer service. This hypothesis was developed based on the idea that higher levels of buyer-perceived vending solution implementation success should lead to increased perceptions of service benefits. Measures originally developed by Claassen et al. (2008) based on the authors' review of the literature are used to inquire about service improvements (including questions aimed at studying the impact of industrial vending solutions on the level of supplier responsiveness and the level of customer service received).

Support for the hypothesis is provided by Fawcett et al. (2010) who found that companies that successfully optimize inventory via lean systems such as VMI tend to achieve higher service levels. Kaipia and Tanskanen (2003) and Niranjan et al. (2012) also found that the efficiency derived from collaborative inventory agreements can improve customer service, while Claassen et al. (2008) established that service improvements represent a positive outcome of VMI initiatives.

As previously explained, the asset specificity of industrial vending systems can lead to increased bilateral dependency as well as increased control (Grover and Malhotra, 2003, Tadelis, 2010). The increased level of control and bilateral dependency can help reduce the uncertainty typically found in a transaction process and allow suppliers to provide higher levels of customer service. Perceptions of better customer service can be thought of as the outcome of the increased control and the reduced uncertainty characteristic of successful industrial vending system solutions. Consequently, the following hypothesis is proposed.

H_5: The higher the buyer-perceived industrial vending system success, the more customer service level improvements are achieved.

Inventory Benefits as an Outcome of Industrial Vending System Success

The last hypothesis deals with the relationship between buyer-perceived vending solution implementation success and inventory management benefits. Collaborative agreements such as VMI represent a managerial response to counteract inventory management issues and challenges. Inventory management problems include issues related to stock outs and stock loss (Kang and Gershwin, 2005), inventory control and service levels (Morey, 1985), and overall inventory accuracy of finished goods (French, 1980).

The hypothesis was developed based on the belief that higher levels of buyer-perceived

vending solution implementation success should lead to increased perceptions of inventory benefits. The additional outcome related to inventory benefits was included in this study based on the review of the literature (e.g. Waller et al. (1999) and Dong et al. (2007)) and a series of interviews with supply chain professionals. Survey items were developed following discussions with industry professionals and include questions related to inventory availability, inventory count accuracy, and overall inventory levels.

Support for the hypothesis is provided by Fawcett et al. (2010), who established that collaborative relationships can improve inventory management and result in higher levels of asset utilization, as well as Cetinkaya and Lee (2000), who found that stock out situations are less frequent, and inventory-carrying costs are reduced with vendor managed solutions.

From a TCT perspective, the asset specificity of industrial vending systems can help increase transparency and improve the flow of information between buyers and vendors. Improved information flow can, in turn, lead to greater control as well as increased perceptions of outcome success (Tadelis, 2010, Yigitbasioglu, 2010). Greater control and transparency can then help organizations reduce uncertainty and manage inventory levels more efficiently. The following hypothesis is therefore proposed.

H_6: The higher the buyer-perceived industrial vending system success leads to increased perceptions of inventory benefits.

The authors propose the path diagram in Figure 1. The model establishes that the quality of the information generated by the industrial vending system, the exchange of information exchange between buyer and supplier, and the buyer-vendor relationship positively affect the buyer's perception of industrial vending implementation success. The successful implementation

of industrial vending should result in cost savings, enhanced service levels and inventory benefits.

METHODOLOGY

Survey Development and Data Collection

Following the literature review, a survey instrument was developed to investigate the constructs of interest. As previously noted, the survey instrument is based in part on the work of Claassen et al. (2008) even though changes were necessary due to the different constructs and research purposes. To ensure the content validity of the survey items, a review by a panel of subject-matter experts was performed. Six supply chain professionals (two from academia and four from related business and consulting fields) were asked to evaluate the survey questions. The group reviewed the questionnaire not only for readability and ambiguity (Dillman, 2000), but also for match of items and constructs. The feedback received from the expert panel was used to revise the questionnaire and improve both its readability as well as its ability to capture relevant information before it was administered.

The authors chose to post the survey instrument online and contact potential respondents via email. An online survey instrument was used in order to gather data more quickly and reduce the time and costs associated with the data collection process. The target population included supply chain managers in positions of responsibility to comment on their firm's usage of industrial vending solutions. Supply chain professionals' contact information was obtained via three organizations: the Institute for Supply Management, the Council for Supply Chain Management Professionals, and the Association for Healthcare Resource & Materials Management. A total of 2896 usable email addresses were obtained.

A pilot study was conducted first. 100 supply chain professionals were randomly selected from the list of contacts. The initial mailing resulted in a response rate of 20 percent within one week. A second reminder was then sent to non-respondents the following week producing an additional 20 responses, which resulted in a net response rate of 40 percent for the pilot sample. The results of the pilot sample, including a comparison of early to late respondents, indicated that no major changes needed to be made to the survey instrument. However, the pilot respondents did suggest very specific operational questions that were outside of the scope of this study. For example, a few respondents asked the very specific question on how certain other branded solutions compare to their systems. The authors determined this type of question would be better addressed through individual marketing surveys for a particular vendor.

After the pilot study, the first wave of 2796 emails was sent and yielded 259 responses. After four weeks a second wave of emails was sent which generated an additional 180 responses. Overall, recipients completed 439 questionnaires (this figure excludes the responses obtained during the pilot study), for a net response rate of 15.7 percent (439 responses out of 2796 emails). All responses were verified using sender IP addresses to ensure that no firm location was represented more than once in the survey. This approach ensured respondent anonymity yet provided a method to infer approximate demographic and location information (McDonald et al., 2012). It was determined that a small number of respondents were from the same firm but not from the same location so, as a result, these responses were included in the study. Non-response bias, on the other hand, was tested by comparing early versus late respondents (Armstrong and Overton, 1977). The first and fourth quartiles of respondents were tested for differences in mean

construct responses. The results of this analysis indicated that there were no significant differences (p-values between .072 to .301) in the responses obtained from the two groups.

Respondent Demographics

Respondent demographics provide an interesting snapshot into the current state of the industrial vending field. The breakdown of the respondents by functional areas was approximately 53 percent from procurement/purchasing/sourcing, 25 percent from operations/production/materials management/warehousing, and 22 percent from logistics/transportation (inbound or outbound). Thirty-nine percent of respondents stated their organizations currently used industrial vending systems (note that only those respondents who indicated that their firms were current users are included in the study results), 10 percent were considering adopting these systems while the remaining 51 percent were not currently using nor considering vending solutions at the time.

With respect to procurement spend, most of the firms (58 percent) reported an annual spend between $10 million and $100 million. An analysis of users versus non-users of industrial vending systems in terms of spend did not reveal any significant differences except for the case of smaller companies (i.e., firms with an annual spend of $1 million or less). While those firms accounted for 11 percent of the non-user group, companies with an annual spend of less than $1 million represented less than two percent of the group of current users. A similar analysis of the adoption of industrial vending across industries indicated there were no major differences except in the Medical and Transportation sectors (while 86 percent of the participants from the Medical sector stated that their companies currently used industrial vending systems, 84 percent of the respondents from the Transportation industry indicated that their firms did not use these types of

solutions). In general, the typical users of industrial vending machines can be found in the Manufacturing and Medical sectors (For a more detailed breakdown, refer to Table I, which provides a summary comparison of current users).

Insert Table I
About here

Users of industrial vending solutions also differ with respect to the items the machines are used for. In the case of non-medical survey participants, industrial consumables such as adhesives, fasteners, etc. (20% of non-medical respondents), MRO items such as spare parts (19%), and industrial safety equipment (19%) were the top three types of items. On the other hand, survey respondents from the medical sector identified controlled substances such as narcotics and other drugs (34%), medical supplies such as latex gloves (31%), and surgical tools (15%) as the top three categories industrial vending systems are used for. On average, current users of vending solutions had 5 machines per location. A separate question was also included in the survey to elicit responses pertaining to how long it took for the industrial vending solution to payback and become beneficial to their firm. In this respect, 74 percent of respondents stated that the implementation of the vending solution became economically beneficial to their organization in less than two years.

RESULTS

The individual items used in the model along with their corresponding means and standard deviations are presented in Table II. The items in the survey utilized a seven-point Likert type scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Insert Table II
About here

Model fit was assessed in two stages, as outlined by Chin (1998). In the first stage, the measurement model was developed and assessed. The second stage tested the structural model and the hypotheses. Sample size requirements were established using the generally accepted guidelines set forth by Nunnally (1979) which suggest using, as a minimum, ten times the number of predictors in the most complex relationship of the model. As shown in Figure 1, in the hypothesized model *perceived industrial vending system success* is related to three antecedents: *information quality* (4 items), *information exchange* (3 items) and *relationship quality* (4 items), and three outcome variables: *cost benefits* (3 items), *service benefits* (3 items) and *inventory benefits* (3 items). The application of the aforementioned guidelines yielded a minimum sample size of 70. With a sample of 171 current users of industrial vending systems, the minimum required sample size was more than satisfied.

Measurement Model

Independent variable constructs were derived from the survey data using exploratory factor analysis. The seven factors were extracted using a principal components analysis followed by a Varimax rotation. An item was considered to load on a given factor if the loading after the rotation was 0.60 or greater for the factor and less than 0.40 for the other factors. The factors were then verified through the use of Eigenvalues equal to or greater than 1.0. Table III displays the different factors and their corresponding loadings. The results indicate that there were relatively high loadings within factors, and no cross-loadings between factors.

Reliability was examined to test the internal consistency of the research variables. Chronbach alpha tests were performed on each construct. The resulting Cronbach alpha estimates (also displayed in Table III) ranged from .85 to .93, which exceeded the .70 cutoff recommended by Nunnally (1979).

Insert Table III
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With respect to the fit of the measurement model, a normed chi-square value of 1.967 indicated acceptable fit (Kline, 2005). The root mean square error of approximation (RMSEA) value of .067 was within the .05 to .08 range suggested by Hair et al. (1998), further indicating adequate model fit. With respect to the comparative fit index (CFI) and the incremental fit index (IFI), the values of .930 and .931 also indicated acceptable model fit since they both exceeded the .90 cutoff recommended by Hu and Bentler (1999).

The assessment of the measurement model also included an analysis of the discriminant and convergent validity of the constructs. The results are summarized in Table IV. The average variance extracted (AVE) for each construct was at least 0.60. These results indicated adequate convergent validity for all constructs since all AVE values exceeded the minimum value of 0.50 recommended by Fornell and Larcker (1981). Finally, the square root of the AVE of each construct exceeded the respective inter-construct correlations, indicating acceptable discriminant validity for all seven constructs used in the study (Fornell and Larcker, 1981).

Insert Table IV
About here

A Harman's single factor test was conducted to test for common method bias (CMB) (Harman, 1976). The resulting unrotated solution was examined to determine if the majority of the variance in the model was explained by a single factor (Podsakoff et al., 2003). The test results indicated that CMB was not an issue since the maximum percentage of variance explained by a single factor was less than 50 percent.

Structural Model

The proposed structural equation model was tested and confirmed using the AMOS software package and the sample of current industrial vending system users. Figure 2 details the results of the structural model as well as the different fit statistics. With respect to the fit of the structural model, a 2.12 normed chi-square value indicated reasonable model fit (Kline, 2005). The RMSEA value of .074 was within the .05 to .08 range suggested by Hair et al. (1998), also indicating adequate goodness-of-fit. A CFI value equal to .914 and an IFI value of .916 exceeded the .90 cutoff recommended by Hu and Bentler (1999) and further indicated acceptable model fit.

Insert Figure 2
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After confirming the fit of the structural model, all of the hypotheses were simultaneously tested. Table V displays the results of this portion of the analysis. H_1, which examined the relationship between information quality and perceived industrial vending system success, was supported with a standardized regression weight of 0.293 and a *p*-value of 0.000. Information exchange was found to have a positive impact on perceived industrial vending system success

(H_2 supported with a standardized regression weight of 0.438 and a *p*-value of 0.000). Finally, relationship quality was found to have a positive impact on perceived industrial vending system success as H_3 was supported with a standardized regression weight of 0.211 and a *p*-value of 0.004).

Perceived industrial vending system success, on the other hand, was found to be related to cost (H_4 supported with a standardized regression weight of 0.821 and a *p*-value of 0.000), service (H_5 supported with a standardized regression weight of 0.673 and a *p*-value of 0.000), and inventory (H_6 supported with a standardized regression weight of 0.798 and a *p*-value of 0.000). Overall, while caution must be used (since standardized path coefficients are expressed in terms of units of standard deviation), the coefficients may be generally interpreted as follows: if information exchange were increased by one standard deviation while all other variables were held constant, perceived industrial vending system success would be expected to increase by 0.438 standard deviations. On the other hand, all variables held constant, a one unit increase in standard deviation for relationship quality would increase perceived industrial vending success by 0.211 standard deviations. A statement can be made that, in terms of standardized units, the direct effect of relationship quality seems to be less than the effect of information exchange on perceived industrial vending success.

Insert Table V
About here

Discussion

The descriptive statistics provided in Table II indicate that most of the mean values for the constructs are close to 6 (out of a 7 point scale), while the standard deviations are generally

consistent across all constructs and items. The construct that measured the quality of information generated by the industrial vending system resulted in a mean response of 5.97 out of 7, indicating that respondents generally agree that the adoption of their vending solution can result in improved information accuracy, adequacy, reliability and timeliness. Even though Claassen et al. (2008) found that the effect of information quality on the success of VMI initiatives was not significant in practice, the findings in this study show that the quality of the information provided by industrial vending machines has a positive impact on the perceived success of industrial vending systems. This finding is relevant to professionals because it indicates that industrial vending solutions, as a specific form of VMI, can help reduce the costs and risks associated with inadequate or insufficient information.

The second hypothesis looked at the connection between information exchange and perceived success. The information exchange construct mean was 6.08 out of 7, indicating that respondents believe that these type of solutions can facilitate information exchange between buyers and suppliers. While Claassen et al. (2008) had originally found that the exchange of information is an important factor in VMI initiatives, the research presented here corroborates that conclusion for the specific case of industrial vending systems. Overall, the results suggest that industrial vending solutions can allow buyer and supplier organizations to exchange and obtain the information necessary to effectively manage day to day operations.

The third hypothesis dealt with the relationship between relationship quality and perceived success. The construct mean was 5.66 out of 7, indicating that respondents, overall, believe that industrial vending solutions can help improve the relationship between buyers and suppliers. While the hypothesis results presented here support that conclusion that the buyer-vendor relationship quality plays a significant role in successful vending solutions, the lower

standard weight (.211) may indicate that a particularly close relationship with the vending solution provider is not necessary as long as the vendor performs the contractual obligations in a satisfactory manner. For example, the buyer-vendor relationship may start out very close in the setup phase of the vending solution but then fall back to a more at-arms-length relationship once the set up phase is over and the system is functioning properly.

In terms of the three outcome variables, the study results indicate that there exist benefits afforded to firms that successfully adopt industrial vending. The fourth hypothesis looked at the relationship between vending implementation success and cost benefits. While previous research had established the link between VMI solutions and cost reductions, the results of this study provide support for the specific case of industrial vending systems. The cost benefits construct mean was 5.72 out of 7, indicating that respondents believe vending solutions bring with them cost benefits. In addition, the overall majority of current users indicated that the systems paid for themselves and were cost effective in less than two years. Interestingly, Claassen et al. (2008) had originally found that the impact of traditional VMI initiatives on cost benefits was the weakest of all the outcomes included in their analysis. The results of this study, on the other hand, indicate that the relationship between perceived industrial vending success and cost benefits had the highest standardized coefficient (0.821) of all three outcome effects.

. Results also suggest that industrial vending solutions can result in service benefits (as indicated by their mean response of 5.32 out of 7) as well as inventory benefits (mean response of 5.88). Past research had established that organizations that successfully implement traditional VMI systems tend to achieve improved customer satisfaction. The fifth hypothesis results confirm those findings and provide support for the notion that the successful implementation of industrial vending solutions can lead to higher levels of supplier responsiveness as well as higher

levels of customer service. The results from the last hypothesis, which looked at the relationship between buyer-perceived success and increased perceptions of inventory benefits, also reinforce the findings of traditional VMI research and help corroborate the relationship for the case of industrial vending solutions. More specifically, the survey results indicate that the adoption of industrial vending systems can result in improved inventory availability and count accuracy, as well as reduced total inventory levels.

CONCLUSIONS

The purpose of this study was to empirically investigate the relationships between a series of enablers, buyer-perceived system success and different performance outcomes of industrial vending solutions. To accomplish the stated research objective, a survey instrument was developed, data was collected from current users of industrial vending systems, and a structural equation model was developed and tested. While previous research had investigated traditional VMI solutions, the results presented in this study provide support for the specific case of industrial vending systems, an emerging supply chain topic that has been previously ignored by the academic community.

Implications for Research and Practice

The findings presented in this paper have important implications from both a managerial and an academic perspective. The study results provide evidence that the successful implementation of VMI solutions (such as industrial vending systems) is strongly tied to the exchange of information and the quality of the relationship between partners (as previously established by Claassen et al. (2008)) as well as the quality of the information generated by the

systems. It is therefore apparent that both parties need to be clear with each other in terms of their expectations and abilities prior to entering into an industrial vending program. Only after determining that it is in fact possible to align both organizations in such a manner that optimizes the flow and quality of information, should managers consider entering into an industrial vending relationship.

With respect to the relationship between channel partners, firms that consistently work towards improving their relationships should be better able to manage day to day operations while maintaining the flexibility necessary to take advantage of changes in the market place. In this respect, the study results indicate that the successful adoption of industrial vending systems can help improve the relationship between two firms by making it more tightly joined and transparent.

The study findings also have relevant implications from the perspective of TCT. This research study not only represents a novel application area of TCT but also provides empirical support for key premises and assumptions. As suggested by this theory, firms develop a need for control mechanisms due to the parties' inability to receive, retrieve and communicate information without error as well as the potential for parties to act in an opportunistic manner. The results presented in this study indicate that industrial vending machines can result in timely, accurate, adequate and reliable information, as well as enable improved information exchange and buyer-vendor relationships. The findings therefore confirm, from a TCT standpoint, that industrial vending systems can help address the above mentioned need for control mechanisms, reduce the expenses associated with monitoring the relationship, reduce the potential for decision makers to act in their own self-interest, and ultimately moderate both transaction costs and risks.

With respect to the outcomes of successful industrial vending systems, respondents were quite clear about the potential for reducing costs while increasing the level of customer service received by their firms. Given shrinking profit margins, shorter product lifecycles and the corresponding need to reduce time to market in a cost effective manner, these are important considerations for many organizations. As a result of the greater control and proper structural alignment provided by industrial vending solutions, respondents also noted the potential for improvements in inventory management. These findings thus confirm, from a TCT viewpoint, that industrial vending solutions represent a means to achieve greater control of a firm's operation and reduce the risks associated with unexpected events and outcomes.

From a practitioner perspective, this study provided a detailed picture of the current state of the industrial vending field and analyzed different business sectors with respect to the usage of these systems. The survey results indicated that industrial vending systems can be used by organizations to stock a wide variety of supplies ranging from MRO items and spare parts to narcotics and other controlled substances. The study findings also suggest that the successful implementation of these solutions can lead to distinct benefits across different industries including the medical, manufacturing and transportation sectors.

Even though industrial vending usage currently represents only a portion of the potential market, the survey results also indicate that the adoption of these systems will become more widespread in the future. While over ten percent of the respondents stated their organizations were considering adopting these solutions, future growth is also illustrated when comparing the current number of machines per location (five machines, on average) to the preferred or ideal number of machines indicated by respondents. In this regard, almost two-thirds of the participants indicated they would prefer to have six or more machines per location.

In addition, this research has implications for organizations that have not yet considered industrial vending systems. Results presented in this paper can help managers make better informed decisions about allocating resources to improve relationships with suppliers, achieve greater control of operations, reduce risks and improving performance. In this sense, this study found that vending solutions can result in timely payback, increased quality and flow of information between vendor and user organizations, and provide concrete value with regards to cost, service, and inventory management. In terms of financial payback, for example, almost three-fourths of current users reported industrial vending systems were cost effective within 2 years.

Firms interested in achieving improved inventory management, increased service levels and tighter costs control should therefore examine their organizational structures to determine whether industrial vending solutions might be attractive for them. In this respect, the up-to-date information presented in this article should help supply chain managers evaluate present and future industrial vending alternatives.

Limitations and Research Agenda

This research study has some potential limitations. One issue is the fact that all survey participants were from the United States, which may limit the study's generalizability to other countries and regions. Another limitation is that this study focused exclusively on buyer (or user) perceived industrial vending system success. Incorporating the vendor (or supplier) perspective on the impact of industrial vending could help further generalize the findings of this study. Furthermore, additional factors which may motivate managers to continue the use of industrial vending systems, such as procedural or informational justice (Liu et al., 2012), could

be investigated. One other limitation is related to the fact that the different survey items in this study represent perceptions of the enablers and outcomes of industrial vending system success. In this respect, including items that represent more objective measures of the benefits and efficiencies of industrial vending (such as actual cost savings) may be preferable. These limitations notwithstanding, this paper contributes to both managerial and academic fronts and has relevant research implications.

Given the increasing need for real time information and process control, industrial vending represents an important stream of future research. Specifically, the results of this study indicate the need for additional research to help further characterize the benefits indicated by the study participants. Future studies should investigate what firms' must give up in order to realize those benefits and, based on the law of diminishing returns, determine the extent to which industrial vending technology investments are justified. A second and equally important stream of future research should focus on the rate of adoption of industrial vending systems and why certain firms have been slow to adopt these solutions given their potential benefits as well as the relatively short payback periods reported by the study participants. Finally, the framework of transaction cost theory could be employed to investigate issues related to the adoption of integrated vending solutions and cloud technologies (e.g., the asset specificity required to support the transaction or the different costs resulting from the uncertainty surrounding the adoption of such systems), and to develop standard procedures for users and providers in order to reduce the transaction costs associated with the implementation and use of those solutions and technologies.

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Table I: Respondent Organization Industry Class Breakdown

Industry Subcategory	Total	Survey %*	Industry %**
Manufacturing	60	35.1%	38.3%
Electronics/Electrical	7		
Aerospace	2		
Machinery (Industrial/Commercial)	12		
Chemical/Plastics	16		
Fabricated Metal Products	17		
Automotive	6		
Medical	58	33.9%	22.0%
Hospitals	47		
IDN	9		
Military/VA/Government Provider	2		
Equipment Provider	2		
Logistics	19	11.1%	12.2%
Transportation	5		
Warehousing/Distribution	14		
Public Sector	6	3.5%	7.1%
Utilities	3		
Government/Public Administration	3		
Other Services	6	3.5%	4.2%
Wholesale Trade	4		
Retail Trade/Merchandising	2		
Professional Services	5	2.9%	16.6%
Educational	1		
Professional/Scientific/Technical	4		
Other (Not Listed)	17	9.9%	-
Totals	171	100.0%	100.00%

* "Which best describes your firm's industry?"

** Sources: http://www.ism.ws/files/Membership/2012MembNeedsSurvey.pdf, http://cscmp.org/sites/default/files/user_uploads/footer/downloads/demographics-2013-12.pdf, and http://www.ahrmm.org/ahrmm/about_ahrmm/advertising_and_sponsorship/files/2014_Editorial_Calendar_final.pdf in a weighted combination.

Table II: Survey Items

Please indicate the extent to which you agree with each of the following statements (1 = strongly disagree, 7 = strongly agree)

Item		Mean	Std. Dev.
Information Quality		**5.97**	**0.82**
IQ1	The information that the industrial vending machines(s) provides is timely.	6.13	0.84
IQ2	The information that the industrial vending machines(s) provides is accurate.	6.01	0.96
IQ3	The information that the industrial vending machines(s) provides is adequate.	5.82	1.10
IQ4	The information that the industrial vending machines(s) provides is reliable.	5.92	1.03
Information Exchange		**6.08**	**0.96**
IS1	The industrial vending machine(s) enables both my organization and our supplier to operate more efficiently.	6.06	1.06
IS2	The industrial vending machine(s) provides both my organization and our supplier with access to actual usage data.	6.09	1.01
IS3	The industrial vending machine(s) provides both my organization and our supplier with access to inventory data.	6.08	1.00
Relationship Quality		**5.66**	**0.93**
RQ1	Compared to the ideal situation, we are satisfied with our supplier's performance.	5.63	1.10
RQ2	We can count on this supplier's support when it comes to important needs and requirements.	5.82	0.92
RQ3	We are convinced that this supplier will live up to all deals and agreements.	5.65	0.98
RQ4	Our view of the relationship conforms with the supplier's view of the relationship.	5.53	1.21
Perceived Industrial Vending System Success		**5.87**	**1.05**
PS1	The implementation of the industrial vending machines(s) was a good idea.	6.12	1.07
PS2	The industrial vending machine(s) has produced more advantages than disadvantages	5.92	1.23
PS3	The industrial vending machine(s) has helped us achieve our operational goals.	5.58	1.14
Cost Benefits		**5.72**	**1.07**
CB1	The industrial vending machine(s) has helped us reduce our total inventory costs.	5.54	1.35
CB2	The industrial vending machine(s) has helped us reduce our hoarding and pilferage costs.	5.94	1.18
CB3	The industrial vending machine(s) has helped us reduce our stockout costs.	5.70	1.21
Service Benefits		**5.32**	**1.14**
SB1	The industrial vending machine(s) has helped this supplier be more responsive to our needs.	5.35	1.35
SB2	The industrial vending machine(s) has helped this supplier provide higher levels of customer service.	5.37	1.25
SB3	The industrial vending machine(s) has helped make our supply chain more flexible.	5.25	1.27
Inventory Benefits		**5.88**	**0.97**
IB1	The industrial vending machine(s) has helped us improve our inventory availability.	5.89	1.10
IB2	The industrial vending machine(s) has helped us improve our inventory count accuracy.	5.96	0.97
IB3	The industrial vending machine(s) has helped us reduce our total inventory levels.	5.79	1.24

Table III: Exploratory Factor Analysis

			Factor Loadings						
Construct	**α**	**Items**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**
Information Quality	0.85								
		IQ1	0.115	**0.806**	0.102	0.105	0.159	0.082	0.119
		IQ2	-0.026	**0.696**	0.105	-0.022	0.110	0.160	0.325
		IQ3	0.289	**0.726**	0.185	0.127	0.077	0.210	0.011
		IQ4	0.161	**0.786**	0.180	0.218	0.206	0.170	0.099
Information Exchange	0.93								
		IS1	0.309	0.245	0.169	0.275	0.217	**0.617**	0.210
		IS2	0.225	0.252	0.209	0.221	0.218	**0.807**	0.201
		IS3	0.273	0.257	0.228	0.115	0.196	**0.786**	0.248
Relationship Quality	0.91								
		RQ1	**0.821**	0.169	0.085	0.089	0.139	0.162	0.188
		RQ2	**0.841**	0.026	0.138	0.197	0.128	0.144	0.073
		RQ3	**0.842**	0.115	0.138	0.069	0.085	0.174	0.075
		RQ4	**0.818**	0.173	0.163	0.045	0.092	0.090	0.181
Perceived IVS Success	0.90								
		PS1	0.295	0.248	0.107	0.339	0.254	0.234	**0.630**
		PS2	0.245	0.209	0.187	0.332	0.194	0.209	**0.752**
		PS3	0.253	0.158	0.269	0.164	0.241	0.212	**0.683**
Cost Benefits	0.88								
		CB1	0.148	0.299	0.203	**0.662**	0.216	0.279	0.242
		CB2	0.115	0.083	0.256	**0.756**	0.303	0.136	0.298
		CB3	0.177	0.128	0.379	**0.745**	0.201	0.134	0.137
Service Benefits	0.87								
		SB1	0.166	0.196	**0.797**	0.179	0.121	0.279	0.132
		SB2	0.174	0.198	**0.818**	0.257	0.053	0.187	0.125
		SB3	0.197	0.135	**0.713**	0.210	0.276	0.017	0.180
Inventory Benefits	0.85								
		IB1	0.052	0.300	0.110	0.204	**0.678**	0.158	0.391
		IB2	0.231	0.200	0.115	0.315	**0.734**	0.158	0.128
		IB3	0.186	0.136	0.227	0.154	**0.816**	0.203	0.147

Table IV: Discriminant and Convergent Validity of Constructs

			Construct						
	Construct	**AVE**	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
1.	Information Quality	0.596	**0.772**						
2.	Information Exchange	0.832	0.594	**0.912**					
3.	Relationship Quality	0.716	0.405	0.579	**0.846**				
4.	Perceived IVS Success	0.724	0.562	0.680	0.534	**0.851**			
5.	Cost Benefits	0.712	0.529	0.625	0.405	0.695	**0.844**		
6.	Service Benefits	0.712	0.490	0.581	0.446	0.566	0.671	**0.844**	
7.	Inventory Benefits	0.672	0.545	0.614	0.428	0.715	0.708	0.538	**0.819**

Note: Square root of the AVE on diagonal in bold.

Table V: Structural Model Results

Path	St. Weights	*p*	Note
$H_{1.}$ Information Quality → Perceived Industrial Vending System Success	.293	.000	Supported
$H_{2.}$ Information Exchange → Perceived Industrial Vending System Success	.438	.000	Supported
$H_{3.}$ Relationship Quality → Perceived Industrial Vending System Success	.211	.004	Supported
$H_{4.}$ Perceived Industrial Vending System Success → Cost Benefits	.821	.000	Supported
$H_{5.}$ Perceived Industrial Vending System Success → Service Benefits	.673	.000	Supported
$H_{6.}$ Perceived Industrial Vending System Success → Inventory Benefits	.798	.000	Supported

Figure 1: Proposed Model

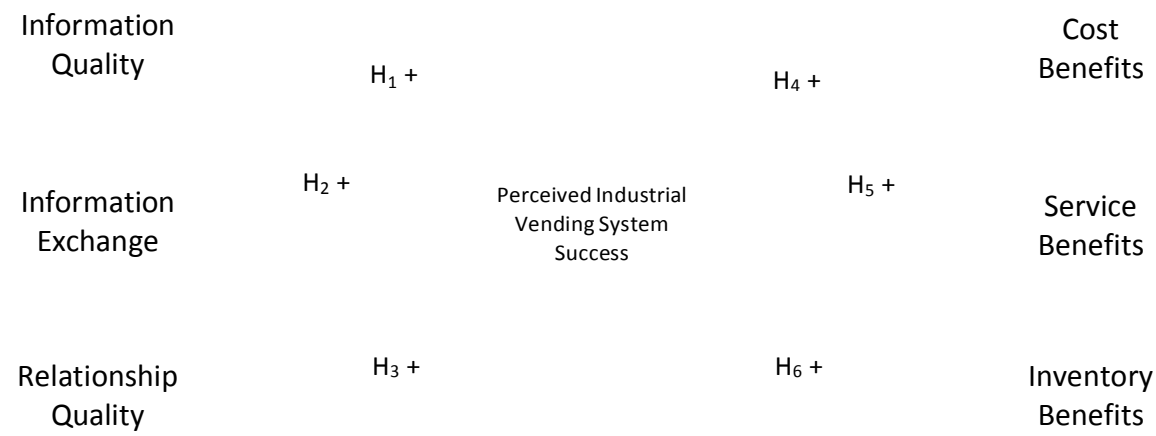
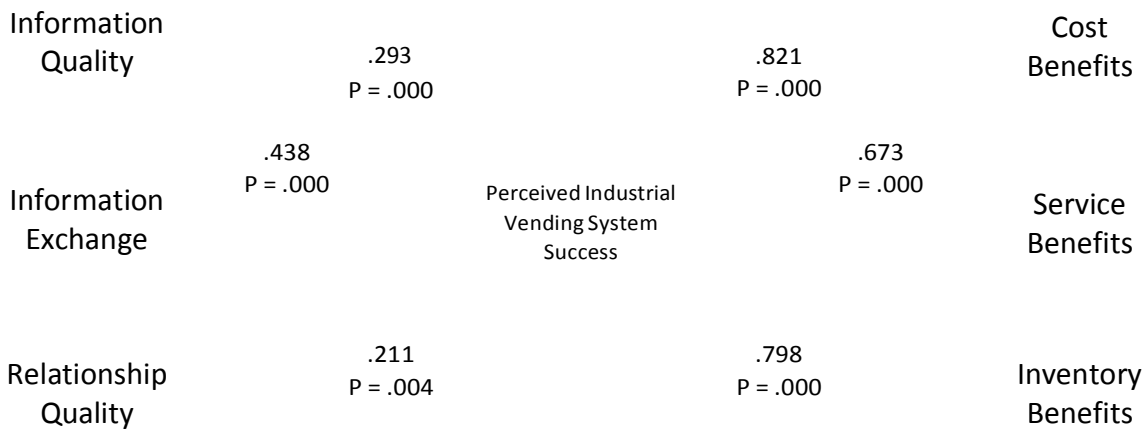


Figure 2: Proposed Model Results



Goodness of Fit Statistics

Degrees of Freedom 221
Chi Square 468.246 (p = .000)
RMSEA .074
Comparative Fit Index (CFI) .914
Incremental Fit Index (IFI) .916