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Dynamic Pricing in Supply Chain

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ABSTRACT

The process of generating revenue involves the dynamic pricing concept because it has a direct relationship with the supply chain. This research paper provides a clear overview of the application of dynamic pricing in the progressive business environment. The different purposes that require an application of dynamic pricing highlight the perishable approach to dynamic car pricing. This research paper goes on to provide the tactics of applying dynamic pricing to the sale of cars. In light of this, it shows various advantages and disadvantages arising from the employment of this technique. The above information gives an insight into comprehension of the quantitative notations and the optimal price models. There is a review of the findings of dynamic pricing as a direct result of the collection of this information. They expound on the optimization of consumer behavior and their relation to the purchasing of vehicles. The practical implications, as per the research paper, show a direct effect on the consumers. New strategies often cause a change in the manner of approaching business activities, meaning that there are also social implications. Conclusively, the research paper analyzes the originality of the content and highlights the value of dynamic pricing to ensure the success of the perishable approach to vehicle pricing.

Keywords: automobile industry, automobile market dynamics, dynamic pricing, pricing models, and supply chain.

1) BACKGROUND

The automobile industry has been growing at a rapid rate in the past decade with new large market players like China coming in to play an increasingly greater role. Big firms have arisen in the motor vehicle value chain and they are building relationships with each other on a global level that largely determine pricing in the industry (Sturgeon and Lester, 2004). The nature of the automobile industry plays a big role in determining market practices including the supply chain and pricing strategies. Auto parts and other accessories tend to be specific to vehicle models and companies; this compels players in the supply chain to work closely with leading auto manufacturers (Holweg and Phil, 2004). This kind of relationship between suppliers and manufacturers is largely responsible for driving up transaction costs and limiting economies of scale in the industry, as a result the current pricing practices in the industry are largely centered on gaining a profit per vehicle sale (Sturgeon and Lester, 2004). Because of increasing marginal costs that are limiting supply chain profits, most auto suppliers still resort to pricing policies that aim at gaining profits for every motor vehicle sale (Reichhart and Holweg, 2008). Some of the shortcomings of the pricing practices in the current automobile industry include over emphasis on cost-based pricing and competition-based pricing (Dutta et al., 2002). Companies have shown preference for cost-based pricing mainly because of the ready availability of data for pricing, however its main weakness is that it largely ignores aspects related to demand and competition e.g. price elasticity and competitive price levels. Competition-based pricing is common in the automobile industry mainly because it takes into account the competitive situation; however its main weakness is that important aspects related to demand are often ignored (Hinterhuber & Bertini, 2011). Strong competitive focus on pricing also increases the risk of price wars; this is exemplified in the 2005-2009 pricing wars that faced domestic car market in the US. Such price wars largely harm healthy competition and risk the long term profitability of suppliers. However, it is becoming increasingly evident that changes in pricing strategies towards modern models can also benefit the motor industry as is the case in other industries like electronics and consumer goods (Berger, 2005).

A number of studies have revealed that pricing is one of the factors with substantial and immediate impact of the profitability of a company. Small changes in price can increase or reduce the profitability of a company by as much as 50% (Hinterhuber and Bertini, 2011). Pricing in the motor industry, like in all other industries, concerns methods applied by companies in determining their final selling prices (Hinterhuber, 2004). Although pricing techniques in the motor vehicle industry may differ depending on geographical location or markets, there are three basic categories of pricing approaches; competition-based pricing, cost-based pricing, and value-based pricing (Mitchell, 2011). Traditionally, the motor vehicle industry has largely utilized cost-based and value-based pricing, but with time it is getting increasingly evident that success in the market is dependent upon application of a variety of

methods. New pricing models that not-necessarily emphasize on cost of placing a vehicle on the market or the real value of a vehicle will have to be considered (McCaskey and Brady, 2007). The main idea is that pricing should be able to strike a balance that will ensure overall profitability even if lesser profits or even losses have to be made in a few instances. Dynamic pricing is one approach that can be applied to achieve profitability in the motor supply chain as it has produced positive results in other industries (Dutta et al., 2002).

2) INTRODUCTION

Dynamic pricing and research in dynamic pricing have been around since the 1970s. However, developments in this concept really took off following the passing of the Airline Deregulation Act in the USA in 1978. Since this time dynamic pricing has been widely studied and different definitions developed for the concept. Until now, it is still difficult to give dynamic pricing an exact and concise definition because of a number of reasons including the fact that it is interpreted differently by representatives of different business and scientific spheres (Anderson and Narus, 2008). The most common definition of developed in the American airline industry. It stated that dynamic pricing is a tool used to maximize revenue by selling a suitable product to a suitable client at a suitable price (Ingenbleek et al., 2010). This definition was later supplemented by the words “in suitable time”. In the context of most current markets, dynamic pricing is considered as an attempt by sellers or suppliers to force customers to pay the highest possible price they are willing (Nagle et al., 2010). Although it is considered a new way of practicing the old price discrimination that was witnessed in the 1960s and 1970s, it is useful for many areas of industry and service provision as it helps towards optimum resource allocation in real life (Ingenbleek et al., 2003). This clearly indicates the importance of dynamic pricing in cost intensive industries like the motor vehicle industry. In normal markets, the principles of pricing hold that the market should be able to control product prices by balancing supply and demand. However, in the modern markets in many sectors including the motor industry, fixed costs remain high most of the time while marginal costs are low (Nagle et al., 2010). This means that setting prices on the basis of marginal costs makes it impossible to retrieve initial investment, dynamic prices becomes one of the best options for profitability in such cases.

Dynamic market conditions give the management of organizations a chance to analyze their pricing strategies appropriately (Anderson and Narus, 2008). This means that there is the generation of interest in this concept as it can be a single determinant of profitability. In light of this, dynamic pricing entails an overall analysis of all the vehicles in the company and finding an appropriate way of encouraging the customers. It is necessary to take absolute care during this process because poor pricing strategies will quickly send potential customers away. The organization has to see to it that its pricing policy is in line with the objectives of the customers.

A good pricing strategy is optimal for the survival of the business as it covers all the aspects of expenditure. However, optimal pricing might also mean pricing a vehicle lower than the overall costs of production and purchase. A good example is the Bugatti, whose development in Germany cost an average $5 million but was sold for only one fifth of the price. Dynamic pricing takes a look at the entire business environment to ensure customers get the best support to make purchases. Dynamic pricing in the motor industry needs careful consideration in order to guarantee a stream of reliable revenues (MacPherson, 2008).

However, there is a sincere challenge in the effective management of a dynamic pricing strategy because it requires a thorough process of planning to allow for the generation of revenues. The conventional approach to appropriating the prices of vehicles in a dynamic market is difficult and could easily disillusion a business. However, dynamic optimization in stochastic markets will assist in arriving at suitable solutions to ensure that business entities can maximize their profits. There is a need to pay careful attention to the demands of customers to ensure the adoption of effective policies in a business.

2.1) Purpose of study

The general purpose of this study is to contribute towards strengthening of supply chain management in the motor industry. One of the ways of achieving this is through proper pricing strategy development that targets profitability in the supply of automobiles. The study focuses on dynamic pricing as a suitable strategy towards increasing profitability in the industry. Strengthening of supply chain management will have several impacts in the automobile industry. First, it is anticipated that better pricing in the motor vehicle industry should be able to increase profitability both for manufacturers and suppliers. Greater profitability in the industry in turn will increase the capacity of all stakeholders to create better quality and value for customers (Biller et al., 2002). Improvement of the auto supply chain will also enable penetration into new automobile markets (Dutta, 2003). Even though there has been growth in motor vehicle sales in the past decade, there are still many upcoming markets for the future especially in the emerging markets and developing countries.

The main aim of this research paper is to look for optimal methods of conducting dynamic pricing. There is not a single approach that has been a guarantee for profitability in companies and, therefore, the formulation of the right methodology is a significant purpose. There is a plighting need to observe various factors to ensure that there is the adoption of the right approach. In addition, there is the issue of changing consumer demand that has a huge influence on dynamic pricing. Price changes in the inventory and distribution channels need thorough consideration as well (Humphrey and Memedovic, 2003).

3) REVIEW OF LITERATURE

3.1) Supply chain management in auto industry

Greater competition in the auto industry and low profitability has compelled manufacturers to seek improvements in the way they interact with the automobile supply chains as well as customer (Lummus et al., 2008). Supply chain management has been defined by the Global Supply Chain Forum as the integration of key business processes from the final users through the suppliers that provide products, services, and information to consumers (Lambert et al., 1998). Supply chain management has been further described by Scavarda and Hamacher (2003) as a set of strategic actions that utilize a supply chain to develop, produce, and market products that provide essential benefit to final customers. The automobile industry is known globally for its development and introduction of better management systems one of them being supply chain management. Currently, the industry is involved in the active development of greater capacities in supply chains (Rice and Hoppe, 2007). Although this is largely driven by dwindling profitability in the industry and the need to increase profit margins, the activities of the automobile industries are also stimulating other industries to follow suit (Smock, 2001).

Trends in the automobile industry have been changing all the time since the genesis of the industry, however in the past two decades greater developments have been witnessed in the industry especially with regard to supply. The major trends that have been observed recently include changes in supply chain business orientation, reduction in number of suppliers, globalization, and adoption of global platforms (Burt, 2000). According to Holweg and Miemczyk (2003), business orientation in automobile supply chains has been transforming in recent times with the result that it is now determined by the final customer. This is evident from the fact that the traditional mass production model of automobile industry has been replaced by Build-to-Order model largely driven by customer demand (Burt, 2000). According to Hill (1998), globalization involves transformations towards an integrated and interdependent world where business in all its respects is global and not local any more. Globalization in the automobile industry has been largely driven by saturation of the traditional auto markets as well as the rapid growth of markets in emerging economies and developing countries (Humphrey et al., 2000).

Outsourcing on the other hand is a practice whereby part of the operations of an organization is carried out by another organization in an interdependent relationship (Pires, 1998). Outsourcing in supply the automobile industry involves sharing of responsibilities among the players in the supply chain of the industry (Smock, 2001). The European Association of Automotive Suppliers (CLEPA) indicates that the added value of suppliers in the business has

increased tremendously in the past twenty years due to outsourcing (Gormezano, 2000). A study by Frauhofer (2004) projected that the total vehicles built at suppliers premises would increase to over 77% by 2015. The other main trend that has been observed in automobile supply chain management is rationalization and reduction in the number of suppliers. According to Collins et al. (2007) this trend is quite strong in the auto industry due to a number of factors; one of these is establishment of partnerships between supply chain members due to reduction on the number of first tier supply companies (Bidault and Butler, 2005). The other factor is opening up of world markets thus making local companies with smaller resources to compete with multinationals and therefore lose their viability in developing countries (Correa, 2010).

With the new trends in the automobile supply chain, managers in the chain are expected to be increasingly competent and develop supply chain management capabilities that will ensure sustainable profitability and increased performance in the automobile industry (Evans and Danks, 2008). Some of the capabilities required include speed and reliability in delivery, low distribution costs and correct pricing strategies (Min and Keebler, 2010).

3.2) Trends in supply in the automobile industry

One of the current trends that characterize the supply chain in the automobile industry is differentiated outsourcing. Over the past few years outsourcing in the industry has increased due to differences in labor costs and disadvantages of scale (Collins, Bechler & Pires, 2007). So as to be able to benefit from continued outsourcing, automobile supply chains providers are offering flexible modular solutions to serve the needs of different manufacturers. Another new trend that has taken root now is the sourcing from countries where manufacturing is at a low cost. However, auto manufacturers and suppliers are all looking at the total cost of sourcing including quality, logistics, and management (Collins, Bechler & Pires, 2007).

All the new trends in the automobile supply chain affect pricing of vehicles because of the profitability dynamics involved. The influence of IT and e-commerce on markets all over the world, particularly in supply chain management has been great. As a result, the ability to be able to dynamically change the prices of products according to market conditions has increased. The Direct-to-Customer (DCT) model is one of the factors that have largely influenced dynamic pricing and it is largely practiced by electronic giants like Dell Computers and the Amazon marketing company. The application of the DCT model in the automobile industry has been growing steadily, in 1999 about 40% of all customers that bought new vehicles in the USA used the internet to do so, by 2000 that number had increased to 55% (Elmaghraby & Keskionocak, 2008). While it has been observed that most customers inquire invoice prices of vehicles through the internet before making purchases from

dealers, many third parties are currently trying to convince buyers to use their buying services to purchase vehicles. This kind of environment enhances the application of dynamic pricing in marketing and selling vehicles over the internet. In the last few years there has been an evolution in internet pricing from just provision of invoice prices to referral sites where customers can request price quotations, and finally to sites that allow purchasing on the internet (Agrawal & Kambil, 2010). For this reason, dynamic pricing is gaining prominence in marketing of automobiles through the internet and even in showrooms.

3.3) Impacts of dynamic pricing model on strengthening supply chain management

The automobile industry was categorized as a low clock industry by Fine (1998), this was attributed to its high probability of attaining sustainable competitive advantage. Over a decade later and now it is evident that those companies with good strategies have greater competitive advantage in the industry. One of the strategies that determine competitive advantage has been identified as collaboration with auto supply chains (Fisher, 2007). Many auto manufactures now work closely with supply chains to move their products and determine competitive prices. Studies by Demeter et al. (2006) revealed that pricing activities by automobile companies influence their supply chain configurations and functioning. According to Handfield and Nicols (1999), strategic supply chain management involves strategic management of various factors including flow of material and information, and supply chain partnerships. However, (Hitt, 2011) indicates that pricing is one of the most important strategies in supply chain management.

Dynamic pricing plays a great role in the profitability and overall viability of auto supply chain companies in the automobile industry. There are many factors that determine dynamic pricing; however they can be placed into a number of smaller categories. The first category is customer characteristics. The level of customer knowledge about automobiles in general plays an important role in the modeling of dynamic prices (Hitt, 2011). It has been established that myopic customers will always buy when the product prices are lower than what they are willing to pay, these are customers who value price over quality or future considerations. However, strategic customers are more technical to deal with as they optimize their buying behavior depending on the pricing strategy of a supplier. These are some of the factors that must be considered in dynamic price modeling. Other factors related to customer knowledge include spontaneous buying behavior and lack of information which then prevents customers from behaving strategically in the market (Aviv and Pazgal, 2008).

Another factor that plays a big role in dynamic price modeling is fair pricing. Fair prices by automobile supply chains have been linked to existence of

dynamic pricing (Bolton et al., 2006;). Customers evaluate product prices and compare them with those of other suppliers to see whether they are acceptable, reasonable and justifiable. When customers perceive price unfairness they get dissatisfied and tend to spread negative information that in turn damages a supplier's reputation in the market (Campbell, 2009). Price fairness must therefore be considered seriously during dynamic pricing in the automobile industry as it may directly affect auto sales in future.

Another important factor in dynamic pricing is market structure. According to Feng and Xiao (2000), dynamic pricing is determined by the level of competition faced by an organization. A dynamic pricing model is thus supposed to consider the competitive nature of the market to determine the correct price for a market. Finally, product demand is one of the most important factors in dynamic price modeling as demand must be definite for a dynamic price model to be successful (Puterman, 2004). Product demand must therefore be monitored and evaluated regularly because it forms a central part of the model.

3.4) Model

The following pricing model is commonly applied in determination of dynamic prices in automobile industry and other large industries like airlines and electronics (Biller et al, 2002).

$$(P_i-C_i)*\{V_{i,0}-V_{R,ind}*E_i(P_{ave}-P_{ave,0})+/-\Sigma_j V_{R,Comp}*\beta*CC_{ij}E_{ij}(P_i-P_j)\}$$

Key:

P: Price
C: Cost
V: Volume
β: Customer awareness
CC: Shared Customers
E: Market elasticity

In the model, Price (P) refers to the price of an automobile as determined by the model. Cost (C) denotes the cost incurred in placing the product in the market. On the other hand Volume (V) is the total volume of units (vehicles) supplied in a given market for sale. Customer awareness is an index of the measure of customer awareness about the product e.g. a particular car model, this is identified through market research to establish customer awareness. Shared customers denotes the proportion of customers that a company shares with other companies, this is also established through market research. Finally, market elasticity is a measure of the volatility of the market in terms of pricing and supply of vehicles.

This model places into consideration three major factors; cost of placing the product (automobile on the market), this includes production and supply cost; customer (Includes customer comparison of industry prices for similar autos,

awareness, readiness to buy, and attractiveness of the product; finally the model considers competition between all suppliers in the market. In general, the three major factors in the development of the dynamic pricing algorithm are customer, competition, and cost (Biller et al., 2002). With data collected through market research, it is possible to determine the suitable dynamic pricing point that guarantees continuous purchases and the generation of profits for the business.

On the other hand, the qualitative model for ascertaining dynamic pricing involves determination of other influencing factors of car purchases among consumers. These include additional factors that stimulate the choices that customers make. Therefore, to determine the optimum level of dynamic pricing, it is paramount to include these measures. Otherwise, pricing decisions made on the basis of the formula alone may not be effective. Factors in the customer's environment that prevent them from making certain purchases have to be considered. Additionally, the company's design factors also contribute to the total sales of vehicles as customers make choices depending on the automobile models they like (Jakle et al., 2004).

3.5) Settings and conditions of the proposed dynamic pricing

The dynamic pricing model in this research paper applies to the automobile market, which is mainly influenced by price variations. Proper pricing is significant in the generation of revenues as companies look to cut on losses. For this reason, suppliers in the automobile industry collect large amounts of data on consumer behavior in the car market. This is done through frequent market research. The dynamic pricing model depends upon a number of important conditions. First, dynamic pricing should be applied mainly in large developed markets where market information flows freely through internet between suppliers and customers. This is because dynamic pricing largely depends on availability of market information. For a supplier to apply the dynamic pricing model successfully, they need to have current information about production and operating costs, and the volumes of merchandise available in the market at any given time. Another condition that needs to be fulfilled is that the level of customer awareness about particular products should be measured through market research based indices. Similarly, it is essential to know the amount of customers that the supplier shares with other suppliers. Finally, the market elasticity index of the particular market in which the supplier is operating has to be measured.

Most current pricing practice among vehicle suppliers is largely based upon emphasis on cost-based pricing and competition-based pricing. Companies have shown preference for cost-based pricing mainly because of the ready availability of data for pricing, and it ensures that the price of each vehicle pays back the cost incurred in placing it in the market. However, the dynamic pricing model incorporates aspects related to demand and competition e.g.

price elasticity and competitive price levels thus coming up with prices that balance customer needs and company profitability. Competition-based pricing is common in the automobile industry currently. However, it is more important to consider aspects related to demand and customer buying preferences in the current market which is what the proposed model is doing.

4) METHODOLOGY

4.1) Study design

This study employed a case study approach in determining the practicability and viability of the dynamic pricing model applied for supply chains in the automobile industry. The study involved a supplier of the Honda Civic Model. Data about all the parameters of study including cost, volume of sales, customer awareness, market elasticity and shared customers (Competition) was collected from the records of the company with permission from the management (Note: Only past data not important for current company strategy was collected). This information was then applied in the dynamic pricing model to determine the dynamic prices at which the supplier should have sold vehicles at that time. The price estimated by the model was then compared to prices in that period and conclusions drawn. The case study approach was significant because there is no history about previous dynamic pricing modeling attempts that had elements of success in the automobile industry. Dynamic price modeling is a relatively new strategy in the changing world of motor sales and sufficient gathering of information will be essential for its success. Application of this model will ensure that the adoption of solutions is in line with the goals of various business entities and consumers.

4.2) Data collection

Data was collected from Marion Industries Inc., this is one of the leading suppliers of Honda in the USA and North America in general. The data was collected from the company through the consent of the management for the purposes of this study. Data collection particularly involved request of all the relevant data from the company databases. Qualitative data was collected both from the company market research data as well as through interviews with market research officer at the company who provided additional information not in the database. The interview also included clarifications about the supplier’s views in dynamic marketing and the viability of the model.

5) FINDINGS

This study established that the utility value of the Honda Civic is a significant factor that influences the level of purchases. From the actual findings, a low extreme pricing of 923 units only led to the generation of 12 sales demand. It was also ascertained that the income levels for consumers within this price range were an average 13,458 units. This means that the consumers have a high regard for the vehicle's value of utility in spite of their income levels as quality will always precede their preferences (Heathcote, 2000).

The above findings have implications on the overall strategy of dynamic pricing for the business. This is because there was a significant variation in selection of the high price for the Honda Civic. The findings indicate that at a price level of 8,478 units, the demand for the vehicle was at 5. The average income level for customers at this range was about 13,458 units, leaving a residual value of 6.75. Thus, the highest demand level was 45 with an average price of 3,541 units. The average income level for the consumers at this point was 31,548 units.

The way that consumers perceive the pricing of vehicles offers a good view on how automobile suppliers can develop vehicle marketing and pricing strategies. This is the single factor that will ascertain the generation of significant revenues from the dynamic pricing strategy (Wolfgang, 2002). This methodology places into consideration from the consumer behavior and how other variables affect their purchases. It establishes the easiest way of finding the right dynamic pricing strategies because these variables have a significant influence on the type of vehicles the consumers will purchase. For example, a consumer's personal income will greatly determine the car markets they will visit and their subsequent purchases. Similarly, aspects such as their location, preferences, personalities, and gender will influence the level of purchases that they make.

These findings offer a reflection of the consumers' preferences that need consideration to guarantee a boost in sales. Those from the optimization model also include the qualitative and intuitive findings that will help the marketers to understand the behavior of consumers. There is the adoption of a standard method that determines all the results from the consumer information. The information reveals the influences of pricing and demand in the purchase. There is an analysis of the manner in which customers make a move for this vehicle in addition to issues that arise in terms of optimization. Given that the consumers' desires and preferences take center stage, they will only go after those vehicles that have a high utility because of the perception of high quality and standards.

The findings reveal that the average pricing and the income levels of the consumers impact their purchases. From the findings, at a price level of 8,478

units, the demand for the vehicle was at 5 while the demand level was 45 at an average price of 3,541 units. It is evident that demand level increases with reduction in price. Therefore, an analysis of demand in the market should hinge on these two factors. Clearly, there is an obvious relationship in the purchase of the Honda Civic with a change in any one of the variables. Thus, when the price of the Honda Civic goes up, there is a decline in the demand and minimal inclination to make purchases. However, behavioral analysis shows that high income earners will not wane on their interests to purchase the Honda Civic. This is as long as it remains affordable and within their price ranges (Holtz, 2004).However, the findings also reveal that the demand for the vehicle remains fairly constant after a year regardless of income or price variations.

6) RESEARCH LIMITATION

The main limitation of this research paper was the lack of a reference guide to gauge the findings. This is because the practice of dynamic pricing has never had full engagement where it could cause significant generation of revenues. Dynamic pricing receives little consideration from most businesses because the prices of cars have always had a fixed perception. However, there has been the bypassing of this limitation as a result of effective experimentation. There are still significant risks in existence that will require careful consideration by the business. Mitigating them will allow for an effective dynamic pricing policy that will meet all the consumer needs (Georgano, 2000).

The implications of this research paper highlight the fact that marketers need to pay keen attention to their customers' needs. This is because demand is the central aspect that influences the level of sales any business makes. Thus, it is assumed that the consumer's personality and preferences will play a prime role in determining the vehicle's level of purchase. In addition, the evaluation of these estimations is within a year after the release of the car. This implies that the shortest period of profitability is preferable to the marketers.

7) RESEARCH IMPLICATIONS

7.1) Practical implications

There are a number of practical lessons that car sellers can derive from this case study to help boost their sales. The practicality of this study implies that an analysis of both the consumers and market is favorable for the business. Typically, marketers will analyze the level of demand at a particular price and supply the vehicle to the market. In the case of Honda Civic, it is possible to get high sales records for the vehicle at a relatively high price if there is sufficient demand in the market (Ball, 2009).

However, this has the propensity of changing rapidly because other personal factors will influence a consumer's ability to purchase. Therefore, marketers

need to have a more personal approach in the way they sell their vehicles to allow consumers critically analyze their options. Another significant implication is that the vehicle's utility value will easily scare customers to the competitors. It is essential for the business to ensure the development of high quality cars that meet the current technological standards and consumer preferences. This factor will guarantee the speed of sales for certain vehicles in the market.

7.2) Social implications

There are certain social observations that marketers need to consider in ensuring the growth of sales. In dynamic pricing, all the factors relating to the sale of a vehicle in the market are essential. For this reason, the vehicles in production need to observe certain social trends that have been in existence for a long time. Usually, consumers will highly regard vehicles that have high utility values that cause the demand to soar. However, there should be the factoring in ethical considerations such as pollution to add more utility value to the vehicle. This is imperative as it will directly increase the level of purchases from the consumers.

Another important social implication in dynamic pricing is social stratification in the society. In order to reap the true benefits of dynamic pricing by realizing high revenues, it is necessary to target certain pockets of the population. This means that there is a need to develop and sell vehicles for those consumers within the limits of social class on the basis of pricing. In light of this, it is possible to generate an extra amount of sales from low income consumers than high income consumers by judging their preferences and uniqueness.

8) CONCLUSION

The findings indicate that will be no changes among the high income earners within a year. Correspondingly, there will be a reduction in the demand for Honda Civics among the pockets of low income earners as a result of an increase in the prices. This will reduce the total sales attributable to them and prompt the organization to lower their prices. The main variable that is showing the true effect of dynamic pricing is demand. This is the quantity of products or services in request from consumers to make a purchase. It is a significant influence of dynamic pricing because it allows the business to form a strategic plan that will ensure maximum generation of revenues. Demand is significant in any market because it has a direct relationship with the consumer. This is because the determinants of demand for products and services are aspects such as income levels of consumers and the prices.

Dynamic pricing is a fairly new concept that has no previous standing in other businesses. The consequence of this is the opening up of new consumer markets with high growth potentials that will increase profitability. Therefore,

ascertaining the appropriate level for the pricing of vehicles will result in a boost in business activities as customers seek quality and high utility worth.

There is a lot of value in applying this concept since the storage of information pertaining to all consumer levels is a possibility. This is critical as it becomes easier to penetrate the market and understand the implications of the current levels of demand. It provides good guidance to the organizations as they can plan for existing and future car models to fit the preferences of the consumers. In the present car market, the perception about consumers is that they have a lot of knowledge about the car models they need. Thus, the companies need to have confidence in their knowledge by factoring in their considerations to develop the most appropriate models. From the proposed dynamic pricing model the main lesson that has come out clearly is that the model depends on correct data inputs, this means that unlike the other pricing methods that have been applied depending on competition or cost, dynamic pricing requires thorough market research and reliable data to build the indices required. For example any wrong data or poor computation on a factor like market elasticity would easily lead to poor pricing. It is therefore essential that a supplier builds the model over time and allocates sufficient time in which to pilot-test the model and measure its reliability before full implementation.

9) REFERENCES

Agrawal, M., Kumaresh T. & Mercer G. (2001), "The False Promise of Mass Customization", *The Mckinsey Quarterly*, Vol. 3, pp. 23

Agrawal, V. & Kambil, A. (2010), "Dynamic Pricing Strategies in Electronic Commerce", working paper, Stern Business School, New York University.

Anderson, J. & Narus A. (2006), "Business Marketing: Understand What Customers Value", *Harvard Business Review*, Vol. 76, No. 6, pp. 53-65

Anderson, J., Narus J. & Van Rossum, W. (2006), "Customer Value Propositions in Business Markets", *Harvard Business Review*, Vol. 84, no. 3, pp.91-99

Aviv, Y. & Pazgal, A. (2008), "Optimal Pricing of Seasonal Products in the Presence of Forward-Looking Consumers", *Manufacturing and Service Operations Management*, Vol. 10, pp. 339-359.

Ball, J. (2009), "Six Products, Six Carbon Footprints", *Wall Street Journal*, Vol. 1, No.2, pp.17.

Berger, S. (2005), *How We Compete*, MIT Industrial Performance Center, Doubleday, New York.

Bidault, F. & Butler C. (2005), *Buyer Supplier Cooperation for Effective Innovation*, M2000 Executive Report, 17.

Biller, S., Chan D., Simchi-Levi J. & Swann L. (2002), *Dynamic Pricing and the Direct-to Customer Model in the Automotive Industry: Technical Results and Proofs*, Technical Report, Georgia Institute of Technology, accessed 27 Aug 2013 <http://www.isye.gatech.edu/»jswann/publications>

Bolton, L. & Alba, J. (2006), "Price fairness: Good and service differences and the role of vendor costs", *Journal of Consumer Research*, Vol.33, No.2, pp. 258-265.

Burgess, D. (2007), *Veteran and Vintage Cars*, Hamlyn, London

Burt, T. (2000), "Welcome trend, but how soon will it happen? Build to Order, Survey - FT Auto", The Financial Times Ltd, London, Vol. 8, pp. 4.

Campbell, M. (1999), "Why did you do that"? The important role of inferred motive in perceptions of price fairness', *Journal of Product and Brand Management*, Vol. 8, No. 2, pp.145-152.

Collins, R., Bechler K., & Pires S. (2007), "Outsourcing in theAutomotive Industry: from JIT to Modular Consortia", *European Management Journal*, Vol.15, No.5, pp.498-508

Corrêa, H. (2010), *The VW Resende (Brazil) plant modular consortium SCM model after 5 years of operation*, Proceedings of the Twelfth Annual Conference of the Production and Operations Management Society, Orlando.

Demeter, K., Gelei, A. & Jenei A. (2006), "The effect of strategy on supply chain configuration and management practices on the basis of two supply chains in the Hungarian automotive industry", *International Journal of Production Economics*, Vol.104, pp. 555-570.

Dutta, S., Bergen, M., Levy, D., Ritson, M. & Zbaracki, M. (2002), "Pricing as a Strategic Capability" *MIT Sloan Management Review*, Vol.43, no. 3, pp.61-66

Dutta, S., Bergen, D., Levy, M. & Zbaracki M. (2002), "Pricing as a Strategic Capability", *MIT Sloan Management Review*, Vol.43, No. 3, pp. 61-66.

Elmaghraby, W. & Keskinocak, P. (2008), "Dynamic Pricing in the Presence of Inventory Considera-tions: Research Overview, Current Practices and Future Directions", *Management Science*, Vol.49, No.10, pp.1287-1309

Evans, R. & Danks, A. (2008), *Strategic Supply Chain Management*, Gower Publication Company, New York.

Feng, Y. & Xiao, B. (2000), "A Continuous-Time Yield Management Model with Multiple Prices and Reversible Price Changes", *Management Sciences*, Vol. 48, pp. 644-657.

Fine, C. (1998), *Clockspeed – winning industry control in the age of temporary advantage*, Perseus Books, Washigton.

Fisher, M. (1997), What is the right supply chain for your product? *Harvard Business Review*, Vol.75, March April, pp. 105-116.

Georgano, G. N. (2000), *Vintage Cars 1886 to 1930*, AB Nordbok, Sweden

Georgano, N. (2000), *Beaulieu Encyclopedia of the Automobile*, HMSO, London

Gormezano K. (2000), "Original Equipment Automotive Components" Industry InfoNet.

Heathcote, W. (2000), *Autogeddon*, Arcade Publishers, New York

Hill, C. (1998), *International Business: Competing in the Global Marketplace*. IL, Irwin.

Hinterhuber, A. & Bertini, M. (2011), "Profiting When Customers Choose Value Over Price", *Business Strategy Review,* Vol. 22, no. 1, pp.46-49.

Hinterhuber, A. (2007), "Towards Value-Based Pricing: An Integrative Framework for Decision Making", *Industrial Marketing Management*, Vol. 33, no. 8, pp. 765-778.

Hinterhuber, A. & Bertini, M. (2011), "Profiting When Customers Choose Value Over Price", *Business Strategy Review*, Vol. 22, No. 1, pp. 46-49.

Hitt, M. (2011), "Relevance of strategic management theory and research for supply chain management", *Journal of Supply Chain Management*, Vol. 47, No. 1.

Holtz, J. (2004), *Asphalt nation: how the automobile took over America, and how we can take it back*, Crown Publishers, New York

Holweg, M. & Miemczyk, J. (2003), "Delivering the '3-day car'—the strategic implications for automotive logistics operations", *Journal of Purchasing & Supply Management*, Vol. 9, pp. 63-71.

Holweg, M. and Pil, F. (2004), *The second century: reconnecting customer and value chain through build-to-order*, MIT Press, Cambridge, MA.

Humphrey, J. & Memedovic, O. (2003), *The global automotive industry value chain: what prospects for upgrading by developing countries?* Sectoral Studies Series, United Nations Industrial Development Organization, Vienna.

Humphrey, J., Lecler Y. & Salerno, M. (2000), *Global Strategies and Local Realities: The Auto Industry in Emerging Markets,* Macmillan Press, London.

Ingenbleek, P., Debruyne, M., Frambach, R. & Verhallen, T. (2003), Successful New Product Pricing Practices: A Contingency Approach', *Marketing Letters,* Vol.14, No. 4, pp.289-305

Ingenbleek, P., Frambach, R. & Verhallen, T. (2010), "The Role of Value-Informed Pricing in Market-Oriented Product Innovation Management," Journal of Product Innovation Management", Vol. 27, No. 7, pp.1032-1046.

Ingenbleek, P., Frambach, R. & Verhallen, T. (2010), "The Role of Value-Informed Pricing in Market-Oriented Product Innovation Management", *Journal of Product Innovation Management* Vol.27, no. 7, pp.1032-1046.

Jakle, J.A., & Keith, A. S. (2004), *Lots of Parking: Land Use in a Car Culture*, University of Virginia, Charlottesville.

Lambert, D., Cooper M., & Pagh, J. (1998), "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management*, Vol. 9 No. 2, pp. 1-19.

Lummus, R., Vokurka R., & Alber, K. (2008), "Strategic Supply Chain Planning, Production and Inventory", *Management Journal*, Vol. 3, pp 49-58.

MacPherson, J. (2008), *Motor Coach files for bankruptcy protection*, Grand Forks Herald, North Dakota.

McCaskey, H. & Brady, D. (2007), The Current Status of Course Offerings in Pricing in the Business Curriculum', *Journal of Product and Brand Management,* Vol.16, no.5, pp.358-361.

Min, S., & Keebler, J. (2001), The Role of Logistics in the Supply Chain, Sage Publications, California, 2001.

Mitchell, K. (2011), *The Current State of Pricing Practice in U.S. Firms* (opening speech Professional Pricing Society Annual Spring Conference, Chicago, May 3-6, 2011).

Nagle, T., Hogan, J. & Zale, J. (2010), *The Strategy and Tactics of Pricing: A Guide to Growing More Profitably*, 5th ed., Prentice Hall, Upper Saddle River, New Jersey.

Pires, S. (1998), "Managerial Implications of the Modular Consortium model in a Brazilian Automotive Plant", *International Journal of Operations and Production Management*, Vol. 18, No. 3, pp. 221-232.

Reichhart, A. & Holweg, M. (2008), "Co-located supplier clusters: forms, functions, and theoretical perspectives", *International Journal of Operations & Production Management* Vol. 28, No. 1, pp.53-78.

Rice, J., & Hoppe, R. M. "Supply Chain versus Supply Chain:The Hype and the reality", *Supply Chain Management Review*, September/October, pp.46-54.

Scavarda, L., Hamacher, S. (2003), *Trends in the automotive industry's Supply Chain Management*, Production Networks for Regional Development, Porto Alegre, Brazil, pp. 51-60.

Setright, L. J. K. (2004), *Drive On!: A Social History of the Motor Car*, Granta Books, London

Smock, D. (2001), "Supply Chain Perspective: Get Set to Board the Productivity Express", *Supply Chain Management Review*, May-June, pp. 113-117.

Sturgeon, T., & Lester, R. (2004), *The new global supply-base: New challenges for local suppliers in East Asia*, The World Bank and Oxford University Press, Washington, DC.

Wolfgang, S. (2002), *for love of the automobile: looking back into the history of our desires*, University of California Press, Berkeley

Exploring Customer Definition and Representation in Market-Driven NPD in ICT Industry

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ABSTRACT

Purpose: This paper studies product management and R&D managers' views of customer definition and representation in market-driven NPD in ICT industry, when products are developed for a large number of customers. In market-driven context, the customers have different priorities and certain customers may even drive the efforts, but individual customers neither participate directly in the development nor dictate product functionality.
Design/methodology/approach: The study is based on a literature review and an empirical study at the managerial level in two case projects.
Findings: Company management and strategy outline customer definition. Product management collaborates with various stakeholders including marketing, sales, management, direct customers, and end-users in customer definition. Product management was found to be the most important customer representative with regards to R&D. However, other information sources are also utilized.
Research limitations/implications: The study focuses on ICT industry, and two case projects may not offer a generalized picture of the topic. Future work should extend the study to cover more industry sectors and companies.
Practical implications: Company management and strategy must guide customer definition, and management must ensure that product management teams are appropriately resourced and competent. A systematic way of working and good collaboration among product management, R&D, and other internal stakeholders is needed. While a focus on select customers is important, other customers in the value chain must also be considered. Product management and R&D professionals should also have some direct contact with customers to ensure proper customer understanding and to tackle conflicting internal stakeholder views.
Originality/value: Past literature emphasizes customer orientation and cross-functional integration, especially between R&D and marketing. However, prior work has not adequately distinguished between the product management and

marketing functions in market-driven NPD. Companies can utilize the study findings to improve their product development focus.

Keywords: customer, market-driven, New Product Development (NPD), product development, product management, research and development (R&D), and stakeholder.

Article classification: Case study

1) INTRODUCTION

Customers are typically considered the most important external stakeholders in product development. Understanding market and customer needs is claimed to be a precondition for a new product success (Cooper, 2011). Customer orientation can be seen as part of market orientation strategy together with competitor orientation and inter-functional coordination (Narver and Slater, 1990). Cross-functional integration is considered to positively affect NPD performance, and approaches to understanding customer needs are proposed in integrated product development models (Brettel et al., 2011; Cooper, 2012; Ulrich and Eppinger, 2012). Nonetheless, many companies operate in global markets with increasingly complex products and diverse needs, which demand special attention to methods for fulfilling market and customer requirements. The aforementioned also applies to technology-intensive information and communications technology (ICT) industry, where products are often combinations of tangible and intangible components (Hacklin et al., 2009).

Effective product management is claimed to be one of the NPD best practices (Kakar and Carver, 2012). Product management function aims for customer satisfaction and long-term value for the company via continuous optimisation and renewal of the product portfolio. Product management consists of various elements, such as product and customer analysis that include identifying both stated and unstated customer needs, understanding competitor offerings, road-mapping, strategic management, and vision. More operational tasks include, for example, product lifecycle management, internal and external collaboration, release planning, and requirements elicitation, prioritisation, and management (Maglyas et al., 2012). Requirements typically come from customers, other stakeholders, and technology-related factors (Mottonen, 2009). Requirement elicitation, which is also considered as a requirement engineering activity, focuses on the identification of information sources and requirement discovery (Sommerville, 2005).

In a market-driven context, products are typically offered to a large number of customers. While customers have different priorities and certain customers may even drive the efforts, individual customers neither participate directly in the development nor solely dictate product functionality. Furthermore, besides customers, other important requirement sources exist. Market-driven product

development is characterised by the need to balance different requirements types, market-pull and technology-push trade-off, and release planning and requirements selection (Fogelstrom et al., 2010). Requirements flow continuously from various internal and external sources, such as marketing, sales, customer care, users, and customer studies (Gorschek et al., 2012).

Despite many studies on market and customer orientation, customer voice in NPD, and cross-functional integration (e.g. Alam, 2005; Brettel et al., 2011; Ernst et al., 2010; Griffin, 2005; Narver and Slater, 1990; Rafiq and Saxon, 2000), past research has mostly focused on research and development (R&D) and marketing integration. Product management and marketing have not adequately been distinguished in NPD literature, although they are separate departments within an organisation. This study takes another perspective and explores how product management and R&D managers view customer definition and representation in market-driven NPD in ICT industry.

The research questions are set as follows:

- How are customers defined in the literature and by product management and R&D managers in market-driven NPD in ICT industry?

- Who are the customer representatives from product management and R&D perspectives?

The research questions are addressed through both the literature and an empirical study. The literature part of the paper focuses on customer definition and involvement in product development, and presents a conceptual framework for the study. The empirical study covers industry practices at the managerial level through two case projects.

2) REVIEW OF LITERATURE

2.1) Customers

Customers, also known as clients, purchasers, and buyers, are organisations or parts thereof, either business-to-business (B2B) customers or end-user consumers (Peppers and Rogers, 2011). Customers can be current or potential, and all others with problems and needs who seek either product or service solutions (Griffin, 2005). From a manufacturer's viewpoint, customers include distributors, retailers, and persons who buy products from the retailers (Caplan, 2001).

The customer relationship can be direct or indirect, and the customer may be either a paying customer or a non-paying one. Customers may also participate in value creation (Prahalad and Ramaswamy, 2004). Besides customers, internal stakeholders affect product quality, and should be involved in

development early enough (Lukas and Maignan, 1996). Internal stakeholders are important, especially for companies operating in international markets, due to limited contact with customers (Conduit and Mavondo, 2001).

Customers are key players in business ecosystems and an important source for product development projects; their input is critical to ensure product success (Alam, 2005; Cohen et al., 2002; Griffin, 2005; Kinnunen et al., 2013). Customer input can reduce uncertainty and enable the development of foresight to better meet customers' future needs (Un and Cuervo-Cazurra, 2009). Bidirectional communications and joint problem solving with customers enables understanding needs that are difficult to express, as well as developing successful products (Bonner, 2010). However, too close relationships with customers may restrict a company's ability to respond to market changes, and in market-driven environment companies must find the right balance between market-pull and technology-push (Fogelstrom et al., 2010; Isoherranen and Kess, 2011; Rothwell, 1992; Sull, 1999).

In addition to immediate customers, an expanded customer base and the context in which the product is used should be considered, as adoption of the entire supply chain is a pre-requisite for new product success (Berggren and Nacher, 2001; Jones and Ritz, 1991). Describing an expanded customer base and analysing the whole value chain provides an understanding beyond the direct customer, and may lead to value innovation (Donaldson et al., 2006; Goodrich and Aiman-Smith, 2007; Kim and Mauborgne, 1997). Product end-users must be considered in all cases, but other types of customers and stakeholders may also need to be taken into account (Griffin, 2005; Ulrich and Eppinger, 2012). A customer selection matrix with different segments and types of customers, such as lead users close to the company, is proposed for choosing the customers to focus on (Alam, 2005; Ulrich and Eppinger, 2012, von Hippel, 1986).

Acquiring useful knowledge from customers is challenging (Un et al., 2010). Challenges vary by industry. Typical challenges in Business-to-business (B2B) market include a large number of parties in the relationships and downstream customers often being outside the company's control (Hillebrand and Biemans, 2011; Tikkanen et al., 2000). Business-to-consumer (B2C) markets, in turn, involve a large numbers of individual customers. Understanding the behaviours of different consumer groups is difficult, and marketing research can have a significant role (Kotler and Keller, 2009; Suwannaporn and Speece, 2010).

2.2) Product development and customer involvement

Product development transforms market opportunities into production, sale, and delivery of completely or partially new products (Krishnan and Ulrich, 2001). Product development projects can be classified into research and development (R&D) projects, breakthrough projects, platform projects,

derivative projects, incremental improvements, and fundamentally new products (Schilling and Hill, 1998; Ulrich and Eppinger, 2012).

Small change projects entail interacting with customers in order to acquire tacit knowledge about their needs and current product deficiencies. New product development (NPD) to existing markets, in turn, requires translating customers' tacit unmet needs into product features without having an existing product. In NPD to new markets, customer interaction typically takes place only when a prototype is available (Un and Cuervo-Cazurra, 2009).

Interest in customer empowerment and integration in NPD has grown in recent years in business and academia (Fuchs and Schreier, 2011; Schaarschmidt and Kilian, 2013). However, the results are mixed and depend on the type of customers involved; for example, NPD with new customers and lead users may improve innovation results (Bartl et al., 2012; Lau et al., 2010).

In terms of involvement, product development can be categorised into design for, design with, and design by customers. In the design for approach, products are designed on behalf of customers, which also characterises market-driven product development (Fogelstrom et al., 2010; Kaulio, 1998). Customer studies, such as interviews and focus groups, are typically utilised in this approach. In the design with approach, customers can additionally give feedback on the proposed design, whereas in the design by approach, customers actively participate in the design of their own product (Kaulio, 1998). Customers also have active role in customer co-creation and open innovation (Chesbrough, 2003; Prahalad and Ramaswamy, 2004).

In addition to customer involvement, cross-functional integration and continuous learning among R&D, marketing, manufacturing, and sales functions are considered to improve product development performance (Brettel et al., 2011; Ernst et al., 2010; Suwannaporn and Speece, 2000).

2.3) Conceptual framework

While product management is considered to be important (Kakar and Carver, 2012), past studies (e.g. Brettel et al., 2011) have not adequately addressed its role in NPD. The conceptual framework in this study aims to view customers in NPD from product management and R&D perspectives, since these functions manage and implement customer requirements and define customer experiences (Maglyas et al., 2012).

A company can have a number of direct customers with different levels of importance. Customer needs are affected by both internal and external stakeholders in the organisation. Direct customers may also have customers that can be final customers or intermediaries. Figure 1 illustrates customer definition and representation from product management and R&D perspectives.

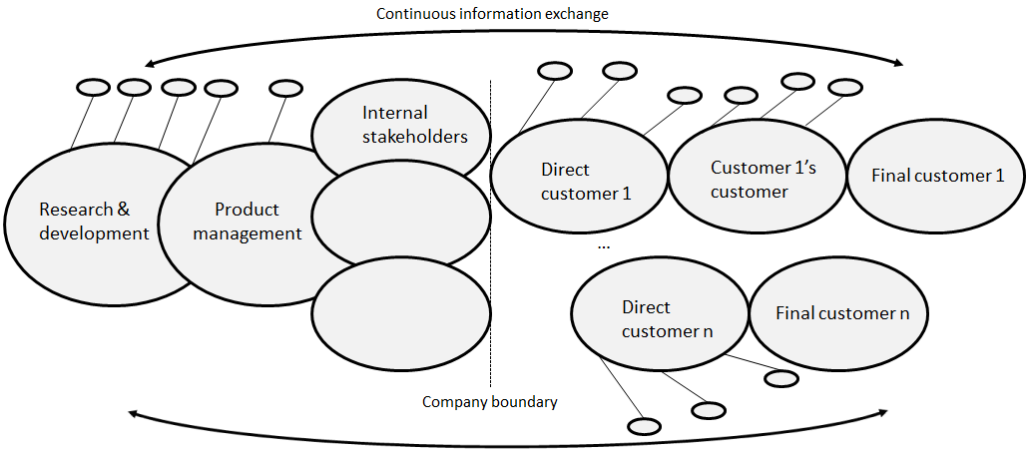

Figure 1: Customer definition and representation from product management and R&D perspectives

Some customers are represented by the company's internal stakeholders, whereas other customers and their needs must be identified by other means. Product management and R&D have to take into account many type of customers with different needs. Product management is assumed to have a major role in customer definition and in internal collaboration with customer-facing functions. In addition, successful requirement engineering is needed to transfer the right requirements, and hence enable creation of products that meet customer needs.

3) METHODS

The empirical study is based on two case projects including insights from interviews with mid-level managers. The companies were chosen from ICT industry; they are headquartered in Northern Europe and operate in global markets. Both of the companies have many decades of product development experience and are recognised as key innovators in their markets. Thus, their NPD practices were assumed to represent leading practices in their industry. The companies were selected so that they would represent NPD in both B2B and B2C markets. Interviewees were selected based on their experience and involvement in the studied projects, and they represented both product management and R&D (Table 1).

A semi-structured interview process was used to gain insights into the cases and the respondents' thoughts regarding the issues studied. The interviews typically lasted around one hour, and they were recorded and transcribed for analysis. The interview questions were designed to gain each manager's perspective on customer definition and representation in product development. The interviews started with general questions on product development in the company, but also included specific questions about the case project, its

stakeholders and customers, how customers were defined, and who represented them in the project.

Table 1: List of interviewees in the case projects

Case	Interviewee	Role	Industry experience
A	1	Product management	+10 years
	2	Concept management	+10 years
	3	Product management	+15 years
	4	Software product owner	+10 years
	5	Programme management	+15 years
	6	Project management	+10 years
B	1	Head of product management	+20 years
	2	Product management	+20 years
	3	Product management	+25 years
	4	Technical solution management	+25 years
	5	Platform system design management	+20 years

The data were analysed using a qualitative approach of reading the interviews several times, each time going deeper into the data to discover connections, patterns, and comparisons. Emerging patterns were structured into more generic categories that helped refine the conceptual framework and define the key concepts.

3.1) Empirical surveys

3.1.1 Case A

Case A is a software project of a large ICT company that operates in a global B2C market. The company's final products that are sold to consumers include combinations of hardware, software, and services. The case project entailed a software release programme starting from concept development and ending with the launch. In addition, the architecture of the software platform used in the final products was renewed. The products were targeted to a specific consumer group, but also the wider market, a large number of distribution partners, and geographical requirements were considered. In contrast to earlier projects in the company, the product definition was started from scratch, and only a core set of features was defined for the sales start. In addition, the product development operation practices were renewed. This included, for example, specifying testing of new features already in their definition phase, and changing requirement and error database structures to support the new

mode of operation. The project fits the characteristics of market-driven product development presented earlier in this paper. In terms of size and newness, it was considered a large-scale, radical project. The development model used in the company was based on agile principles for the software parts and concurrent engineering for the hardware components.

3.1.2 Case B

Case B is a hardware and embedded software project of a large ICT company that operates in a global B2B market. The project entailed the development of a new product platform to replace the current solution in the market. The platform is used by the company's business lines, which productize final products consisting of hardware, software, and services to large number of customers. The products were focused on selected key customers, but also offered to the wider market, including the consideration of different technical and geographical requirements. The product was very complex, and therefore the development time was relatively long. The project fits the characteristics of market-driven product development presented earlier in this paper. The project represented a typical platform development project in the company, although it was somewhat larger than usual projects in the organization. The development model was based on concurrent engineering for hardware components and agile principles for software parts.

3.2) Project key stakeholders and customer definition

3.2.1 Case A

In case A, various stakeholders were identified for the project, and interviewees presented many viewpoints for customer definition. Figure 2 illustrates the customer definition in case A.

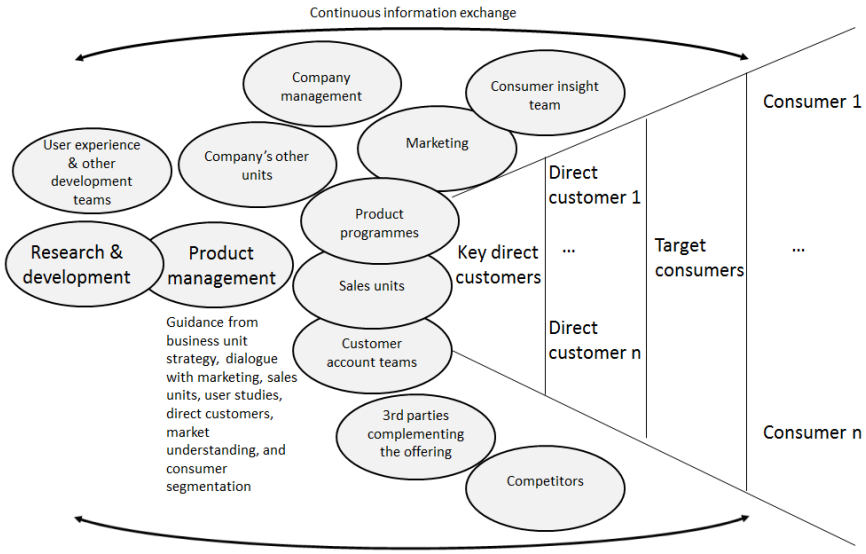

Figure 2: Customer definition from product management and R&D perspectives in case A

Product management persons saw that key external stakeholders in the project included consumers (product end-users), distribution partners (direct customers), and competitors. In addition, one interviewee pointed out the factor of external innovation partners. Regarding internal stakeholders, the R&D organization, sales units, customer account teams, and product programs using the software were classified as key partners. Marketing and other internal sources for consumer data and competitor information were also seen as important. In addition, other company units, such as other business unit and a long-term research unit, were categorised as key stakeholders. The need for technology-push and market-pull balance in NPD was emphasised, since both were considered to be essential.

Product management persons highlighted many ways to define customers. Dialogues with marketing, sales units, and regions were considered to be important, and business unit strategy was also seen to provide guidance for customer definition. In addition, the largest direct customers were considered to be important in the customer definition. However, consumers were clearly identified to be the most important customer group, and the definition of consumer customer was assisted by collecting and analysing user databases and studies. Furthermore, company-wide market understanding and consumer segmentation were seen as beneficial.

From R&D persons' perspective, key external stakeholders included direct customers, consumers, and third-party application developers. Key internal stakeholders, in turn, included product management, product programmes using the software, sales units and regions, marketing, and the internal organisation dealing with third-party application developers. In addition, development teams at different sites, the user experience team, and company management were considered as key stakeholders.

R&D persons saw that customer definition came from product management, marketing, and consumer insight teams. In addition, the management team for the product programme utilising the software, and especially its product manager, were considered to be involved in customer definition. Interviewees also mentioned a 'theme person' who illustrated a target consumer, but it was unclear to them who had created that theme person.

3.2.2 Case B

In case B, customer needs were considered to drive NPD at least in short-term, but own innovation was also seen as important. Fewer project stakeholders were identified than in case A, and customer definition was also viewed differently. Figure 3 illustrates the customer definition in case B.

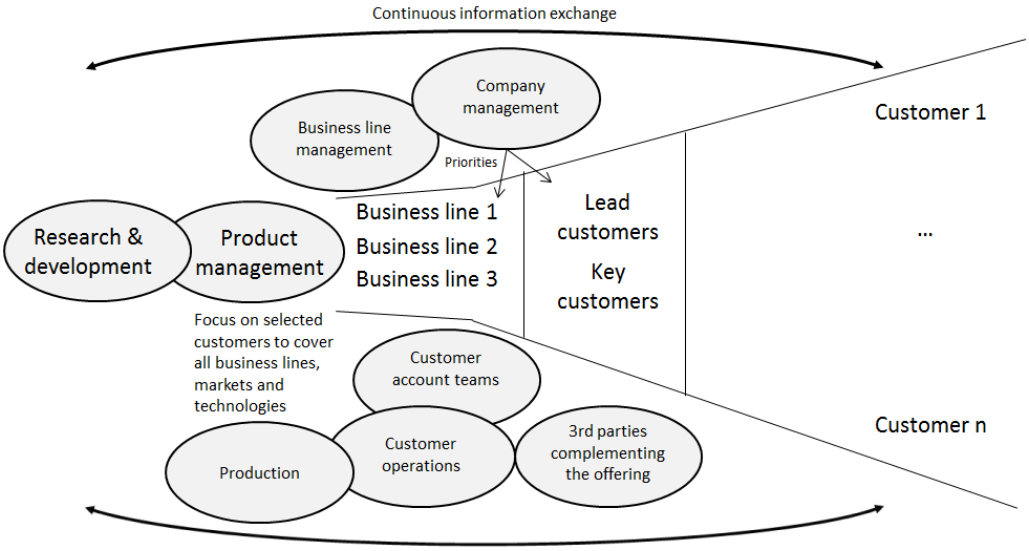

Figure 3: Customer definition from product management and R&D perspectives in case B

For product management persons, the most important external stakeholders in the project included direct customers and third parties complementing the company's offering. Key internal stakeholders, in turn, were considered to be business lines that funded the development, the R&D organisation, customer account teams, management, operations taking care of customer installations, and production.

Product management persons' customer definition included both customers and internal stakeholders. The company had three business lines that were considered to be the key internal stakeholders, and the business lines were prioritised based on sales volumes and growth potential. The company's customer base consisted of hundreds of direct customers. The company had defined priority markets, and the most important customers were classified as key and lead customers. Customer prioritisation was done by the company management. However, product management persons saw that there were still too many focus areas, and the priorities were not clear. To ensure sufficient customer understanding, the product management team had selected some lead customers for direct connections. In addition to sales volumes, the selection criteria aimed to cover different types of customers, all three business lines, and various geographical and technical aspects.

R&D persons perceived direct customers to be the key external stakeholders in the project. Key internal stakeholders, in turn, included product management, business lines, business line management, and portfolio management that facilitated decision making regarding technology choices. Customer prioritisation was acknowledged, but customers were considered to have too short-term and narrow focuses from a platform development point of view. Regarding internal stakeholders, a lead business line, which might not have the

highest business priority but productises the platform first, was also considered important.

3.3) Customer representation in development

3.3.1 Case A

In addition to customer definition, the representation of customers during development was also analysed. Figure 4 illustrates customer representation in case A.

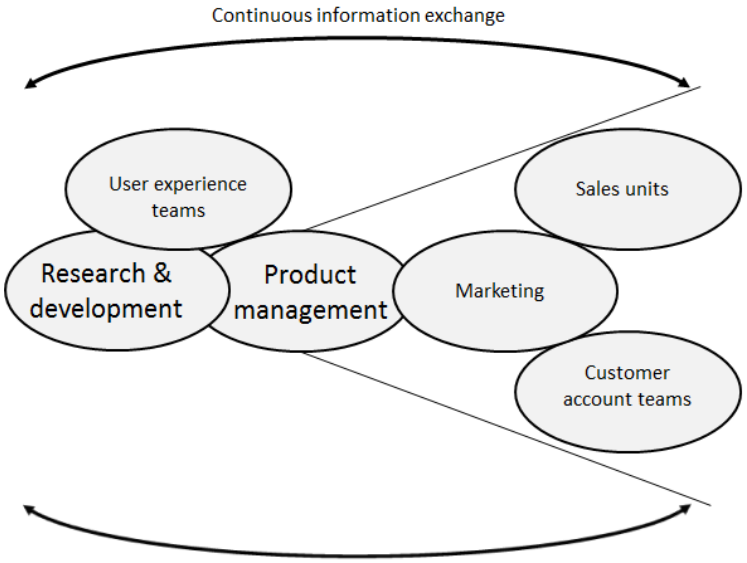

Figure 4: Customer representation from product management and R&D perspectives in case A

Product management persons saw that product management represents customers with regards to R&D. Customer voice to product management, in turn, came from sales units, customer account teams and other regional contacts in direct contact with customers, and marketing. In addition, user databases and market surveys were seen as important information sources in order for product management to gain the necessary knowledge to represent customers in development. Customer related information and its systematic collection and use were considered to be essential. Genuine user understanding, product and feature finalisation, and differentiation in the implementation were stressed, since competitors had access to similar market data. Product management lacked sufficient face-to-face interaction with end-users, and therefore distributing information on target consumers throughout organisation was critical.

R&D persons also considered product management to represent customers during development, and product management was expected to collaborate with relevant stakeholders to acquire necessary information from the customers. On the other hand, user experience teams were also seen to

represent the end-user view during development, since these teams possessed an understanding of detailed product functionalities from a usability perspective. In this particular project, the requirement database and existing products were checked to identify critical customer features, and these were discussed iteratively with stakeholders close to customers. Contrary to the previous projects, only a core set of features was defined for sales start. In addition, end-user research, analyses, testing, market data, and error databases provided customer-related information during development. R&D interviewees stressed that unnecessary handovers between product management and R&D must be avoided in project definition phase. In addition, particularly feature developers were considered to benefit from seeing how end-customers use the product. However, this was too expensive to achieve in practice, and developers were encouraged to use the products under development to gain a user perspective.

3.3.2 Case B

Customer representation during development was also analysed in case B. Figure 5 illustrates the customer representatives in case B.

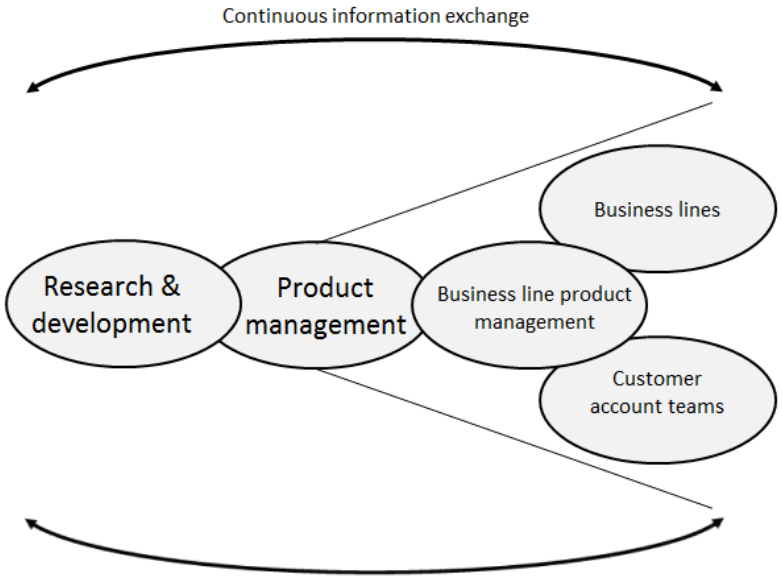

Figure 5: Customer representation from product management and R&D perspectives in case B

As in case A, product management persons saw that product management represents customers with regards to R&D. The customer representatives from product management's perspective consisted of business lines, their product managers, and key customer account teams in contact with direct customers. Tools for customer representation and providing feedback included databases and the relevant contacts in the organisation. In addition to meetings at customers' facilities, key customers were also invited to visit the company to discuss special topics directly with product management. Market reports were also used to some extent. Internal stakeholder representation was ensured with

business lines' participation in the project organisation. Downstream customers (direct customers' customers) were given only brief consideration, since the direct customers were seen to represent their views anyway. Product management interviewees stressed the importance of customer contacts, and talking to key customers directly was considered as a good practice. Account teams' and customers' views were seen to differ sometimes, since the account teams focused on current product sales. Product management's own vision in product definition was also stressed, because the customers seemed to be uncertain on their long-term needs. Early involvement of internal stakeholders in the project and good co-operation between product development and R&D were seen as valuable.

R&D persons also saw that product management represents customers in development. This was considered a good arrangement; although it was pointed out that product management has 'to interpret things that customers do not know they want'. Discussions, presentations, and spread sheets were used to communicate customer views before entering the requirements into the relevant tools. Regarding internal stakeholder representation, technical management and concept teams with representation from business lines were pointed out. It was also emphasised that understanding customers was important but difficult. In addition, better prioritisation of customers was desired. Time-wise, both customers and internal stakeholders' focuses were seen to differ from R&D's focus. However, it was remarked that both current customer issues and long-term needs must be considered in NPD.

4) DISCUSSION

This study indicates that customer definition and representation in market-driven product development is not unambiguous. Product management plays a key role in both customer definition and representation, and must effectively co-operate with many stakeholders to ensure a product that meets customer and market needs while providing business sustainability. Product management teams must understand the overall picture and take responsibility for finding the right balance and product priorities, both from the customer and the business perspective. However, R&D cannot transfer the responsibility for understanding the customer solely to product management, since the right product design involves deciding on a great number of details. In addition, seamless cooperation between R&D and product management teams is required.

4.1) Theoretical implications

The literature discusses the importance of market and customer orientation, customer voice in NPD, and cross-functional integration (e.g. Alam, 2005; Brettel et al., 2011; Cohen et al., 2002; Ernst et al., 2010; Griffin, 2005; Narver and Slater, 1990; Rafiq and Saxon, 2000). However, past research has mostly

focused on R&D and marketing integration, and has not adequately distinguished between the product management and marketing functions in NPD. Furthermore, in market-driven context products are typically offered to a large customer base, which significantly complicates customer definition and representation in NPD. In addition, customers may not directly participate in actual development. The literature review and the cases analysed in this study provide new viewpoints on how product management and R&D managers view customers in market-driven NPD in ICT industry.

The role of product management has been discussed in the literature (Maglyas et al., 2012). The results of this study indicate that product management plays a key role in customer definition and representation in market-driven NPD in ICT industry. In addition, co-operation with many internal stakeholders was emphasised in both cases. This finding is in line with cross-functional integration (Brettel et al., 2011; Kakar, 2012; Narver and Slater, 1990) and the role of internal stakeholders (Conduit and Mavondo, 2001), which have been considered important in the type of context where the case companies operate. Nonetheless, this study complements past research by bringing out the importance R&D and product management cooperation.

The study also illustrates the differences between B2C and B2B markets. In case A, end-users were seen to be more important than direct customers. On the other hand, in case B, downstream customers were considered only briefly. This finding complements the results of Hillebrand and Biemans (2011).

4.2) Managerial implications

Creating a successful product requires that the target customers are clearly defined. This study indicates that product management's role is essential in market-driven NPD; companies must therefore ensure that product management teams are competent and appropriately resourced. Company and business unit strategy should provide proper guidance to ensure that the focus and the priorities are clear. In addition, product management must collaborate with various stakeholders including marketing, sales, and management in customer definition.

The study results highlighted the importance of internal stakeholders and cross-functional integration. Managers should target systematic ways of working and good co-operation among internal stakeholders to ensure that customer views are taken into account. Forming a customer definition should be seen as a dialogue between product management and stakeholders close to the customers. In addition, effective co-operation between product management and R&D is vitally important.

Whereas product management is the most important customer representative with regards to R&D, there are other useful information sources through which

R&D can gain customer understanding in terms of design decisions. The role of documentation is important, since customer information flows via several stakeholders. In addition to internal inputs, product management and R&D professionals should aim for direct contact with customers, since proper customer understanding results in better decisions and tackles problems related to conflicting internal views. While a focus on selected customers is important, the whole value chain must be considered in order to create a product that meets market needs.

5) CONCLUSIONS

The significance of customers as key product development stakeholders is evident. However, increasingly complex global markets pose challenges for companies to fulfil market needs. This applies especially when products are offered to a large number of customers, rather than a single customer deciding on the functionality. The validity of customer information that flows via various stakeholders is also a challenge. This study explores product management and R&D managers' views of customer definition and representation in market-driven product development in ICT industry.

The results indicate that customer definition in market-driven product development is not unambiguous. Company management and strategy must guide customer definition. Product management plays a key role in defining customers, and companies must therefore ensure that product management teams have the appropriate resources and competencies. Effective co-operation between product management and internal stakeholders should be targeted. Product management was found to be the most important customer representative with regards to R&D. However, R&D must also gain customer understanding in order to ensure the right design decisions. In addition, sometimes facing customers directly is recommended for both product management and R&D professionals.

The limitations of this study include the focus on the ICT industry and the fact that only two case projects were researched. In addition, due to the study nature only internal managers were interviewed. Recommended future study includes how well the study findings apply to different types of companies and industries. In addition, customer need identification and the methods used should be analysed. Finally, prioritisation of unique needs and the relationships between requirements and stakeholders deserve attention.

6) REFERENCES

Alam, I. (2005), "Interacting with customers in the new product development process", Kahn, K.B. (Ed.), "*The PDMA handbook of new product development"*, 2nd edn., John Wiley & Sons, Inc., New Jersey, 249-262.

Bartl, M., Füller, J., Mühlbacher, H. and Ernst, H. (2012), "A Manager's Perspective on Virtual Customer Integration for New Product Development", *Journal of Product Innovation Management.* 29 (6), 1031-1046.

Berggren, E. and Nacher, T. (2001), "Introducing new products can be hazardous to y our company: Use the right new-solutions delivery tools", *Academy of Management Executive*. 15 (3), 92-101.

Bonner, J.M. (2010), "Customer interactivity and new product performance: Moderating effects of product newness and product embeddedness", *Industrial Marketing Management*. 39 (3), 485-492.

Brettel, M., Heinemann, F., Engelen, A. and Neubauer, S. (2011), "Cross-functional integration of R&D, marketing, and manufacturing in radical and incremental product innovations and its effects on project effectiveness and efficiency". *Journal of Product Innovation Management,* 28 (2), 251-269.

Caplan, F. (2001), "What Is a Customer?" *Quality Engineering,* 14 (2), ix-x.

Chesbrough, H.W. (2003), "The era of open innovation", *MIT Sloan Management Review.* 44 (3), 35-41.

Cohen, W.M., Nelson, R.R. and Walsh, J.P. (2002), "Links and impacts: The influence of public research on industrial R&D", *Management Science*. 48 (1), 1-23.

Conduit, J. and Mavondo, F.T. (2001), "How critical is internal customer orientation to market orientation?", *Journal of Business Research*. 51 (1), 11-24.

Cooper, R.G. (2011), "*Winning at new products: Creating value through innovation"*, 4th edn., Basic Books, USA.

Cooper, R.G. and Edgett, S.J. (2012), "Best Practices in the idea-to-launch process and its governance", *Research Technology Management.* 55 (2), 43-54.

Donaldson, K.M., Ishii, K. and Sheppard, S.D. (2006), "Customer value chain analysis", *Research in Engineering Design*. 16 (4), 174-183.

Ernst, H., Hoyer, W.D. and Rübsaamen, C. (2010), "Sales, marketing, and research-and-development cooperation across new product development stages: Implications for success", *Journal of Marketing.* 74 (5), 80-92.

Fogelstrom, N.D., Gorschek, T., Svahnberg, M. and Olsson, P. (2010), "The impact of agile principles on market-driven software product development", *Journal of Software Maintenance and Evolution*. 22 (1), 53-80.

Fuchs, C. and Schreier, M. (2011), "Customer empowerment in new product development", *Journal of Product Innovation Management.* 28 (1), 17-32.

Goodrich, N. and Aiman-Smith, L. (2007), "What does your most important customer want?", *Research Technology Management*. 50 (2), 26-35.

Gorschek, T., Gomes, A., Pettersson, A. and Torkar, R. (2012), "Introduction of a process maturity model for market-driven product management and requirements engineering", *Journal of software: Evolution and Process*. 24 (1), 83-113.

Griffin, A. (2005), "Obtaining customer needs for product development", Kahn, K.B. (Ed.),*"The PDMA handbook of new product development"*, 2nd edn., John Wiley & Sons, Inc., New Jersey, 211-227.

Hacklin, F., Marxt, C. and Fahrni, F. (2009), "Coevolutionary cycles of convergence: An extrapolation from the ICT industry", *Technological Forecasting and Social Change.* 76 (6), 723-736.

Hillebrand, B. and Biemans, W.G. (2011), "Dealing with downstream customers: An exploratory study", *Journal of Business and Industrial Marketing*. 26 (2), 72-80.

Isoherranen, V. and Kess, P. (2011), "Strategy Orientation Analysis in the Mobile Phone Case Business", *Modern Economy*. 2, 395-402.

Jones, J.M. and Ritz, C.J. (1991), "Incorporating distribution into new product diffusion models", *International Journal of Research in Marketing*. 8 (2), 91-112.

Kakar, A.K. and Carver, J. (2012), "Best Practices for managing the fuzzy front-end of software development (SD): Insights from a systematic review of new product development (NPD) literature", *7th Pre-ICIS International Research Workshop on Information Technology Project Management (IRWITPM 2012)*, pp. 49-58.

Kaulio, M.A. (1998), "Customer, consumer and user involvement in product development: A framework and a review of selected methods", *Total Quality Management*. 9 (1), 141-149.

Kim, W.C. and Mauborgne, R. (1997), "Value innovation: the strategic logic of high growth", *Harvard business review*. 75 (1), 102-112.

Kinnunen, T., Sahlman, K., Harkonen, J. and Haapasalo, H. (2013), "Business ecosystem perspective to new product development", *International Journal of Business Development and Research.* 1 (1), 5-20.

Kotler, P. and Keller, K.L. (2009), "*Marketing management"*, 13th edn., Pearson Prentice Hall, USA.

Krishnan, V. and Ulrich, K. (2001), "Product development decisions: a review of the literature", *Management Science*. 47 (1), 1-21.

Lau, A.K.W., Tang, E. and Yam, R.C.M. (2010), "Effects of supplier and customer integration on product innovation and performance: Empirical evidence in Hong Kong manufacturers", *Journal of Product Innovation Management.* 27 (5), 761-777.

Lukas, B.A. and Maignan, I. (1996), "Striving for quality: The key role of internal and external customers", *Journal of Market-Focused Management*. 1 (2), 175-187.

Maglyas, A., Nikula, U. and Smolander, K. (2012), "*What do practitioners mean when they talk about product management?*", in 20th IEEE International Requirements Engineering Conference, RE 2012 Proceedings, 261-266.

Mottonen, M., Belt, P., Harkonen, J. and Lin, B. (2009), "Managing requirements in ICT companies", *Business Process Management Journal.* 15 (6), 968-989.

Mottonen, M., Harkonen, J., Belt, P., Haapasalo, H. and Simila, J. (2009), "Managerial view on design for manufacturing", *Industrial Management and Data Systems.* 109 (6), 859-872.

Narver, J.C. and Slater, S.F. (1990) "The effect of a market orientation on business profitability", *Journal of Marketing*. 54 (October), 20-35.

Peppers, D. and Rogers, M. (2011), "*Managing customer relationships: A strategic framework"*, 2nd edn., John Wiley & Sons, Inc., New Jersey.

Prahalad, C.K. and Ramaswamy, V. (2004), "Co-creation experiences: The next practice in value creation", *Journal of Interactive Marketing.* 18 (3), 5-14.

Rafiq, M. and Saxon, T. (2000), "R&D and marketing integration in NPD in the pharmaceutical industry", *European Journal of Innovation Management.* 3 (4), 222-231.

Rothwell, R. (1992), "Successful industrial innovation: critical factors for the 1990s", *R&D Management*. 22 (3), 221-240.

Schaarschmidt, M. and Kilian, T. (2013), "Impediments to customer integration into the innovation process: A case study in the telecommunications industry", *European Management Journal,* (in press).

Schilling, M.A. and Hill, C.W.L. (1998), "Managing the new product development process: Strategic imperatives", *IEEE Engineering Management Review*. 26 (4), 55-68.

Sommerville, I. (2005) "Integrated requirements engineering: A tutorial", *IEEE Software*. 22 (1), 16-23.

Sull, D.N. (1999), "Why good companies go bad", *Harvard Business Review*. 77 (4), 42-48, 50-52, 183.

Suwannaporn, P. and Speece, M. (2000), "Continuous learning process in new product development in the Thai food-processing industry", *British Food Journal.* 102 (8), 598-614.

Suwannaporn, P. and Speece, M.W. (2010), "Assessing new product development success factors in the Thai food industry", *British Food Journal.* 112 (4), 364-386.

Tikkanen, H., Alajoutsijärvi, K. and Tähtinen, J. (2000), "The concept of satisfaction in industrial markets: A contextual perspective and a case study from the software industry", *Industrial Marketing Management.* 29 (4), 373-386.

Ulrich, K. and Eppinger, S.D. (2012), "*Product design and development"*, 5th edn., McGraw Hill, New York, NY.

Un, C.A. and Cuervo-Cazurra, A. (2009), "Interactions with customers for innovation", Costanzo, L.A. and MacKay, R.B. (Eds.), "*Handbook of Research on Strategy and Foresight"*, Edward Elgar Publishing Limited, Northampton, MA, 362-279.

Un, C.A., Cuervo-Cazurra, A. and Asakawa, K. (2010), “R&D collaborations and product innovation", *Journal of Product Innovation Management*. 27 (5), 673-689.

Von Hippel, E. (1986), “Lead Users: a Source of Novel Product Concepts”, *Management Science*. 32 (7), 791-805.

Guidelines for New Thailand Quality Award Applicants: Lesson Learned from Southeast Asia Past Winners

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ABSTRACT

The purposes of this research are to define Thailand Quality Award (TQA) primary roadmap and to investigate the successful firm's characteristics that influence TQA. TQA is the highest recognition of quality management that awarded to Thai companies that have excellence quality management system which comparable to international standards. Past sixty national quality award or NQA's winners across Southeast Asia were used as the representatives for studying and analyzing the common successful characteristics as well as the TQA primary roadmap. In addition, interview with the past winner company's executive to gain more insights into the TQA preparation and planning. The statistical results revealed that there are only two out of nine sample characteristics: (1) Employee focus award status, (2) Age of company correlated to the time duration spent for the award. However, there were medium and low level of correlation appeared for those characteristics. Furthermore the primary TQA roadmap has been proposed and quality management information of many NQA's winners was undisclosed that caused limitation to access the useful information.

Keywords: business development, quality management, quality roadmap, and TQA.

1) INTRODUCTION

Hereafter national quality award or NQA is refer to the overall national quality award in Southeast Asia countries including TQA which those countries were used as the representative NQA's winners in this research. NQA is the highest level of national recognition for performance excellence to promote awareness of Total Quality Management (TQM)[1]. It is an annual award given to the excellent companies that have had excellence quality management practices and system. The award recipients have exhibited high capability in the marketplace. Customer satisfaction is the result of performance excellence and influences customer loyalty which impact to profitability (Eugene *et al*., 1994; and Roger, 1996). In addition, innovation and creativity in solving operational problems, addressing customer concerns, and coming up with better products and services have been part of how well quality is being practiced within an organization (Fasil and Osada, 2011; and Ropret *et al*., 2012).

National Quality Award has been established in many countries around the globe with the same objectives; to motivate the awareness of quality toward performance excellence and share organizations' successful[2]. Southeast Asia is one of the continents that almost country members established their own nation quality award program. This demonstrated that Southeast Asia has well conscious of quality awareness and willingness to enhance the nation economics. All country in Southeast Asia has adopted the NQA criteria from Malcolm Baldridge National Quality Award (MBNQA) of the United States with all criteria were added up to of 1,000 points total score. However some criterion was weighted by different score in each country. There are total seven award criteria as shown in the framework figure 1;

Figure 1: Baldrige Criteria for Performance Excellence Framework
Source: http://www.nist.gov/baldrige/publications/business_nonprofit_criteria.cfm

[1] The National Institute of Standards and Technology (NIST) (2012): About the Malcolm Baldrige National Quality Award, see http://www.nist.gov/baldrige/enter/apply.cfm

[2] The National Institute of Standards and Technology (NIST) (2012): Malcolm Baldrige National Quality Award, see http://www.nist.gov/public_affairs/factsheet/mbnqa.cfm

The applicants that exceed a specific score will receive the award. For TQA, the applicants must reach over 650 total score points in order to receive TQA. Regularly the criteria shown in figure 1 can be used as guidelines however the level of successful might be varied between each company depended on the level consistence and effective improvement.

1.1)Problem statement

The future trend of competitive in the market tends to continuously increase. For instance, Association of Southeast Asian Nations or ASEAN Economic Community 2015 (commonly AEC 2015) is the upcoming regional free trade which will eventually include other Asian countries in the future. The quality competition represents a significant challenge for the sustainable competitive advantage due to the perception on quality as a battleground on global competition. To overcome the quality competition, a company's management needs to understand the prerequisite and properly prepare for a quality-award application (Manasserian, 200; and Fasil and Osada, 2011). As a result, there is a need to develop a basic roadmap or framework to help prepare a firm when attempting to improve its quality management.

1.2) Objectives

Certainly there are more or less company would like to know how to prepare and win TQA. Moreover there is no any document provided which exact operations that lead to succeed TQA. Therefore this research aims to provide the quality approaches that can be applied to improve the performance towards TQA winning. However achieving the award is considered as the outgrowth of business excellence but the feedbacks of assessment are the main part that the award applicants should focus on because it will be useful for further business improvement. If there are the clear approaches provided, it can help to reduce award preparation time. Well prepared strategies are essential to improve performance and direct focus to the point it would help to reduce preparing time and increase efficiency.

Thus, the objectives of this research are to provide the quality roadmap to succeed TQA also determine the successful firm characteristics from the past winners that associated to the length of time in order to achieve TQA. The result will be useful as the guidance to any companies that desire to achieve TQA not only for Thai companies but also any companies in the countries that used MBNQA criteria for their NQA program.

2) REVIEW OF LITERATURE

Kevin and Vinod (2000) discovered that the income increase in the companies that have effective TQM implementation but the level of financial impacts varied among firm characteristics. The firm characteristics have unique

difficulty that might relate to difficulty of TQA preparation. So this study hypothesized total nine hypotheses the sample characteristics that might related to TQA successful. First the firm size**,** Chen and Donald (1994) researched on how is competitive behavior of small firms differ from large firms. The small firms are faster implementers for their competitive actions also quickly respond in execute actions due to their simple structure in contrast to the large firms which have more complex organization structure. Second the private firms and public agencies, the difficulty of management between private firms and public agencies might differ. There is strong support by Bretschneider's (1990) that public agencies take longer decisions making regarding to more red tape exist than the private firms. Third the manufacturers and service companies, from Nicholas *et al.* (1997) questionnaire survey showed that the manufacturers use more quality management practices than the service providers. So this can be assumed that because of job characteristics caused the manufacturers use more quality management practices. Fourth the subsidiaries and parent companies, John and Ram (2005) studied about the relationship between parent company and subsidiaries and found that the parent company located Research and Development (R&D) in their subsidiaries abroad mainly for the purposes of the products development also adaption of processes for the parent company. The subsidiaries are more likely to have more experience practices than the parent companies. In addition the subsidiaries are considered as small company with more simple structures than the parent companies. These differences might cause different length of time for preparing TQA between parent and subsidiary companies. Fifth the foreign and domestic owned companies, José and Pedro (2002) researched about patterns of entry, post-entry growth, and survival of domestic and foreign-owned firms. They discovered the survival rate after the enter into the market for seven years, it was found that foreign-owned companies have higher survival rate and lower hazard rate than domestic company. For post-entry growth observation after five years survival showed that both domestic and foreign companies have grown in size over their lives but faster rate in foreign firms. These are the example of the differences between foreign and domestic owned companies. Sixth the quality award status, Kelvin and Vinod (1997) supported that the company that won the quality management related awards is recognized to have effective TQM implementation. The evidences showed there was changing in operating performance of the firms after won quality awards also do better on sales growth. So gaining quality award status might reflect the better performance for further improvement than not gaining and this is the difference of quality award status. Seventh the ISO 14001 certification, Goh *et al.* (2006) provided the empirical evidences of ISO 14001certification has a positive impact on company performance, specifically on perceived economic and environmental impact as well as perceived customer satisfaction. ISO 14001 represents that the company response for the social and environmental. Customer notification of ISO 14001 influenced purchase and result to high returns to the company. Thus gaining ISO 14001 certification might result advantages to the company and provide the experience of some quality practices. Eighth the employee

focus award, Gedaliahu and Shay (1999) said there was a strong and significant relationship between employees training and firm performance. Receiving any human resource management (HRM) related certification represents the maturity of HRM that could enhance the company performance towards TQA. Finally the company Age, Kevin and Vinod (2000) suggested that it is never too late to invest TQM. Moreover Rhee's (1995) model showed that the company which adopted TQM earlier can earn positive return earlier than the competitors which implement TQM later. The companies which entered into the market earlier are more like to have more maturity in TQM practices also having better performance than other younger companies if they implemented effective TQM earlier.

3) RESEARCH METHODOLOGY

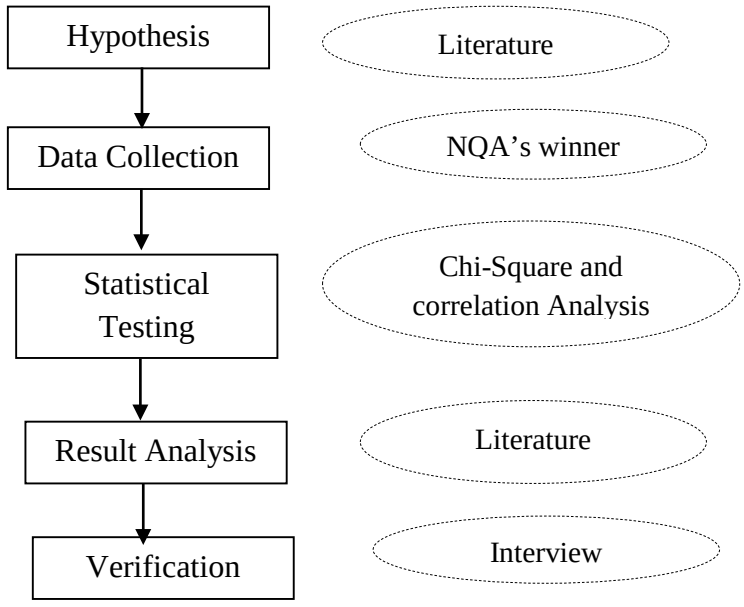

Figure 2: Research Methodology

The first step is to develop the hypotheses which are derived primarily from the literature reviews. There are altogether nine hypotheses proposed. They are: (1) There is relationship between size of company and the length of time spent to achieve TQA, (2) There is relationship between types of company (Private firm/Public agency) and the length of time spent to achieve TQA, (3) There is relationship between types of company (Manufacturer/Service company) and the length of time spent to achieve TQA, (4) There is relationship between types of company (Parent/Subsidiary) and the length of time spent to achieve TQA, (5) There is relationship between types of company (Foreign owned company/Domestic owned company) and the length of time spent to achieve TQA, (6) Quality award relates to the length of time spent to achieve TQA, (7) ISO 14001 certification relates to the length of time spent to achieve TQA, (8) the employee focus award relates to the length of time spent to achieve TQA, and (9) the age relates to the length of time spent to achieve TQA.

Then collect the statistical data from the NQA's winner information according to each hypothesis and categorize the company characteristics by checking size of company whether it is large or small company using the cutoff point at 500 employees, whether public agency or private company etc. See appendix A. There are two statistical methods taken to complete this study: (1) Correlation Analysis by using program SPSS 16 for the first to eighth hypothesis, and (2) Chi-Square test of association for the last hypothesis by using program Minitab 15.

The analysis focuses on the relationship between the particular firm characteristics and the length of time preparing for TQA. The length of TQA preparing time in this case is the number of years spent since the year receiving ISO 9000 until the year of winning TQA. ISO 9000 is a sign of beginning of quality management maturity and both ISO 9000 series and business excellence models are based on TQM philosophy. However there is a big gap of maturity level between ISO 9000 and NQA (B.G. Dale *et al*., 2000). An organization should follow ISO 9000 standards first and then implement TQM practices to improve the profit margin and customer retention (Ron Kurtus, 2001). Dale *et al*. (2000) also concluded that organizations need some practices and experience with TQM before being able to effectively use self-assessment against an excellence model. Thus, ISO 9000 series are the indicator of TQM maturity initiative and the year of receiving ISO 9000 was used as a reference point to see the number of years that the past winners spent to increase their capability from maturity beginning level to the highest level. Therefore, all firms have been certified ISO 9000 before obtained NQA.

Finally, the verification the results and findings by interview with the TQA's winner executive and draw the quality roadmap. There are past winners from six countries; Thailand, Singapore, Malaysia, Vietnam, Indonesia, and Philippines with total sixty past winners to study and analyze due to all adopted the same award criteria from MBNQA. The data of each company were collected from the past until year 2012 (see appendix A). After that, the TQA primary approach flow chart will be drawn. Then interview with the past winner company's executive about the flow chart prepared and the statistical results of the successful characteristics. The interview will provide more understandings about the practicality and shortcomings of the proposed guidelines.

4) RESULTS

Hypotheses 1 to 8 are analyzed by using Chi-Square test of association due to Chi-Square test is the test that used for the test of independence among the pair of variables which is qualitative data and the test results shown in table 1. Table 1 showed the statistical results of the firm characteristics for hypothesis 1 to 8.

Table 1: Chi-Square summary results for hypothesis number 1 to 8

Hypothesis	Characteristics	P-value	Reject/Accept H_0
1	Size (small/big)	0.737	Accepted
2	Public/Private	0.657	Accepted
3	Manufacturing/Service	0.275	Accepted
4	Parent/Subsidiary	0.659	Accepted
5	Foreign/Domestic owned company	0.516	Accepted
6	Quality award	0.579	Accepted
7	ISO 14001 certification	0.183	Accepted
8	Employee focus award	0.009	Rejected

The null hypothesis (H_0) stated that the two variables; characteristic and length of time spent for preparing TQA are independent from each other. Therefore, rejecting H_0 means the two variables are related to each other. The results from Table 1 reveal that employee- focus award is the characteristic that relates to the length of time spent for preparing TQA while the remaining characteristics are independent. The workforce- focus award correlated to the length of time preparing TQA at the medium level of correlation coefficient(r) of 0.367. Some of the awards include the Outstanding Award of Employee Welfare launched by The Ministry of Labor and Social Welfare of Thailand.

For the last characteristic, the age of company is analyzed by using Correlation analysis. Age refers to the age of company since establishment until received NQA. It is found that there is a relationship between a company's age and the length of time using for preparing TQA. Figure 3, the scattering plot shows the correlation coefficient (r) of -0.1493. The negative sign of correlation coefficient (r) represented the opposite relation between the age of company and length of time. This can be interpreted that more aging more using less time for TQA preparation. Due to the correlation coefficient (r) of -0.1493 represented the level of correlation of small level. The company's average age since its establishment until becoming a NQA recipient is approximately 20 years.

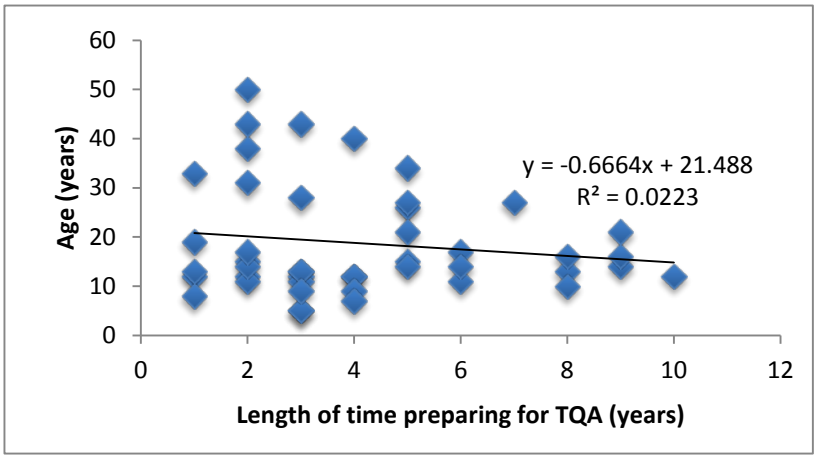

Figure 3: Scattering plot of the correlation between age of company and the length of time for NQA preparation

Finally, after interviewed with TQC past winner's executive at CP Retailink Co., Ltd which received TQC in 2010 and currently applying and currently looking forward for TQA this year (2013). Mr.Cherdpong Danyuttasilp, general manager of Business Unit development Bureau at CP Retailink Co., Ltd who is the leader of drawing the application and driving personnel within the organization to follow TQA framework. Mr.Cherdpong works for this current role for 6-7 years. He shared the experiences and the roadmap of achieving TQC which were likely similar to the findings of this research so the primary approach was summarized as Figure 3 below.

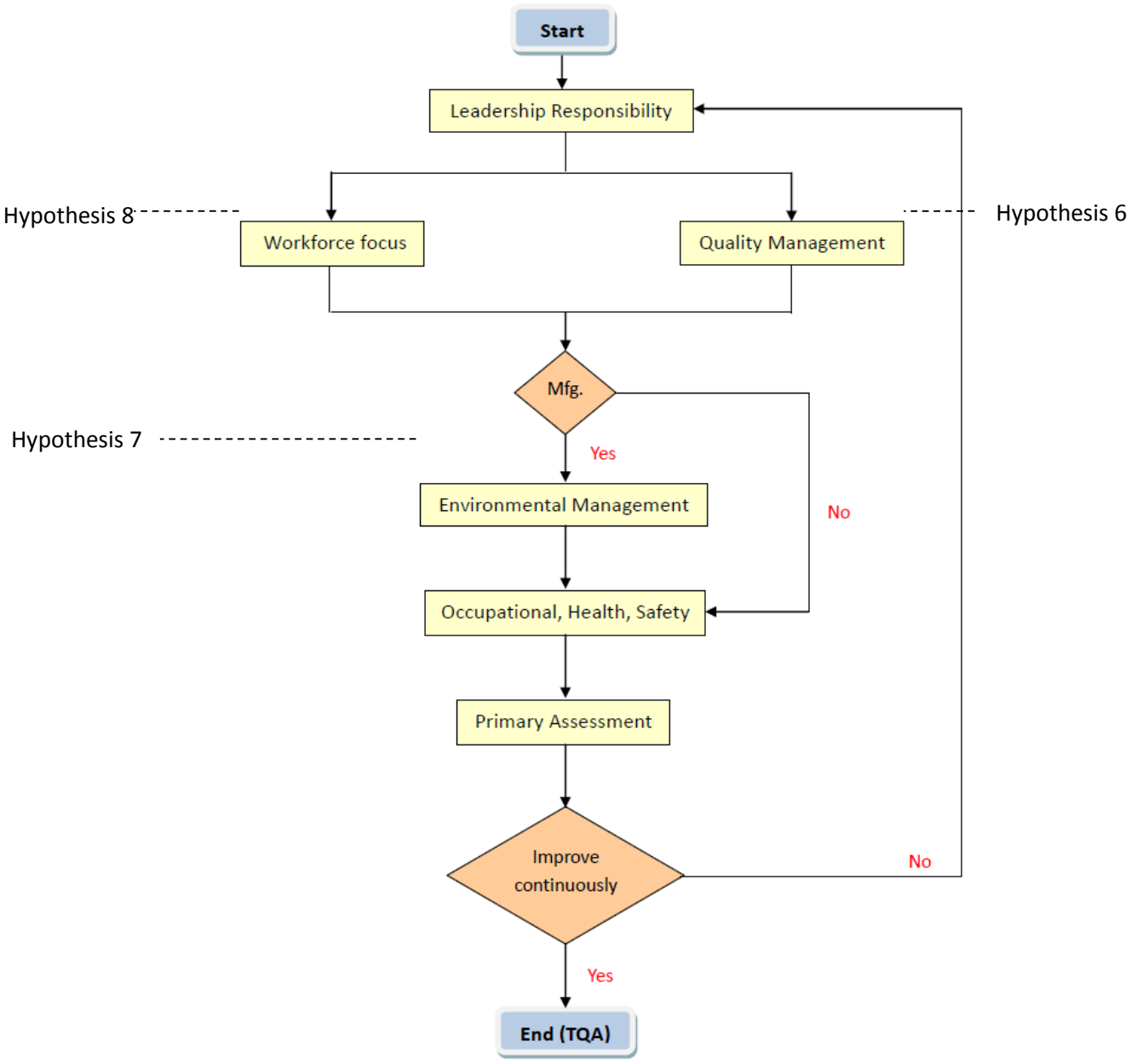

Figure 4: Primary Roadmap to success TQA

5) DISCUSSION

The quality roadmap shown in Figure 4 is the roadmap retrieved from some hypothesis that related to the tangible characteristics especially the quality management related award status. From the interview session with one of CP Retailink Co., Ltd executive who is in charge of driving TQA within his organization (note that CP Retailink Co., Ltd operated business as a service company), he agreed that the TQA roadmap shown Figure 4 can possibly be a primary approach and was similar to his company roadmap. However each company can create or add another practice into the roadmap but should contain those practices that contain in Figure 4. The crucial parts are leadership, workforce focus, and quality management that should be concerned, especially the leadership. The leader of company is the key person who defines the strategy and delivers the strategy then drives the company towards successful. The leader should understand about TQA strategy the most and attempt to transfer the improvement intention to employees involved within the organization. Workforce focus and Quality management are the approach that the applicant should follow and it can be parallel operations because they are equally likely important.

The company should attempt to gain any awards related to those approaches for TQM practicing due to more practices are more experiences and cause increase capability. Due to workforce is considered as a driving force of the organization, without efficient workforce without any moves. Paying attention to the staffs is the fundamental of organization successful. Even though there was only approximately 30% of the past winners that achieved any awards related to workforce focus. But the statistical result support that there was relationship between workforce focus award and the length of time preparing for TQA success. Nevertheless workforce focus is still considered as a important practice due to Gedaliahu and Shay (1999) supported that there is a strong and significant relationship between employees training and firm performance.

Quality management in this case referred to ISO 9000 certification and any quality awards related to quality management. ISO 9000 is the basic standard recognition that the company should earned for practicing quality management experiences. The findings support that there was 70% of available past winner companies through Southeast Asia obtained ISO 9000 certification prior NQA and 74% that earned Quality Management award before achieve their NQA. These could be supported that almost company emphasized on quality management.

Even though the rest of practices are not core factors and receiving the certifications or award recognitions can be negotiated but assure that the company follow those approaches. For example environmental management is a proportion of 5% of TQA total score. But in reality this criteria are more

likely less affect to the service companies or any other companies that operated with less impact to environment because they are less concern to environmental impacts. The example of environmental management is ISO 14000 certification with approximately 54 % of past winners received it before achieved NQA. Moreover Occupational Health and Safety (OHS) is the practice that supports workforce focus operations because it direct related to workforce well-being. Happy and safe work environment reflect effective production output. The example certification of OHS is OHSAS 18000 which is the standard that represents the management of minimize hazardous work that caused harmful to employees and loss of property.

The last step is primary assessment which the company follow TQA criteria; (1) Leadership, (2) Strategic planning, (3) Customer focus, (4) Measurement, analysis, and knowledge management, (5) Workforce focus, and (6) Operation focus. If the results of primary assessment are not satisfy then it turns back to leader responsibility to rethink and verify step by step and try to improve until the overall results meet the trend of improvement of along 3 years.

The statistical findings supported that almost the example of firm characteristics were not related to the length of time preparing for TQA and the comments obtained from interview were similar to the statistical results. The statistical results revealed that the workforce focus and age of company were related to the length of time for preparing TQA. For workforce focus importance was mentioned earlier and the age of company could be support by the scattering plot in figure 3 which represented more aging more using less time of TQA preparation. Aging companies were assumed that have more effective and more capability but in reality the younger company may have equally or more capability compare to the aging company which entered to the market earlier.

Furthermore, TQA is considered as a part of quality management recognition but there is no requirement that every companies in Thailand must be certified TQA. However achieving TQA provide the advantages such as the reputation obviously and capability assessment that lead to improve the performance. Almost global top 50 brand value companies of year 2013 which are the global successful companies have not been certified by NQA. There was only 10% of them has been awarded NQA. These findings could be supported that without NQA recognition does not guarantee that you will not success in the market. Significantly, the success is depends on the willingness and effort also the effective methods that applied for business improvement. Even though NQA recognition are more likely meaningless to some companies but NQA framework is the tool that can be applied for capability improvement comparable to the international standard.

In summary, the TQA roadmap in Figure 4 is a primary roadmap that derived from the literature reviews with the suggestion of the executive of CP Retailink

Co., Ltd who responded directly to drive the organization toward TQA until his organization received TQC in 2010 so he was considered as having familiar experiences with more than 6 years experience in preparing TQA. Almost contents that contained in Figure 4 are the main standards that acceptance worldwide and the company should follow. For example "Quality Management" is referred to ISO 9000 series certification or any other award that related to quality management system, "Environmental Management" is referred to ISO 14000 series, "Occupational, Health, Safety" is referred to OHSAS 18000 series. For the sequence that should start from Workforce focus or could be referred to human resource management because the human resources is the most important asset of the organization[3] so the company should start the roadmap by focus on human resource management first. In addition the company can simultaneous focus on quality management due to TQA was derived from total quality management principal. But for the other sequences can be modified according to the nature of each company.

6) CONCLUSION

These findings can be used as the primary guideline for understanding about how to achieve TQA effectively to the leaders of the companies that desire to apply and achieve TQA. The challenge and the real successful is how the companies improve their capability and exist in the business as long as they can but not refer to achieving TQA. Because TQA is the recognition for business excellence that given for that period and the recognition has expiration, thus it cannot guarantee the future excellence forever. However the consistent improvement is the operation that always exists forever unless the company stops doing so. From the statistical results, achieving TQA was more likely independent from the sample characteristics. However if every company implement quality management effectively, it would won TQA smoothly. The statistical showed the average time that the representative past winners spent to enhance from ISO 9000 to NQA with approximately 7 years with the standard deviation of approximately 5 years. The standard deviation was relatively large value that can be referred to there might be a lot of variation to achieve TQA. Believe that the leadership was the significant variable that impact to the number of year spent to success TQA because the leadership is the beginning part of business improvement.

[3] Stahl, G.K, I. Björkman, S. Morris. (2012). Handbook of Research in International Human Resource Management. Cheshire: MPG Books Group, UK

7) REFERENCES AND APPENDICES

7.1) References

Anderson, E.W., C. Fornell and D.R. Lehmann. (1994) "Customer satisfaction, market share, and profitability: Findings from Sweden", *Journal of marketing*, Vol. 58, pp. 53-66

Ann, G.E., S. Zailani and N.A. Wahid. (2006) "A study on the impact of environmental management system (EMS) certification towards firms' performance in Malaysia", *Management of Environmental Quality: An International Journal*, Vol. 17, No. 1, pp. 73-93

Baird, K. and Jia Hu, K. and Reeve, R. (2011) "The relationships between organizational culture, total quality management practices and operational performance", *International Journal of Operations & Production Management*, Vol. 31, No. 7, pp. 789-814

Beaumont, N.B., A.S. Sohal and M. Terziovski. (1997) "Comparing quality management practices in the Australian service and manufacturing industries", *International Journal of Quality & Reliability Management*, Vol. 14, No. 8, pp. 814-833

Bretschneider, S.(1990) "Management information systems in public and private organizations: An empirical test", *Public Administration Review*, Vol. 50, No. 5, pp. 536-545

Cantwell, J. and R. Mudambi. (2005) "MNE competence – creating subsidiary mandates", *Strategic Management Journal*, Vol. 26, pp. 1109-1128

Fasil, T. and Osada, H. (2011) "Multiple dimensions of TQM success in developing countries: an empirical study on Deming Prize winners from India and Thailand", *International Journal of Innovation and Learning*, Vol. 9, No. 2, pp. 184-203

Hallowell, R. (1996) "The relationships of customer satisfaction, customer loyalty, and profitability: an empirical study", *International Journal of Service Industry Management*, Vol. 7, No. 4, pp. 27-42

Harel, G.H. and S.S. Tzafrir. (1999) "The effect of HRM practices on the perceptions of organizational and market performance of the Firm", *Human Resource Management*, Vol. 38, No. 3, pp. 185-200

Hendricks, K.B. and V.R. Singhal. (1997) “Does implementing an effective TQM program actually improve operating performance? Empirical evidence from firms that have won quality awards”, *Management Science*, Vol. 43, pp. 1258-1274

Hendricks, K.B. and V.R. Singhal. (2000) “Firm characteristics, total quality management, and financial performance”, *Journal of Operations Management*, Vol. 238, pp. 1-17

Katsikeas, C.S. and R.E. Morgan. (1994) “Differences in perceptions of exporting problems based on firm size and export market experience”, *European Journal of Marketing*, Vol. 28, No. 5, pp. 17-35

Kull, T.J. and Wacker, J.G. (2010) “Quality management effectiveness in Asia: The influence of culture”, *Journal of Operations Management*, Vol. 28, pp. 223-239

Kurtus, R. (2001) “Comparing ISO 9000 and TQM”, *Source: http://www.school-for- champions.com/iso9000/iso_9000_vs_tqm.htm*, 8 October 2012

Lederer, P.J. and S. Rhee. (1995) “Economics of total quality management”, *Journal of Operations Management*, Vol. 12, pp. 353-367

Levine, D.I. and Toffel, M.W. (2010) “Quality Management and Job Quality: How the ISO 9001 Standard for Quality Management Systems Affects Employees and Employers”, *Management Science*, Vol. 56, No. 6, pp. 978-996

Manasserian, T. (2005), “New realities in global markets and Thailand’s economy today”,available at :http://webh01.ua.ac.be/cas/PDF/CAS48.pdf (as of April 2007)

Mata, J. and P. Portugal. (2002) “Patterns of Entry, Post – Entry Growth and Survival – A comparison between Domestic and Foreign Owned firms”, *Small Business Economics*, Vol. 22, pp. 283-298

Ropret, M., Fatur, P., Rodman, K., and Likar, B. (2012) “Factors of successful innovation in services and a performance comparison with manufacturing sector,” *International Journal of Innovation and Learning*, Vol. 12, No. 4, pp. 379- 401

Talib, F. and Rahman, Z., Qureshi, M.N. and Siddiqui J. (2011) “Total quality management and service quality: an exploratory study of quality management practices and barriers in service industry”, *International Journal of Services and Operations Management*, Vol. 10, No. 1, pp. 94-118

Van Der Wiele, A., A.R.T. Williams and B.G. Dale. (2000) “ ISO 9000 series registration to business excellence: the migratory path”, *Business Process Management Journal*, Vol. 6, No. 5, pp. 417-427

7.2) Appendix

Appendix A: Sample NQA's winner representatives throughout Southeast Asia (from total 60 winners)

Number	Country	Company	Size	Type				QA status	ISO 14001 status	Workforce status
1	Thailand	Thai Paper Co., Ltd. (TPC)	Big	Mfg.	Subsidiary	Private	Domestic	Without	With	With
2	Thailand	Thai Acrylic Fibre Co., Ltd.	Big	Mfg.	Subsidiary	Private	Foreign	Without	With	Without
3	Singapore	Ministry of Manpower (MOM)	Big	Service	Parent	Public	Domestic	With	Without	With
4	Singapore	Institute of Technical Education	Big	Service	Subsidiary	Public	Domestic	With	Without	With
4	Malaysia	Sime Darby Property Berhad	Big	Service	Subsidiary	Private	Domestic	With	With	Without
5	Philippines	Integrated Microelectronics, Inc.	Big	Mfg.	Parent	Private	Foreign	With	With	Without
6	Indonesia	PT Petrokimia Gresik	Big	Mfg.	Subsidiary	Public	Domestic	With	With	Without
7	Vietnam	Xanh Ha General Trading Company	Small	Mfg.	Parent	Private	Domestic	Without	Without	Without
8	Vietnam	Mai Linh J.S.C	Big	Service	Parent	Private	Domestic	With	Without	Without

Ranking R&D Institutions of India: An application of DEA

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ABSTRACT

Purpose: One major problem in evaluating the efficiencies of public institutions as pointed out by many researchers is the lack of a good estimate of the production function. There are different methodologies that are adopted to estimate relative efficiencies such as regression, ratio analysis that uses one ratio-at-a-time comparisons to determine relative efficiencies or general performance indexes that used *a-priori* weighting schemes with accompanying assumptions.
Design/Methodology/Approach: However, the methodology of data envelopment analysis (DEA) is considered to be superior to the above as DEA requires no underlying assumptions for inputs and outputs or *a-priori* choice of weights. It further allows us to consider multiple inputs and multiple outputs of a decision making unit and provides us with a procedure to differentiate between efficient and inefficient decision making units. DEA may be able to detect specific inefficiencies that may not be detectable through other techniques like regression or ratio analysis.
The study reported in the paper concerns measuring the relative efficiencies of public-funded research and development laboratories in India (each laboratory being considered as a decision making unit) with data drawn from 12 such laboratories spread over different regions of the country and working on diverse fields of science, engineering and technology. The input data for the study consist of the total number of scientific personnel and the total number of technical personnel working in each laboratory and the output data consist of the number of papers published in Indian journals, the number of papers published in foreign journals, the number of patents filed by these laboratories.
Findings: Both the global efficiency scores and the different local efficiency scores (with specific inputs and outputs) were evaluated and potential improvements were ascertained. The implications of the study results have been analyzed and discussed.
Originality: It is one of the few research studies taken in the context of Indian Research and Development units operating under Government of India.

Keywords: Data envelopment analysis, efficiency scores, potential improvement, public institutions, relative efficiency, research and development laboratory.

Article classification: Research paper

1) INTRODUCTION

Science and technology play a major role in the economic development of nations. Hence, major countries invest heavily in Research and Development (R&D). In the era of globalization and competition, Indian R&D organizations are under immense pressure to perform efficiently and effectively. As per India Vision 2020 (2002), out of 500,000 new patent applications filed globally each year, China accounts for 96,000 and Korea accounts for 72,000, while India accounts for only 8,000. Thus, strategic assets and resources such as research and innovation have become tools in national economic competitiveness (Coccia, 2005). As the situation shows, it becomes a primary responsibility of the policy makers and the top management to evaluate and compare the performance of these R&D organizations more critically. As opined by Cook *et al.* (1995), performance measurement systems must provide quality information to decision makers so that they can determine whether their efforts are used effectively. It becomes imperative to assess the efficiency of the R&D process as it utilizes scarce resources (Sharma and Thomas, 2008).

However, it is difficult to measure how efficient nations use their resources; more particularly, how efficiently are these R&D organizations functioning. One major problem in evaluating the efficiency of public institutions is the lack of a good estimate of the production function. A production function is the functional relation between inputs and outputs. It defines which inputs and how many are needed to produce a specified output. Indeed, the production function approach has a number of significant limitations, which render its usefulness to an evaluation of government-sponsored research projects questionable. The breakthrough came in the research work undertaken by Charnes, Cooper and Rhodes (1978). This was the first paper using the technique of Data Envelopment Analysis (DEA), even though they never named it that way. The present paper reports the results of a study to analyze and compare the efficiencies of R&D laboratories under the Council of Scientific and Industrial Research (CSIR), India, considering a sample of 12 CSIR laboratories adopting the methodology of Data Envelopment Analysis (DEA).

The CSIR is an autonomous society under the Societies' Registration Act, 1860 with the Prime Minister of India as its ex-officio President. The Governing Body is the highest policy decision-making body of CSIR. The Director-General is its ex-officio chairman. The CSIR Headquarters at New Delhi coordinates the activities of the laboratories. The Council enters into bilateral agreements in the fields of pure as well as applied sciences with scientific organizations of various countries.

2) LITERATURE REVIEW

It is difficult to measure the performance of R&D organization because the nature of these organizations and the functions these organizations perform are complex, risky, and uncertain. As opined by Chiesa and Masella (1996); Bremser and Barsky (2004); Loch and Tapper (2001); Brown and Svenson (1998); and Jain and Triandis (1997), it is difficult to identify, measure and compare the performance of R&D organizations. Efficient and productive innovation processes determine whether R&D can serve as a major source of competitive advantage (Werner and Souder, 1997). But the emerging importance of such performance measurement has been fuelled by the growth in global competition (Tassey, 2009). Also the previous researchers have found it difficult to identify the various outputs/inputs as multiple parameters are involved in the system. But the performance of R&D organizations can be compared in terms of their relative efficiencies. As per the existing literature, there are only a few studies conducted on performance measurement of R&D organizations.

2.1) R&D output

Considering individual firms as the sample of their study, Pandit, Wasley and Zach (2011) consider R&D as an input to the innovation process and measures the productivity of a firm's innovative activities in terms of the number and the quality of patents. They argue that both of these variables are measures of innovation output or success, and proxy for the economic value of innovation. The future benefits of R&D that create intangible assets has been compared with the future benefits of capital expenditures producing tangible assets by Kothari, Laguerre and Leone (2002). As innovation includes both technological as well as non-technological innovation, Chen, Hu and Yang (2011) suggest a multi-dimensional measurement schema including patents, royalties and licensing fees and journal articles. Considering a sample of Spanish manufacturing firms, Huergo and Moreno (2011) have analyzed the relationship between R&D expenditures, innovation and productivity growth taking into consideration the possibility of persistence in a firms's behavior. Fortune and Shelton (2012) in their study on 303 firms in the pharmaceutical sector have observed that R&D efforts yields increasing return to R&D effectiveness and found innovative output as an important mediating factor between R&D effort and firm performance. In their study on R&D and the national innovation system, Hu, Yang and Chen (2014) compare R&D efficiency among 24 nations during 1998-2005. In their multiple input-output frameworks, the input variables are R&D expenditure stock and R&D manpower and the output variables are patents, scientific journal articles, and royalty and licensing fees. Wang et al. (2013) have carried out an empirical analysis of high technology firms on R&D, productivity and market value.

Considering public research institutes, Matsumoto et al. (2010) have carried out case studies on market-impact creation outputs from the National Institute of Advanced Industrial Science and Technology, and have modeled R&D output generating economic impact along four stages – R&D output, technology transfer, commercialization, and market impact. This is in line with Roy *et al.'s* (2003) earlier

study where a model to measure the effectiveness of research units was developed. The aspects of technology transfer from public R&D laboratories and the impact on the development of regional industrial clusters have been the thrust areas of the authors' prior research (Roy and Mohapatra, 2002; Roy, 2004, 2006; Roy and Banerjee, 2007; and Roy, 2009). Lee *et al*. (2011) have presented a R&D performance monitoring, evaluation and management system for national R&D to mirror not only short-term but also long-term R&D outcomes.

2.2) Applications of DEA

Johnes and Johnes (1992, 1993) carried out pioneering research in the field of application of DEA in scientometrics where the authors investigated the technical efficiency of UK university departments of economics as producers of research. Rousseau and Rousseau (1997, 1998) used the methodology of data envelopment analysis as a tool for constructing scientometric indicators for evaluating the performances of countries and regions. Mahmood *et al.* (1996) have used the methodology of DEA to investigate into the productivity of 78 commercial system projects. Other applications of DEA include banks (Brockett *et al*., 1997); different units of US Air Force (Charnes et al., 1985a); universities (Reichmann, 2004), Japanese manufacturing firms (Goto and Suzuki, 1989); journals (Lozano and Salmeron, 2005), and public research institutes (Rama Mohan, 2005). Chen, Hu and Yang (2011) have compared R&D efficiency of nations based on various output-oriented R&D efficiency indices that are developed by data envelopment analysis approach.

Coccia (2001, 2004) developed *dual* performance functions by using discriminant analysis (DA) along with Wilk's method. Chen *et al.* (2004) used data envelopment analysis (DEA) technique in 31 computers organizations in Taiwan by considering multiple inputs and outputs. Kim and Oh (2002) conducted a study on designing a R&D measurement system for Korean researchers. Wang *et al.* (2005) have developed extensive evaluation criteria for multidisciplinary R&D projects in China for ranking and rewarding. DEA has been used by Garg *et al.* (2005) as one of the methodologies to assess the impact of All India Council of Technical Education (AICTE) funding on R&D and educational development in India.

Commenting on earlier studies on CSIR in India by the authors, Roy *et al.* (2007) have earlier carried out a study on CSIR exploring the impact of age, research area, and rank on its scientific productivity, again using DEA as one of the methodologies. In an earlier study (Gupta *et al*., 2000), market orientation of CSIR laboratories were analyzed. Another study has focused on forecasting of scientific manpower in CSIR (Roy *et al*., 2001).

An internal study was carried out by CSIR to assess the effectiveness of its six R&D organizations by using cost-benefit analysis (Tikoria *et al.*, 2009). The authors used a hybrid approach of using AHP and DEA to measure and compare the performance of a group of Indian national R&D organizations involved in applied as well as basic

research in chemical and botanical sciences. Thus, from the existing literature, it can be observed that very few researches have been conducted for the evaluation of R&D performance in India.

In the present study, the DEA model has been developed for a group of R&D organizations belonging to CSIR. CSIR has 38 R&D laboratories all over the country and 80 centers. The numbers of employees are more than 20,000 people that constitute around 5100 scientists, around 10,300 technical and around 5600 total administrative & non-technical people. Government of India (GOI) allocates funds of approximately INR 1,000 crores (approx. 222 million USD) per year (Banwet *et al.*, 2008).

3) AIM OF THE STUDY

The aim of the study is to analyze and compare the relative efficiencies of R&D laboratories functioning under the Council of Scientific and Industrial Research (CSIR), India. A sample consisting of 12 CSIR laboratories have been considered for this study.

4) METHODOLOGY

The methodology of Data Envelopment Analysis (DEA) has been adopted for this study. DEA, as developed by Charnes *et al.* (1978) and extended by Banker *et al.* (BCC) (1984) is a linear programming procedure for a frontier analysis of inputs and outputs. The procedure does not require a priori weights on inputs and outputs. Data Envelopment Analysis (DEA) evaluates the relative efficiency of decision-making units (DMUs) but does not allow for a ranking of the efficient units themselves. An important methodological feature of this DEA technique is that it can determine the production performance of an entity (DMU) by relatively comparing it with those of others. Charnes *et al.* (1978) concluded that 100% efficiency is attained for a DMU only when:

- None of its outputs can be increased without either increasing one or more of its inputs or decreasing some of its other outputs.
- None of its inputs can be decreased without either decreasing some of its outputs or increasing some of its other inputs.

This definition accords fully with the economist's concept of pareto-optimality. The relative efficiency has been defined in the following fashion: 100% relative efficiency is attained by any (unit) only when comparisons with other relevant (units) do not provide evidence of inefficiency in the use of any input or output. Charnes *et al.* (1985a) have characterized a unit as influential if it is frequently used in the calculation of efficiency scores. Other notable references in this area include Charnes *et al.* (1985b, 1994), Sengupta (1995) and Coelli (1998). Hibiki and Sueyoshi (1999) have presented a new DEA approach referred to as 'DCR (DEA cross reference) efficiency measure'. Sueyoshi (1999) has described a new DEA ranking approach that combined efficiency analysis (by DEA) with index measurement (by DEA sensitivity

analysis). Seiford and Zhu (1999) have discussed the determination of returns to scale in DEA.

In DEA the performance of each unit under study is compared with that of every other one. Units that perform best, use their inputs more optimally than the other ones. The most optimal units form a frontier, called the 'efficiency frontier'. Less performing units need more inputs to produce the same amount of output and are therefore situated at some distance of the frontier. The (in)efficiency of such a particular unit is represented by the radial distance from the efficiency frontier. The DEA methodology suggests a radial evolution from the source towards the target point on the frontier, which represents what that unit could be achieving. Units situated on the efficiency frontier will have a relative efficiency rate of 1 (they are 100% efficient). The efficiency frontier is said to envelop all decision-making units (DMUs). This is why the technique is called Data Envelopment Analysis. A unit that is not situated on the efficiency frontier has a reference set consisting of those 100% efficient units that are nearest to it. The reference set allows us to calculate the input discounts and, occasionally, the output discounts that are necessary to obtain an efficiently performing unit. A modified version of DEA based upon comparison of efficient DMUs relative to e reference technology spanned by all other units have been developed by Andersen and Petersen (1993).

In DEA studies on R&D efficiency measurement, we can find examples of different input and output variables. Referring to Chen et al. (2011) presented DEA model on R&D efficiency of nations, the input variables were full-time researchers and technicians and R&D expenditure and the output variables were patents, royalties and licensing fees and scientific journal articles. Wang and Huang (20007) used two output variables – patents and SCI and EI articles, and Lee and Park (2005) used three output variables – patents, technology balance of receipts, and journal articles, in their respective studies on relative efficiency of R&D activities across nations. Lee et al. (2008) have adopted both the Analytical Hierarchy Process (AHP) and DEA in R&D evaluation. Lee *et al*. (2009), comparing the performance of national R&D programs in South Korea have used 10 output variables including academic publications and patents.

4.1) Sample

The sample consisting of 12 R&D laboratories under the CSIR have been considered for this study. Table 1 exhibits the R&D labs where they have been assigned a unit number for calculation purposes.

Table 1: The List of R&D Laboratories under Study

Unit 1	Central Electro Chemical Research Institute (CECRI), Karaikudi.
Unit 2	Central Electronics Engineering Research Institute (CEERI), Pilani.
Unit 3	National Physical Laboratory (NPL), New Delhi.
Unit 4	Institute of Microbial Technology (IMT), Chandigarh.
Unit 5	National Botanical Research Institute (NBRI), Lucknow
Unit 6	Central Mining Research Institute (CMRI), Dhanbad.
Unit 7	Structural Engineering Research Institute (SERI), Madras
Unit 8	Regional Research Laboratory (RRL), Bhubaneswar.
Unit 9	National Geophysical Research Institute (NGRI), Hyderabad.
Unit 10	Regional Research Laboratory (RRL), Jammu Tawi
Unit 11	Central Drug Research Institute (CDRI), Lucknow.
Unit 12	National Metallurgical Laboratory (NML), Jamshedpur.

4.2) Data structure

The data on DEA has been classified into two categories:

- Input Indicators.
- Output Indicators.

The input indicators are scientific manpower and technical manpower of the laboratory. The output indicators are Indian papers (papers published in Indian journals), foreign papers (papers published in foreign journals), and number of patents (filed and granted). This information has been collected from the Annual Reports of the concerned 12 CSIR laboratories.

5) ANALYSIS OF THE DATA

The data set was analyzed to find out the efficiency of R&D laboratories under the CSIR, India. In the analysis, efficiencies have been classified into two categories. The first one is called the Global efficiency and the other one is known as the Local efficiency. When the efficiency is evaluated with CCR, which assumes constant returns to scale (CRS) is known as global efficiency. On the other hand, when the efficiency is evaluated on basis of BCC model, which assumes Variable return to scale (VRS) is called local efficiency.

The global efficiency scores are evaluated considering all the 12 R&D laboratories and all the input and output indicators together. Since to get the Frontier Analyst plot, either one input indicator and two output indicators or one output indicator and two input indicators are required, different combinations of the input and the output indicators have been considered for evaluating the local efficiency scores. Here in the analysis, input or output indicators have not been allotted any weights.

6) RESULTS AND DISCUSSION

6.1) Global efficiency scores

Since the aim of the study is to analyze and compare the efficiencies of R&D laboratories, first the analysis and comparison of global efficiency scores have been considered. In this phase, analysis of the overall efficiency scores of all units and the details like potential improvements, reference comparison, etc., have been carried out.

Considering the exhibits as given in Table 2, in which the global efficiency scores are presented. It could be inferred from this table that (when all the inputs and outputs are taken into consideration), five units viz. unit 4 (IMT, Chandigarh), unit 5 (NBRI, Lucknow), unit 7 (SERI, Madras), unit 8 (RRL, Bhubaneshwar), unit 11 CDRI, Lucknow, are relatively 100% efficient as compared to the other laboratories under study. Clearly, a more effective utilization of the given inputs to produce a higher level of outputs makes these five units relatively efficient, compared to the other seven units in the sample. These units were found fully efficient as these R&D institutes were able to convert the inputs into outputs in an optimum manner. This implies that scientific and technical manpower contributed to produce papers published in Indian and Foreign journals along with filed and granted patents. However, these are relative efficiency score as this would change as the input/output parameter changes or number of DMU (in this case R&D institutes of India) changes.

Table 2: Global Efficiency Scores

R&D Laboratories (Units)	Efficiency Scores
Unit 1 (CECRI. Karaikudi)	43.43
Unit 2 (CEERI, Pilani)	7.15
Unit 3 (NPL, New Delhi)	30.11
Unit 4 (IMT, Chandigarh)	100-.00
Unit 5 (NBRI, Lucknow)	100.00
Unit 6 (CMRI, Dhanbad)	18.29
Unit 7 (SERI, Madras)	100.00
Unit 8 (RRL, Bhubaneshwar)	100.00
Unit 9 (NGRI, Hyderabad)	52.43
Unit 10 (RRL, Jammu Tawi)	78.59
Unit 11 (CDRI, Lucknow)	100.00
Unit 12 (NML, Jamshedpur)	34.21

6.2) Local efficiency scores

In the second phase of analysis, local efficiency scores have been considered. In the case of local efficiency, frontier plots using one input and two outputs have been considered. Analysis has been carried out by evolving efficiency frontier plots with selected inputs and outputs and by focusing upon the level of efficiency or inefficiency of these units as compared to the reference units lying on the efficiency frontier.

Potential improvements for each unit have also been analyzed. For instance, Table 3 presents the potential improvements for unit 1 (CECERI, Karaikudi). It may be noted from an observation of this Table that if the strength of the scientific and technical manpower are cut down by 56.6% (i.e. to 91) and 83.8% (i.e. to 59) respectively, and if the number of patents is increased by 163.4% (i.e. to 21), it is possible to convert unit 1 into a 100 per cent efficient unit. Clearly, this is only a theoretical possibility, but this does point out the direction along which the laboratory management could proceed in order to improve its efficiency level.

Table 3: Unit 1 (CEERI, Karaikudi) – Potential Improvements

Factors	Actual	Target	Potential Improvement
Scientific Manpower	210	91	56.6%
Technical Manpower	363	59	83.8%
Indian Papers	70	70	0.0%
Foreign Papers	54	54	0.0%
Patents	8	21	163.4%

In all the Frontier plots displaying the data envelopes, the ratio 'output1/input' is taken along the X-axis and the ratio 'output2/input' is taken along the Y-axis.

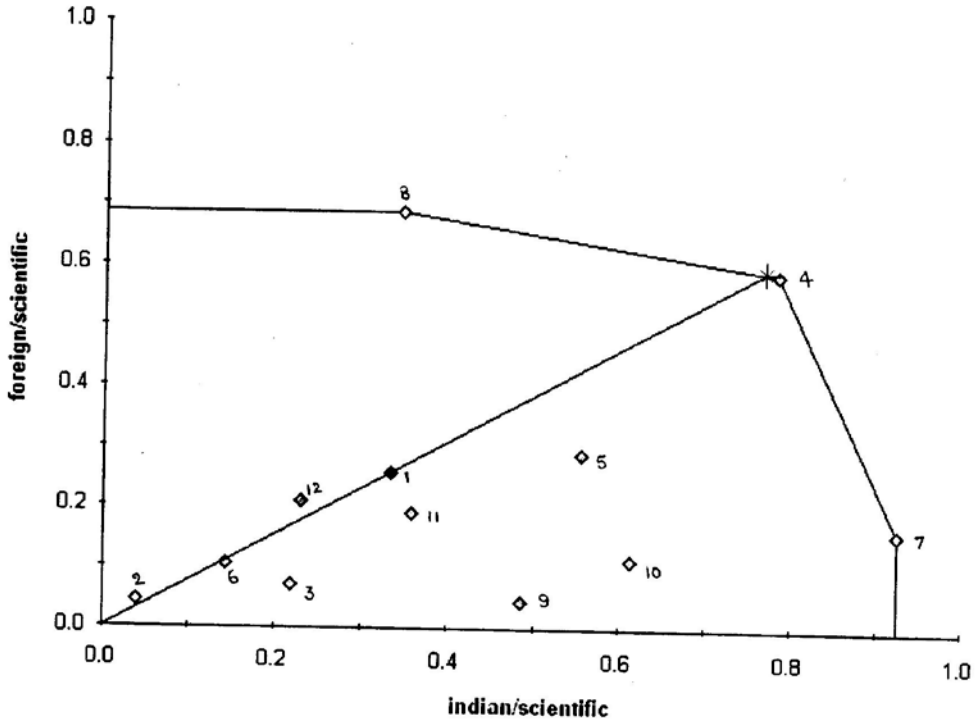
Table 4 presents the local efficiency scores in Case 1 (input indicator: scientific manpower, output indicators: number of Indian and foreign papers), it may be noted that unit 4, unit 7, unit 8 are 100% efficient and unit 2 (CEERI, Pilani) has a very low efficiency score of 7.15%.

Table 4: Local Efficiency Scores – Case 1 (Input: Strength of Scientific Manpower; Outputs: Numbers of Indian and Foreign Papers)

R&D Laboratories (Units)	Efficiency Score
Unit 1 (CECRI. Karaikudi)	43.43
Unit 2 (CEERI, Pilani)	7.15
Unit 3 (NPL, New Delhi)	24.67
Unit 4 (IMT, Chandigarh)	100.00
Unit 5 (NBRI, Lucknow)	66.46
Unit 6 (CMRI, Dhanbad)	18.29
Unit 7 (SERI, Madras)	100.00
Unit 8 (RRL, Bhubaneshwar)	100.00
Unit 9 (NGRI, Hyderabad)	52.43
Unit 10 (RRL, Jammu Tawi)	66.59
Unit 11 (CDRI, Lucknow)	43.03
Unit 12 (NML, Jamshedpur)	34.21

Referring to Figure 1 that shows the frontier plot for the 12 units (12 CSIR laboratories), where the input indicator is the strength of scientific manpower and the

output indicators are the number of Indian papers and foreign papers, it may be noted that in this plot, the ratio 'Indian papers/scientific manpower' is taken along the X-axis and the ratio 'foreign papers/scientific manpower' is taken along the Y-axis. It is observed that unit 4, unit 7 and unit 8, all lie on the efficiency frontier. These efficient units are enveloping all the other units. All the units that are situated on the efficiency frontier are the most optimal units and they have a relative performance ratio of 1 (they are 100% efficient). Less performing units like the other units except unit 4, 7 and 8 need more inputs to produce the same number of outputs and are therefore situated some distance away from the frontier The units that lie on the efficiency frontier actually define this frontier, i.e. best achieved performance. The ratio of the radial distance from the origin to the length of the segment joining the origin and the efficiency frontier, passing through a unit's coordinates, gives the efficiency of this unit. In this graph, most units have unit 4 and unit 8 in their reference set, some of the units have unit 4 and unit 7 in their reference set, and a very few have unit 7 in their reference set.



FRONTIER PLOT

Figure 1: Frontier Envelope (Case 1: Input – Number of Scientific Staff; Outputs – Numbers of Indian and Foreign Papers)

To increase the performance of a non-optimal unit, such as unit 1, the DEA technique suggests a radial evolution from the source towards the target point on the frontier, which represents what that particular unit (unit 1 in this figure) could be achieving. In

this way, it is possible to find out how optimal performance could be achieved by all the inefficient units.

Table 5 presents the local efficiency scores where the input indicator is scientific staff and the output indicators are foreign papers and patents. Referring to this table, it may be noted that unit 4 and unit 8 are 100% efficient and unit 9 is having a very less efficiency score of 6.54%.

Table 5: Local Efficiency Scores – Case 2 (Input: Strength of Scientific Manpower; Outputs: Numbers of Foreign Papers and Patents)

R&D Laboratories (Units)	**Efficiency Score**
Unit 1 (CECRI. Karaikudi)	37.35
Unit 2 (CEERI, Pilani)	6.64
Unit 3 (NPL, New Delhi)	10.37
Unit 4 (IMT, Chandigarh)	100.00
Unit 5 (NBRI, Lucknow)	41.69
Unit 6 (CMRI, Dhanbad)	17.52
Unit 7 (SERI, Madras)	23.60
Unit 8 (RRL, Bhubaneshwar)	100.00
Unit 9 (NGRI, Hyderabad)	6.54
Unit 10 (RRL, Jammu)	44.74
Unit 11 (CDRI, Lucknow)	60.26
Unit 12 (NML, Jamshedpur)	33.02

Figure 2 shows the frontier plot for the 12 units (12 CSIR laboratories), where the input indicator is scientific staff and the output indicators are foreign papers and patents. In this plot, 'foreign papers/scientific manpower' ratio is taken along the X-axis and 'patents/scientific manpower' ratio is taken along the Y-axis and then the graph is plotted. Units 4 and 8 are situated on the efficiency frontier. These efficient units are enveloping all the other units. All the units that are situated on the efficiency frontier are the most optimal units and they have a relative performance ratio of 1 (they are 100% efficient). Less performing units like the other units except units 4 and 8 need more inputs to produce the same number of outputs and are therefore situated on some distance of the frontier. As in Figure 1, the units that are there in the efficiency frontier actually define this frontier, i.e. best achieved performance. In this plot, most units have unit 4 and unit 8 in their reference set, some of the units have unit 4 in their reference set, and some of them have unit 8 in their reference set. To increase the performance of a non-optimal unit, such as unit1, the DEA technique suggests a radial evolution from the source towards the target point on the frontier, which represents what that unit (unit 1) could be achieving. In that way, an optimal performing unit can be achieved for all the inefficient units.

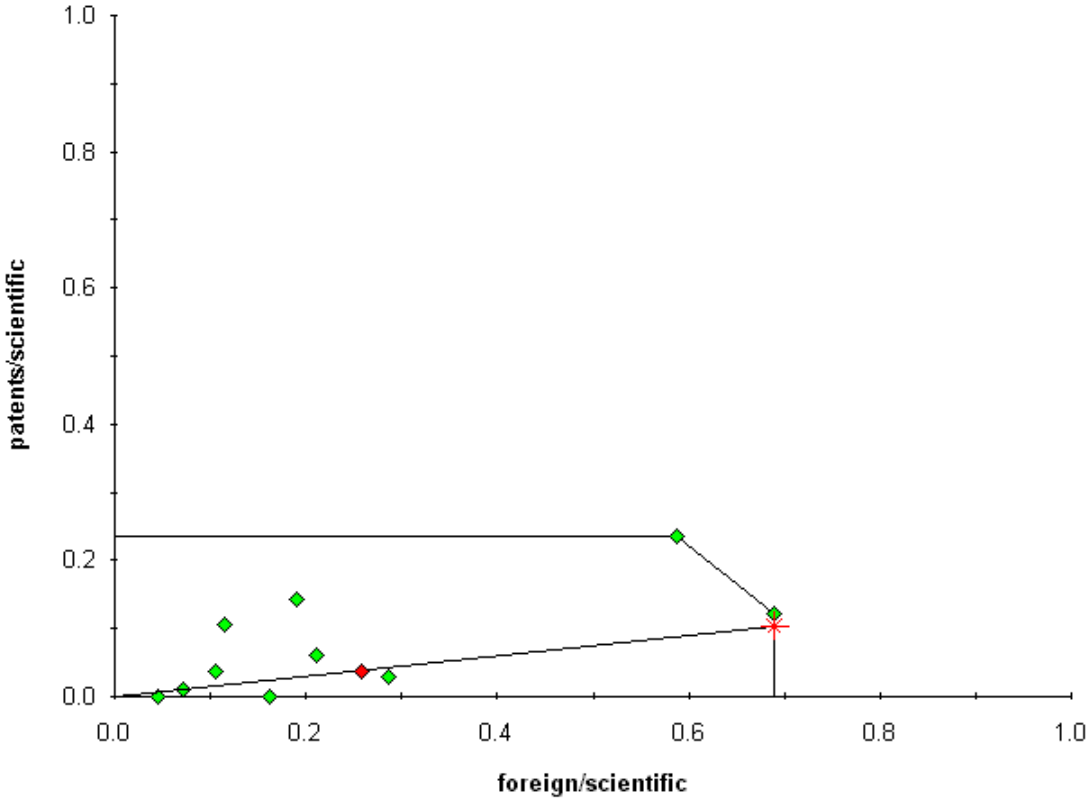


Figure 2: Frontier Envelope (Case 2: Input – Number of Scientific Staff; Outputs – Numbers of Foreign Papers and Patents)

Table 6 presents the efficiency scores of the 12 units when technical staff is taken as the input indicator and Indian and foreign papers are the output indicators. Referring to this table, it may be observed that only unit 5 has been found to be efficient.

Table 6: Local Efficiency Scores – Case 3 (Input: Strength of Technical Manpower; Outputs: Numbers of Indian and Foreign Papers)

R&D Laboratories (Units)	**Efficiency Score**
Unit 1 (CECRI. Karaikudi)	13.92
Unit 2 (CEERI, Pilani)	2.05
Unit 3 (NPL, New Delhi)	19.79
Unit 4 (IMT, Chandigarh)	87.70
Unit 5 (NBRI, Lucknow)	100.00
Unit 6 (CMRI, Dhanbad)	13.50
Unit 7 (SERI, Madras)	31.10
Unit 8 (RRL, Bhubaneshwar)	60.45
Unit 9 (NGRI, Hyderabad)	10.17
Unit 10 (RRL, Jammu Tawi)	47.65
Unit 11 (CDRI, Lucknow)	85.20
Unit 12 (NML, Jamshedpur)	10.68

Figure 3 presents the frontier plot for the 12 units (12 CSIR laboratories), where the input indicator is technical staff and the output indicators are Indian papers and foreign papers. In this plot, 'Indian papers/technical manpower' ratio is taken along the X-axis and 'foreign papers/technical manpower' ratio is taken along the Y-axis and the graph is then plotted. Unit 5 is situated on the efficiency frontier. This efficient unit, unit 5 is enveloping all the other units. All the units that are situated on the efficiency frontier are the most optimal units and they have a relative performance ratio of 1 (they are 100% efficient). Less performing units like the other units except unit 5 need more inputs to produce the same number of outputs and are therefore situated on some distance of the frontier. In this plot, all the units have unit 5 as the reference set.

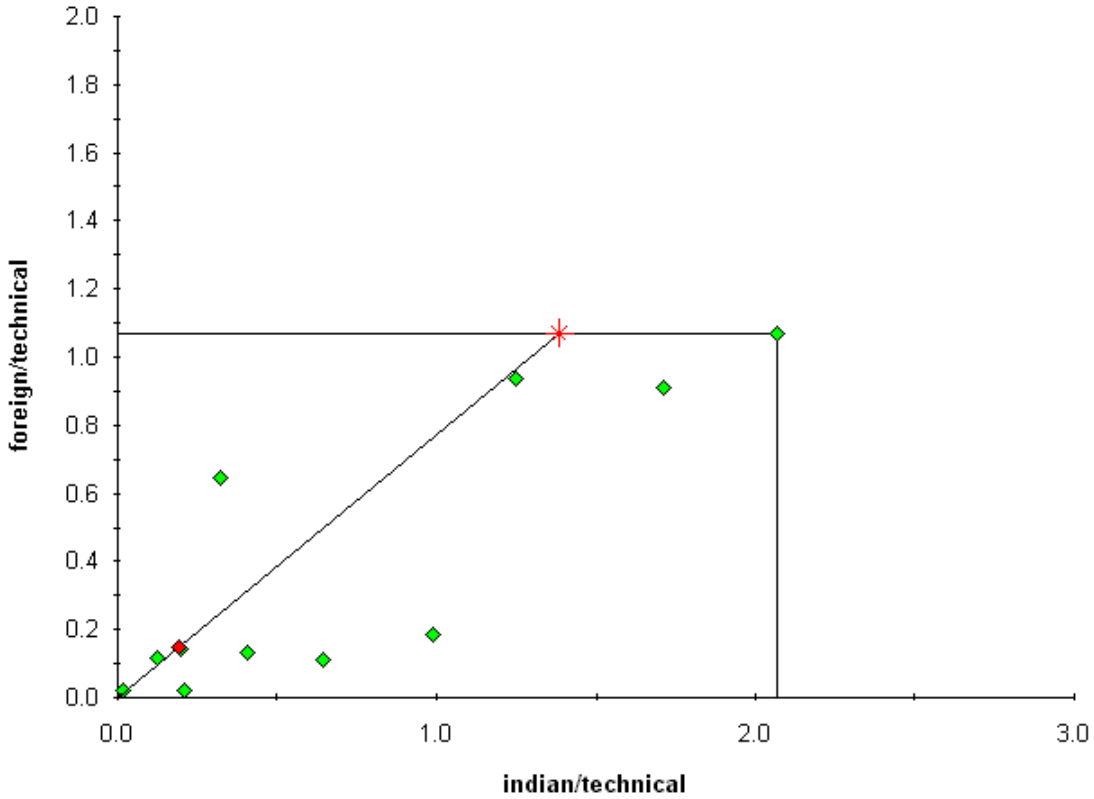


Figure 3: Frontier Envelope (Case 3: Input – Number of Technical Staff; Outputs – Numbers of Indian and Foreign Papers)

To increase the performance of a non-optimal unit, such as unit12, the DEA technique suggests a radial evolution from the source towards the target point on the frontier, which represents what that unit (unit 12) could be achieving. In that way, an optimal performing unit can be achieved for all the inefficient units.

Comparing Figure 1 with Figure 2, it can be observed that if the input indicator is changed the efficiency scores as well as the frontier plot will change. In Figure 1, the input indicator is scientific staff and output indicators are Indian and Foreign papers. But in Figure 2, the input indicator is changed to technical staff whereas the output indicators remain the same as in the earlier figure.

In Figure 1, units 4, 7 and 8 are the efficient units where as in Figure 2, only unit 5 is efficient and forming the efficiency frontier. In Figure 1, the non-optimal units like unit 5, 10 etc. are situated a near the efficiency frontier whereas in Figure 2, only units 4 and 11 are situated near the efficiency frontier and the rest of the units are scattered near the origin. It is comparatively much easier for units which lie close to the frontier to achieve 100% efficiency by targeting improvements in certain selected inputs and outputs as compared to those units which lie far away from the frontier (thus lying nearer to the origin) to achieve the same efficiency level since the target to be achieved is that much more difficult to accomplish.

7) CONCLUSIONS

In the study reported here the methodology of Data Envelopment Analysis (DEA) has been used to analyze and compare the efficiencies of 12 R&D laboratories functioning under the Council of Scientific and Industrial Research (CSIR), India. DEA is a linear programming based technique for measuring the relative performance of organizational units where the presence of multiple inputs and outputs makes comparisons difficult. The input indicators selected for our analysis are the strength of scientific manpower and technical manpower and the output indicators selected are the numbers of Indian papers, foreign papers and patents.

The analysis of the efficiency scores has given us an overall picture of efficiency levels of these 12 research laboratories. Potential improvements of selected R&D laboratories are studied with respect to the reference unit for the analysis. Efficiency Frontier plots with selected inputs and outputs have illustrated this point further by focusing upon the level of efficiency or inefficiency of these units as compared to the reference units lying on the efficiency frontier. This has enabled one to find out the level of effort in terms of inputs and outputs required by a particular unit to achieve a relative efficiency level of 100% from its present state.

The study results have crucial implications for the management of specific CSIR laboratories as well as at the corporate level of CSIR. It is very clear from the results that different CSIR laboratories perform very variedly in terms of the productivity of their scientific and their technical manpower. And the productivity levels of scientific and technical manpower are not exactly in sync. Certain laboratories have fared exceedingly well regarding the relative efficiency of their scientific manpower, some other laboratories have done the same in terms of their technical manpower. So, the management of the laboratories that fare poorly in this DEA analysis have to ponder about these results, think strategically, and attempt to find out the reasons for the poor show, and take corrective steps accordingly in an attempt to reach the efficiency frontier. There is one other issue. For technological innovation to flourish, progress in both scientific research as well as technology development are critical. CSIR, at the corporate level, with the availability of frontier analysis diagrams and the relative efficiency tables that this DEA analysis displays, clearly has a task in hand in providing networking opportunities among the laboratories to augment their respective

potentials and shortfalls so that the organization as a whole could take decisive steps to fulfill its mandated objectives.

8) REFERENCES

Andersen. P. and Petersen, N.C. (1993), A Procedure for Ranking Efficient Units in Data Envelopment Analysis, *Management Science*, Vol. 39 No. 10, pp. 1261-1264.

Banker, R.D., Charnes, A., Cooper, W.W. (1984), Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science*, Vol 30, pp.1078-1092.

Banwet, D.K., Jyoti and Deshmukh, S.G. (2008), Evaluating Performance of National Organizations using Integrated DEA-AHP Technique , *International Journal of Productivity and Performance Management*, Vol. 57 No. 5, pp. 370-388

Bremser, W.G. and Barsky, N.P. (2004), Utilizing the Balanced Scorecard for R&D Performance Measurement, *R&D Management*, Vol. 34 No. 3, pp. 229-37.

Brockett, P.L., Charnes, A., Cooper, W.W., Huang, Z.M. and Sun, D.B. (1997), Data Transformations in DEA Cone Ratio Envelopment Approaches for Monitoring Bank Performances, *European Journal of Operational Research*, Vol 98, pp. 250-268.

Brown, M.G. and Svenson, R.A. (1998), Measuring R&D Productivity, *Research and Technology Management*, Vol. 41 No. 6, pp. 30-5.

Charnes, A., Clark, T., Cooper, W.W., Golany, B. (1985a), A Developmental Study of Data Envelopment Analysis in Measuring the Efficiency of Maintenance Units in the U.S Air Forces, *Annals of Operations Research*, Vol 2, pp. 95-112.

Charnes, A., Cooper, W.W., Lewin, A.Y. and Seiford, L.M. (eds.) (1994), *Data Envelopment Analysis: Theory, Methodology and Applications*, Kluwer Academic Publishers, MA.

Charnes, A., Cooper, W.W., Rhodes, E. (1978), Measuring the Efficiency of Decision Making Units, *European Journal of Operational Research***,** Vol 2, pp. 429-444. Charnes, A., Lewin, A.Y., Morey, R.C., Rousseau, J. (1985b), Sensitivity and Stability Analysis in DEA, *Annals of Operations Research*, Vol 2, pp. 139-156.

Chen, C., Hu, J. and Yang, C. (2011) An International Comparison of R&D Efficiency of Multiple Innovative Outputs: The Role of the National Innovation System, *Innovation Management, Policy and Practice*, Vol. 13 No. 3, pp. 341-360.

Chen, T., Chien, C.F., Wang, J.T. and Lin, M.H. (2004), Using DEA to Evaluate R&D Performance of the Computers and Peripherals Firms in Taiwan, *International Journal of Business*, Vol. 9 No. 3.

Chiesa, V. and Masella, C. (1996), Searching for an Effective Measure of R&D Performance, *Management Decision*, Vol. 34 No. 7, pp. 49-57.

Coccia, M. (2001), A Basic Model for Evaluating R&D Performance: Theory and Application in Italy, *R&D Management*, Vol. 31 No. 4, pp. 453-64.

Coccia, M. (2004), New Models for Measuring the R&D Performance and Identifying the Productivity of Public Research Institutes, *R&D Management*, Vo. 34 No. 3, pp. 267-280.

Coccia, M. (2005) A Scientometric Model for the Assessment of Scientific Research Performance within Public Institutes, *Scientometrics*, Vol 65, pp. 307-321.

Coelli, T.J. (1998), *A Multi-Stage Methodology for the Solution of Oriented DEA Models*, CEPA Working Papers No. 1/98, Department of Econometrics, University of New England, Armidale, NSW 2351, Australia.

Cook, T.J., Vansant, J., Stewart, L. and Adrian, J. (1995), Performance Measurement: Lessons Learned for Development Management, *World Development*, Vol. 23 No. 8, pp. 1303-15.

Fortune, A. and Shelton, L. (2012) R&D Effort, Effectiveness and Firm Performance in the Pharmaceutical Sector, *Journal of Business and Management*, Vol. 18 No. 1, pp. 97-115.

Garg, K.C., Gupta, B.M., Jamal, T., Roy, S. and Kumar, S. (2005) Assessment of Impact of AICTE Funding on R&D and Educational Development, *Scientometrics*, Vol 65 No 2, pp. 151-160.

Goto, A. and Suzuki, K. (1989), R&D Capital, Rate of Return on R&D Investment and Spillover of R&D in Japanese Manufacturing Industries, *The Review of Economics and Statistics*, Vol 71, pp. 555-564.

Gupta, A.K., Bhojwani, H.R., Kaushal, R. and Kaushal, H. (2000), Managing the Process of Market Orientation by Publicly-Funded Laboratories: Case of CSIR, *R&D Management*, Vol 30, pp. 289-296.

Hibiki, N. and Sueyoshi, T. (1999), DEA Sensitivity Analysis by Changing a Reference Set: Regional Contribution to Japanese Industrial Development, *Omega: International Journal of Management Science*, Vol 27, pp. 139-153.

Hu. J. L., Yang, C.H. and Chen, C.P. (2014) R&D Efficiency and the National Innovation System: An International Comparison using the Distance Function Approach, *Bulletin of Economic Research*, Vol. 66, No. 1, pp. 55-71.

Huergo, E. and Moreno, L. (2011) Does History Matter for the Relationship Between R&D, Innovation and Productivity?, *Industrial and Corporate Change*, Vol. 20 No. 5, pp. 1335-1368.

India Vision 2020 (2002), Planning Commission, Government of India, December 2002, available at: http://planningcommission.nic.in/reports/genrep/pl_vsn2020.pdf (accessed on 24th February, 2010).

Jain, R.K. and Triandis, H.C. (1997), *Management of Research and Development Organizations: Managing the Unmanageable*, 2nd ed., John Wiley & Sons, New York, NY.

Johnes, G. and Johnes, J. (1992), Apples and Oranges: The Aggregation Problem in Publications Analysis, *Scientometrics*, Vol 25 No 2, pp. 353-365.

Johnes, G. and Johnes, J. (1993), Measuring the Research Performance of UK Economics Departments: An Application of Data Envelopment Analysis, *Oxford Economic Papers*, Vol 45, pp. 332-347.3

Kim, B. and Oh, H. (2002), An Effective R&D Performance Measurement System: Survey of Korean R&D Researchers, *Omega: International Journal of Management Science*, Vol. 30, pp. 19-31.

Kothari, S.P., Laguerre, T.E. and Leone, A.J. (2002) Capitalization versus Expensing: Evidence on the Uncertainty of Future Earnings from Capital Expenditure versus R&D Outlays, *Review of Accounting Studies*, Vol. 7, pp. 355-382.

Lee, H., Kim, M.S., Yee, S.R. and Choe, K. (2011) R&D Performance Monitoring, Evaluation and Management System: A Model and Methods, *International Journal of Innovation and Technology Management*, Vol. 8 No. 2, pp. 295-313.

Lee, H., Lee, C., Seol, H. and Park, Y. (2008) On the R&D Priority Setting in Technology Foresight: A DEA and AHP Approach, *International Journal of Innovation and Technology Management*, Vol. 5 No. 2, pp. 201-220.

Lee, H.Y and Park, Y.T (2005) An International Comparison of R&D Efficiency: DEA Approach, *Asian Journal of Technology Innovation*, Vol. 13 No. 2, pp. 207-222.

Lee, H.Y., Park, Y.T. and Choi, H. (2009) Comparative Evaluation of Performance of National R&D Programs with Heterogeneous Objectives: A DEA Approach, *European Journal of Operational Research*, Vol. 196 No. 3, pp. 847-855.

Loch, C.H. and Tapper, U.A.S. (2001), Implementing a Strategy-Driven Performance Measurement System for an Applied Research Group, *The Journal of Product Innovation Management*, Vol. 19, pp. 185-98.

Lozano, S. and Salmeron, J.L. (2005), Data Envelopment Analysis of OR/MS Journals, *Scientometrics*, Vol 64, pp. 133-150.

Mahmood, M.A., Pettingell, K.J. and Shaskevich, A.I. (1996), Measuring Productivity of Software Projects: A Data Envelopment Analysis Approach, *Decision Sciences*, Vol 27 No 1, pp. 57-77.

Matsumoto, M., Yokota, S., Naito, K. and Itoh, J. (2010) Development of a Model to Measure the Economic Impacts of R&D Outputs of Public Research Institutes, *R&D Management*, Vol. 40 No. 1, pp. 91-100.

Pandit, S., Wasley, C.E. and Zach, T. (2011) The Effect of Research and Development Input and Output on the Relation between the Uncertainty of Future R&D Performance and R&D Expenditures, *Journal of Accounting, Auditing and Finance*, Vol. 26 No. 1, pp. 121-144.

Rama Mohan, S. (2005), Benchmarking Evaluation of Performance of Public Research Institutes using Data Envelopment Analysis (2005), *Journal of Scientific and Industrial Research*, Vol 64, pp. 403-410.

Reichmann, G. (2004), Measuring University Library Efficiency using Data Envelopment Analysis, *Libri*, Vol 54, pp. 136-146.

Rousseau, S. and Rousseau, R. (1997), Data Envelopment Analysis as a Tool for Constructing Scientometric Indicators, *Scientometrics*, Vol 40, pp.45-56.

Rousseau, S. and Rousseau, R. (1998), The Scientific Wealth of European Nations: Taking Effectiveness into Account, *Scientometrics*, Vol 42, pp.75-87.

Roy, S. (2004) Technology Transfer from National R&D Laboratories and the Development of Regional Industrial Clusters in India, *Industry and Higher Education*, Vol. 18 No. 1, pp. 39-45.

Roy, S. (2006) Networking as a Strategy for Technology Transfer and Commercialization from R&D Laboratories, *Industry and Higher Education*, Vol. 20 No. 2, pp. 123-133.

Roy, S. (2009) Technology Transfer from R&D Centres in India and Development of Industrial Clusters, in Manimala, M.J., Mitra, J. and Singh, V. (eds.), *Enterprise Support Systems: An International Perspective*, ISBN: 978-81-7829-927-3, Sage, New Delhi, pp. 217-227.

Roy, S. and Banerjee, P. (2007) Developing Regional Clusters in India: The Role of National Laboratories, *International Journal of Technology Management and Sustainable Development*, Vol. 6 No. 3, pp. 193-210.

Roy, S. and Mohapatra, P. K. J. (2002) Regional Specialisation for Technological Innovation in R&D Laboratories: A Strategic Perspective, *Artificial Intelligence and Society*, Vol. 16, pp. 100-111.

Roy, S., Gupta, B.M. and Kumar S. (2007), Exploring Scientific Productivity and the Impact of Age, Research Area and Rank: Case of CSIR, India, *Journal of Information Management and Scientometrics*, Vol 3 No 1, pp. 16-26.

Roy, S., Jain, A. and Mohapatra, P.K.J. (2001) Forecasting and Simulation of Scientific Manpower under Various Policy Regimes: Case Study of an R&D Laboratory in India, *Manpower Journal*, Vol. XXXVII No. 1, pp. 23-45.

Roy, S., Nagpaul, P.S. and Mohapatra, K.J. (2003), Developing a Model to Measure the Effectiveness of Research Units, *International Journal of Operations & Production Management*, Vol 23 No. 12, pp. 1514-29.

Roy, S., Nagpaul, P.S. and Mohapatra, P.K.J. (2003) Developing a Model to Measure the Effectiveness of Research Units, *International Journal of Operations & Production Management*, Vol. 23 No. 12, pp. 1514-1531.

Seiford, L. M. and Zhu, J. (1999), An Investigation of Returns to Scale in Data Envelopment Analysis, *Omega, International Journal of Management Science*, Vol 27, pp. 1-11.

Sengupta, J.K. (1995), *Dynamics of Data Envelopment Analysis: Theory of Systems Efficiency*, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Sharma, S. and Thomas, V.J. (2008), Inter-Country R&D Efficiency Analysis: An Application of Data Envelopment Analysis, *Scientometrics*, Vol 76, pp. 483-501.

Sueyoshi, T. (1999), DEA Non-Parametric Ranking Test and Index Measurement: Slack-Adjusted DEA and an Application to Japanese Agriculture Cooperatives, *Omega: International Journal of Management Science*, Vol 27, pp. 315-326.

Tassey, G. (2009), Methods for Assessing the Economic Impacts of Government R&D, *http://www.nist.gov./director/prog-ofc/report03-1.pdf*.

Tikoria, J., Banwet, D.K. and Deshmukh, S.G. (2009), Performance Measurement of National R&D Organisations using Analytic Hierarchy Process: A Case of India, *International Journal of Innovation and Regional Development*, Vol 1, No 3, pp. 276-300.

Wang, C. H., Lu, Y.H., Huang, C.W. and Lee, J.Y. (2013) R&D, Productivity and Market Value: An Empirical Study from High Technology Firms, *Omega*, Vol. 41, No. 1, pp. 143-155.

Wang, E.C. and Huang, W.C. (2007) Relative Efficiency of R&D Activities: A Cross-Country Study Accounting for Environmental Factors in the DEA Approach, *Research Policy*, Vol. 36 No. 2, pp. 260-273.

Wang, K., Wang, C.K. and Hu, C. (2005), Analytic Hierarchy Process with Fuzzy Scoring in Evaluating Multidisciplinary R&D Projects in China, *IEEE Transactions on Engineering Management*, Vol 52 No. 1, pp. 119-29.

Werner, B.M. and Souder, W.E. (1997) Measuring R&D Performance: State of the Art, *Research Technology Management*, Vol. 40 No. 2, pp. 34-41.

Reflecting the Effectiveness of Training on Knowledge Workers through Intellectual Capital

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ABSTRACT

The assessment and evaluation of knowledge workers are often difficult and post serious challenges to a company. The study aims to examine the possibility of using the term intellectual capital or IC as a surrogate to reflect training and skill development programs' effectiveness. This study takes place at the tooling department of the global electronics firm operating in Thailand. Specifically, the study focuses on the perceived benefits from intensive and comprehensive training programs by technicians and line engineers who are considered as knowledge workers. Based on the feedback from 30 surveys completed, it appears that the study's participants positively perceive the benefits and view them as part of their contributions to the company's performance. The reason is that the IC level has increased from 2011 to 2012 or from 3.7838 to 4.0357 respectively. This increase is verified by the decline in the % downtime from 17.5989% in 2011 to 13.5987% in 2012. The following analysis and discussion apparently show the potential use of the IC as a proxy to determine the training programs' effectiveness for knowledge workers. Finally, the future study should try to relate the IC level with motivation, knowledge, and individual and company's performance.

Keywords: human capital, intellectual capital, productivity, and training.

1) INTRODUCTION

Training and skill development program are essential in improving human resources and continuous performance improvement in a company (Fasil and Osada, 2011). Given the emerging of intangible assets in which workers and staffs play a prominent role in a firm's value creation, the attention on improving and sustaining the capability of human capital is inevitable (Wiboonchutikula, 2001; and Hoehn, 2003). In many countries, as the economy has gone through different developmental stages and has transformed from agriculture to manufacturing, manufacturing to service, and service to innovation and creativity; human capital is now considered as a strategic risk for leading firms and companies (Dobni, 2011; and Ropret *et. al*., 2012). In fact, human capital risk is viewed as the most importance in several international reports[4].

Traditionally, training and skill development programs aim to have the immediate aim which is to raise the level of skills and knowledge for task completion (Thomas and Baron, 1994; Marr and Schiuma, 2001; and Manasserian, 2005). The impacts primarily cover quality (e.g., defects and rework) and productivity (e.g., time and waste). Moreover, the training often focuses on accident preventions and awareness on safety regulations. The focus has also included team building and synergy creation among wage earners. The evaluation of training effectiveness is on the on-time completion, the budgets spent, and workers' satisfaction with the contents and the programs. The follow-up assessment is likely to be limited without comprehensive verification whether the improvements in operations and productions are actually resulted from training and skill development programs initiated earlier (Jones and Schilling, 2000). The reason is that blue-collar workers do not have long employment and are often rotated among different tasks (due to the routine and repetitive natures of work). Given the emerging trend of human capital, this assessment practice appears to be insufficient.

Although the assessment is still achievable for blue-collar workers, the impacts on knowledge workers can be ambiguous. In general, there is the recognition of the need to gain better understanding on the impacts that knowledge workers feel from training and skill development program (Elbanna and Naguib, 2009; and Cheng *et. al*., 2010). This need should be considered in parallel with the assessment of new skills and expertise gained. The US Bureau of Labor Statistics (*www.bls.gov*) has shown that the proportion of white-collar and knowledge workers has continued to increase dramatically during the past few decades. By early 1990s, they represent approximately more than 60 percent of the entire workforce in the U.S and other developed countries such as European nations and Japan. As a result, the preparation on knowledge workers' training and skill development program has become more prevalent (Ramirez and Nembhard, 2004).

Knowledge workers perform a task that is usually non-repetitive (Thomas and Baron, 1994). Their work output is often difficult to quantify or measure directly. The task

[4]The Report on the Accenture 2011: Global Risk Management Study and The 2007 Risk of Risks Report published by the Economist Intelligence Unit of the Economist

completion can be achieved by various methods (or there is no best way to perform knowledge work) and requires excellent problem-solving, technical, and unique skills which essentially cover observation, learning, and trouble shooting. It is important to note that the knowledge work task most likely takes longer than that of blue-collar work and often relies groups or teams. By and large, most knowledge workers perform best in connection with others inside and outside a company. The connection includes the interactions among peer groups, customers, suppliers, and regulators. Finally, the training programs need to provide both short- and long-term skills to knowledge workers. These skills deal with the tasks requirements as well as other social skills such as communication and teamwork.

1.1) Problem statement

A lack of clear understanding on the impacts of training and skill development programs on knowledge workers can potentially result in poor planning and preparation. The awareness of how knowledge workers perceive the benefits from training, especially within the context of productivity can potentially improve how the skill development programs are planned, communicated, explained, and delivered. The scope of this study focuses on a large manufacturing firm in Thailand. This firm is considered to be global with high market share and strong foothold in the electronics industry (as having the highest market share in the hard disk business). The framework to be applied in order to capture the workers' perception relates to the term intellectual capital or IC. This term represents an organization's knowledge assets which directly and indirectly contribute to its value generation (Pulic, 2004). See Figure 1.

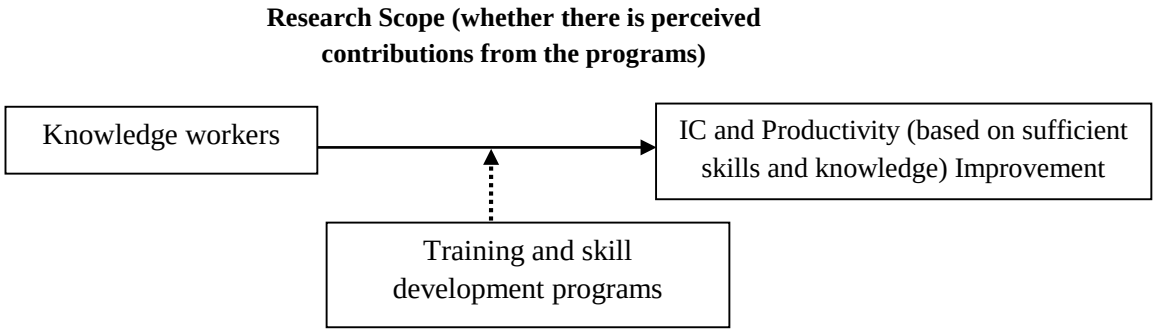

Figure 1: Research scope

According to Edvinsson and Sullivan (1996) and Yound *et al*. (2004), there are many purposes of the IC usages: (1) use of workers' experiences for productivity and quality improvement as well as customer services, and (2) use of knowledge for continuous business improvement. Traditionally, the IC value is primarily derived from the workers (e.g., experiences, expertise, skills, learning, and motivation) and other resources (e.g., computer, and information and communication technology).

Knowledge workers need to be able to conceptualize the perceived benefits and impacts from training on knowledge workers (Dobni, 2011; and Czop and Leszczynska, 2011). The understanding on the impacts on the IC should help

underline the importance of training program preparation. This preparation need to consider the short- and long-term goals of a proposed program and the communication of anticipated impacts on a company's operations to the targeted knowledge workers or staffs. It is important that knowledge workers understand the benefits from training and skill development programs. This understanding should help them visualize or perceive their contributions to enterprise development. Without clear understanding, the effectiveness of training and skill development programs may not be achieved. In other words, the term IC is used to indicate (and reflect) the effectiveness of training and skill development programs (Pulic, 2004; and Schiuma and Lerro, 2008).

1.2) Objectives

The primary aims of this study are to gain the insights into how the knowledge workers perceive the benefits from training and skill development programs and to further examine the possibility of using the term IC to reflect the effectiveness of these ongoing programs. The benefits from this study can be as follows. The first benefit is: (1) to strengthen how training and skill development programs for knowledge workers is assessed and evaluated in order to improve future planning and preparation, and (2) to examine the potential applications of the IC within the context of creative and innovative economy.

2) METHODOLOGY

The research is considered as a case study. The experiment deals with the training to skilled technicians and line engineers who have to deal with machinery problems and breakdowns. Constant trainings and skill development programs have been provided due to the impacts of machines' downtime on cost and productivity. They are considered knowledge workers since they have to deal with the circumstances relating to scheduled and unscheduled maintenance. They are skillful and cannot be easily replaced with comprehensive orientation and training. The questionnaire is to be developed to assess knowledge workers. This questionnaire is based on the IC concept. The high IC value, based on their perception, indicates the positive impacts from training and skill development programs. This questionnaire is to be distributed to the technicians and line engineers who have participated in the training and skill development program of the company under study's tooling department. The questions focus on their viewpoints during 2011- 2012. Then, the statistical analysis is to be applied to help assess and evaluate their responses. This analysis will focus on their perceived benefits from training and skill development programs. These benefits are associated with the IC which also underlines the importance of human capital.

3) RESULTS

The first step is to gather the information on the circumstance relating to the company's tooling department and the importance of technicians and line engineers to the company's operations and performance, especially productivity. The primary role of technicians and line engineers is to ensure the downtime meets the company's policy (which was formally launched in the 2009 fiscal year). This policy can be illustrated as follows. See Figure 2.

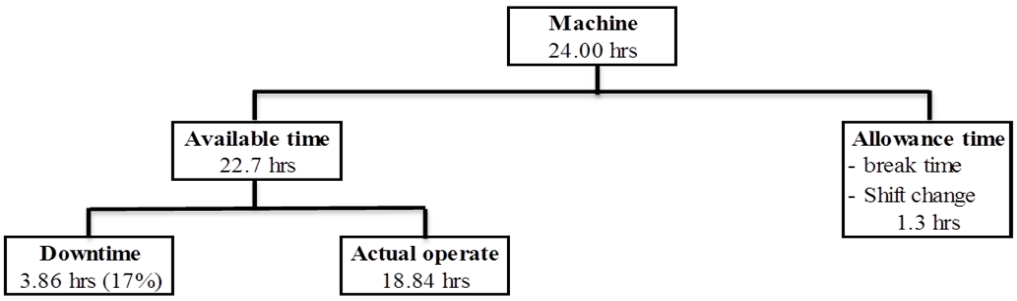

Figure 2: Policy Guideline for Technicians and Line Engineers on Downtime

On the contrary, the actual downtime has exceeded the minimum requirement and has resulted in the productivity level. This prompted the company's management to initiate intensive and comprehensive training programs in cooperation with suppliers and contractors. These training programs have focused on both technical and non-technical skills (e.g., basic quality tools such as the fishbone diagram and the histogram, reporting, and communication). The information from the downtime can be partially demonstrated as follows. See Table 1.

Due to the nature of the production systems and processes, the 17% has to be strictly complied. Production losses not only impacts on the output requirement but also results in the penalty that the company has to pay for late shipments to its clients. In addition, the company's headquarter (located in the U.S.) has instructed the downtime to be lower from the current target of 17% to 10% within four years (to be achieved by 2015). Subsequently, the intensive training and skill development programs have been prepared and deployed since 2010. Some of the program subjects can be illustrated as follows.

Training Subjects:

- Total Productive Maintenance
- Statistical Process Control
- Data Analysis
- Failure Mode and Effect Analysis
- Laser
- Jig & Fixture
- Robotics
- Motor

- Automation
- Sensor and Actuator
- Pneumatics
- Micro Controller
- Machine Vision
- Signal Processing
- Measurement System Analysis
- Basic Statistics
- Geometric Dimensional & Tolerance
- Quality Tools
- Reporting and Presentation
- Trouble Shooting and Problem Solving

Then, the questionnaire is developed and later distributed to a group of technicians and line engineers who are responsible for tool repairs and maintenance within the entire company's operations. Altogether 30 surveys are returned which represents more than 70% of the workforce. The survey's contents have been derived from the key elements mentioned earlier by Edvinsson and Sullivan (1996), Yound *et al*. (2004), and Cheng et al., (2010). The survey results can be illustrated as follows. See Table 2. Also see Table 3 for the overall IC results from 2011 to 2012. For the individual results, see Table 4.

It is important to note that the human capital component shows the highest increase from 2011 to 2012 relatively to the remaining three IC components. The ability to use and apply computer programs to perform required tasks has consistently received the highest level of agreement. Based on the statistical analysis, the overall increase in the IC level is significant. Note that this study uses the IC as a surrogate or a proxy to assess the perceived benefits from training and skill development programs. If the IC has increased, it should indicate that knowledge workers view these programs to be beneficial. Consequently, this increase is interpreted as a firm achieving effective training and skill development program.

Table 1: Partial Illustration of the % Downtime (Target of 17%)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18.35	17.50	16.78	17.48	17.79	18.57	17.51	18.25	16.71
2	18.44	17.75	17.30	17.71	17.35	18.66	16.63	18.10	18.50
3	16.85	16.90	18.17	17.09	18.94	17.47	16.10	18.61	18.14
4	16.06	17.87	17.18	16.77	16.98	18.07	16.15	18.91	18.95
5	17.76	17.39	18.52	16.52	16.81	17.67	18.62	17.32	18.28
6	16.85	16.99	18.26	16.22	17.82	17.43	17.16	16.42	17.22
7	18.91	18.17	18.34	18.63	16.18	18.44	18.32	17.10	16.52
8	17.83	18.47	17.16	18.98	18.01	16.88	17.01	16.10	18.36
9	18.79	17.66	17.21	18.57	16.89	16.12	18.92	18.73	18.95
10	17.10	17.60	17.21	18.99	18.44	18.41	16.16	17.01	18.85
11	18.94	16.14	18.94	16.01	17.46	16.69	18.37	18.99	16.19
12	17.87	18.89	18.70	18.38	17.23	16.11	17.17	17.28	17.51
13	17.69	17.56	18.19	16.02	17.41	16.14	17.46	18.61	18.94
14	17.20	17.03	17.45	17.82	17.71	18.68	18.24	18.89	17.78
15	16.38	16.18	19.00	16.59	17.71	16.72	18.07	16.25	18.82
16	17.92	17.62	18.81	17.70	18.40	17.18	16.33	16.33	16.83
17	17.24	17.80	18.90	17.34	17.85	17.02	17.60	16.46	18.53
18	17.28	16.94	18.42	18.46	16.24	18.45	18.68	18.44	18.77
19	16.46	18.53	17.64	17.79	18.21	18.69	16.85	16.56	16.96
20	18.45	16.20	17.99	16.68	16.19	18.17	17.30	16.24	18.77
21	16.74	17.64	18.43	16.27	17.14	18.40	16.17	18.95	17.66
22	18.96	16.05	17.21	18.93	18.11	18.37	17.44	16.05	18.15
23	18.68	16.49	16.93	17.69	17.51	17.56	17.04	18.86	18.12
24	17.30	16.28	17.16	17.30	17.40	18.52	16.81	18.78	17.46
25	16.01	17.74	17.03	17.39	17.00	18.50	16.31	18.37	18.52
26	17.78	18.23	18.59	16.07	17.89	16.33	18.18	17.92	18.89
27	17.48	16.70	17.91	16.71	17.33	17.07	17.61	16.12	18.16
28	18.14	16.79	16.91	17.94	17.41	17.94	17.87	17.34	18.64
29	18.30	N/A	18.54	18.28	16.91	18.20	18.63	17.48	16.18
30	16.60	N/A	16.03	17.60	18.28	18.80	17.15	16.07	16.90
31	17.83	N/A	18.54	N/A	18.89	N/A	16.03	18.78	N/A
Avg.	17.62	17.33	17.85	17.46	17.53	17.71	17.35	17.59	17.94

Note: N/A indicating plant shutdowns and no operational use productivity, training, of machinery.

Table 2: Results from the Survey

IC	2012		2011	
	Mean N = 30	Standard Deviation N = 30	Mean N = 30	Standard Deviation N = 30
Human Capital				
1. You have the ability to solve technical and customer-related problems.	4.03	0.77	3.40	0.81
2. Your talents and capability have increased from last year.	3.97	0.81	3.30	0.88
3. Your organization is able to attract external assistance when needed.	4.03	1.03	3.97	0.76
4. I can use basic computer programs to perform required tasks such as statistical analysis and information reports.	4.90	0.31	4.43	0.63
5. Your organization offers useful training courses and subjects.	4.50	0.68	4.07	0.91
6. You are satisfied about the knowledge and capability gained on the annual basis.	3.80	0.81	3.63	0.93
7. You are more dedicated and committed to an organization.	3.77	0.94	3.33	0.88
Overall Human Capital Level	**4.14**	**-**	**3.73**	**-**

Table 2: (Continued)

IC	2012		2011	
	Mean N = 30	Standard Deviation N = 30	Mean N = 30	Standard Deviation N = 30
Innovation Capital				
1. Your organization always invests in new ideas and suggestions.	4.13	0.68	3.87	0.94
2. Your organization always looks to build strong teams for new idea generations.	4.10	0.61	3.77	0.82
3. Your organization always introduces new process improvement.	3.90	0.71	3.73	1.08
4. Your organization always pays attention to what others are doing in production processes.	3.77	0.57	3.30	0.95
Overall Innovation Capital Level	**3.98**	-	**3.67**	-
Process Capital				
1. Your organization has effective document control systems.	4.03	0.89	3.83	0.79
2. Your organization often communicates useful information and knowledge to all.	3.97	0.62	4.03	0.56
3. Your organization constantly monitors productivity and quality.	4.30	0.70	3.80	0.933
4. Your organization has essentially all production processes under control.	3.93	0.87	3.70	0.88
Overall Process Capital Level	**4.06**	-	**3.84**	-
Customer Capital				
1. Customers are generally satisfied with your products/services/ process management.	4.00	0.69	3.80	0.81
2. Sales have increased as well as the prospective customers' interests.	3.97	0.67	3.97	0.62
3. Serious complaints have become less common, especially dealing with the on-time delivery.	3.87	0.57	3.80	0.81
4. Market outlook is improving.	3.83	0.75	3.93	0.87
5. Existing customers always repeat their orders.	4.12	0.59	3.97	0.85
Overall Customer Capital Level	**3.97**	-	**3.89**	-

Note: the Scale is 1 to 5.

Table 3: Comparison of Overall IC Levels

IC Components	Year 2012	Year 2011	Improvement (based on 2011)
Human capital	4.14	3.73	11%
Innovation capital	3.98	3.67	8%
Process capital	4.06	3.84	6%
Customer capital	3.97	3.89	2%
Overall IC*	**4.0357**	**3.7838**	**7%**

Note: The equal weight is assigned to each of the four IC components.

Based on the two sample t-test, it indicates that the IC level from 2012 has increased from the 2011 level at the 95% confidence (P-value < 0.05). The overall findings show that the IC level has improved. Due to the use of the IC as a surrogate, this improvement helps underline the perceived benefits from training and skill development programs initiated since 2010.

Table 4: IC Levels from Individuals (Reflecting the Perceived Benefits)

Technician/ Line Engineer	Overall IC Level	
	2012	2011
1	3.65	3.50
2	3.95	4.45
3	4.10	4.45
4	4.55	4.55
5	3.95	3.80
6	3.70	3.35
7	4.80	4.85
8	3.60	4.30
9	1.95	4.30
10	3.55	4.40
11	4.40	4.35
12	4.25	4.00
13	3.65	4.05
14	3.10	3.10
15	4.10	3.50
16	3.60	3.85
17	3.95	4.40
18	3.95	3.80
19	3.70	3.35
20	4.80	4.85
21	3.60	4.30
22	1.95	4.30
23	3.55	4.40
24	4.40	4.35
25	4.25	4.00
26	3.65	4.05

Table 4: (Continued)

Technician/ Line Engineer	Overall IC Level	
	2012	2011
27	3.10	3.10
28	4.10	3.50
29	3.60	3.85
30	3.95	4.40

The study uses the actual downtime level (in %) to verify that the perceived benefits viewed by technicians and line engineers are genuine. The statistical results show that the % downtime has decreased significantly from 2011 to 2012 at the 95% confident level (the p-value level < 0.05) as shown in Table 5. In other words, the overall findings show that the perceived benefits from training and skill development programs have increased (reflected by the increase in the IC level from 3.7838 to 4.0357. This increase is supported by comparing the actual % downtime (which has declined from). This comparison excludes periodic partial plant shutdowns normally taking during October to December each year.

Table 5: % Downtime from 2011 to 2012

Month	% Downtime	
	2012	2011
January	13.5919	17.6193
February	13.4940	17.3257
March	13.5268	17.8540
April	13.6418	17.4643
May	13.6197	17.5317
June	13.6852	17.7083
July	13.4838	17.3521
August	13.4874	17.5917
September	13.8578	17.9429
Average % Downtime	**13.5987**	**17.5989**

4) DISCUSSION

The findings show that the IC increases (in accordance to the survey's results from 30 technicians and line engineers). This increase reflects the perceived benefits from training and skill development programs viewed by the survey participants. In other words, the study uses the IC as a surrogate or a proxy to measure the impacts on individuals' ability to perform the required tasks. Despite this increase, the IC level needs to be verified. Therefore, the actual % downtime during the full-production period is gathered and summarized. It shows the significant decline in the % downtime which is consistent with the perceived benefits that the company's technicians and line engineers view. Note that, for the data collection timeframe, the IC data is collected on October 2011 after the training and skill development program

which took place in September. The same timeframe is also used for the 2012 data collection. This is the reason, for the % downtime, the data is collected for the period from January to September.

The following analysis and discussion further illustrate that training and skill development programs have been carefully planned. The success deployment is credited to the clarity of the programs' goals, contents, expectation, and contributions to the downtown reduction. In addition, the use of IC to evaluate the effectiveness of training and skill development programs is also brought up managerial support. The reason is that the assessment on program effectiveness has been a pending issue to be resolved due to the difference between blue-collar (i.e., production) and knowledge workers. The use of the IC apparently provides excellent feedback that emulates how training and skill development programs are perceived. This underlines the sound managerial implications as there is a need to ensure that the budget spent on training and skill development would be worthwhile.

Finally, the IC also presents potential opportunity in which new efforts to assess the motivation, performance (including productivity), and long-term knowledge to meet task requirements can be formulated. Despite the study' shortcomings of focusing only one company, the potential to examine the issue further becomes more prevalent. This is important since there is a perception that knowledge worker's contributions to the company are not completely immeasurable and their performance information is not useful. Therefore, future IC studies should connect human capital, knowledge and motivation, training, and skill development programs, and performance.

5) CONCLUSION

The primary aims of this study are to gain the insights into how the knowledge workers perceive the benefits from training and skill development programs and to further examine the possibility of using the term IC as a surrogate to reflect these programs' effectiveness. This study takes place at the tooling department of the global electronics firm in Thailand. The focus is on the perceived benefits from training and skill development programs by technicians and line engineers who are considered as knowledge workers. Based on the feedback from 30 surveys completed, it appears that the study's participants positively perceive the benefits and view them as part of their contributions to the company's performance. The reason is that the IC level has increased from 2011 to 2012. This increase is verified by the decline in the % downtime. The following analysis apparently shows the potential use of the IC as a proxy to determine the training programs' effectiveness.

6) REFERENCES

6.1) References

Cheng, S, Lin, J., Hsiao, T., Lin, T. (2010) "Invested resource, competitive intellectual capital, and corporate performance", *Journal of Intellectual Capital*, Vol. 11, No. 4, pp.433 - 450

Czop, K., and Leszczynska, A. (2011) "Entrepreneurship and innovativeness: in search of the interrelationships" *International Journal of Innovation and Learning*, Vol. 10, No. 2, pp. 156-175

Dobni, C. (2011) "The relationship between innovation orientation and organisational performance", *International Journal of Innovation and Learning*, Vol. 10, No. 3, pp. 226- 240

Elbanna, S. and Naguib, R. (2009) How much does performance matter in strategic decision making? *International Journal of Productivity and Performance Management***,** Vol. 58, No. 5, pp. 437- 459

Edvinsson, L. and Sullivan, P. (1996), "Developing a model for managing intellectual capital", *European Management Journal*, Vol. 14 No. 4, pp. 356-64

Fasil, T. and Osada, H. (2011) "Multiple dimensions of TQM success in developing countries: an empirical study on Deming Prize winners from India and Thailand", *International Journal of Innovation and Learning*, Vol. 9, No. 2, pp. 184-203

Hoehn, W. (2003), "Managing organizational performance: linking the balanced scorecard to a process improvement technique", *Proceedings of the 4th Annual International Symposium in Industrial Engineering on the Performance-based Management*, Kasetsart University, Bangkok, pp. 1-12

Jones, S. and Schilling, D. (2000), *Measuring Team Performance: A Step-By-Step, Customizable Approach for Managers, Facilitators, and Team Leaders*, Jossey-Bass, New York, NY

Manasserian, T. (2005), "New realities in global markets and Thailand's economy today", available at: http://webh01.ua.ac.be/cas/PDF/CAS48.pdf (as of April 2007)

Marr, B. and Schiuma, G. (2001), *Measuring and managing intellectual capital and knowledge assets in new economy organizations*, Handbook of Performance Measurement, Gee Publisher, London: UK

Pulic, A. (2004), “Intellectual capital – does it create or destroy value?”, *Measuring Business Excellence*, Vol. 8 No. 1, pp. 62-68

Ramirez, Y. and Nembhard, A. (2004), “Measuring knowledge worker productivity: a taxonomy”, *Journal of Intellectual Capital*, Vol. 5 No. 4, pp. 602-28

Ropret, M., Fatur, P., Rodman, K., and Likar, B. (2012) “Factors of successful innovation in services and a performance comparison with manufacturing sector,”*International Journal of Innovation and Learning*, Vol. 12, No. 4, pp. 379- 401

Schiuma, G. and Lerro, A. (2008) “Intellectual capital and company’s performance improvement”, *Measuring Business Excellence*, Vol. 12, No. 2, pp. 3-9

Thomas, B. and Baron, J. (1994), “*Evaluating knowledge worker productivity: literature review*”, USACERL Interim Report

Wiboonchutikula, P. (2001) *Small and Medium Enterprises in Thailand: Recent Trends Report* published by the International Bank for Reconstruction and Development, the World Bank, Washington D.C., USA

Yound, M., Subramaniam, M. and Snell, S. (2004) “Intellectual capital profiles: an examination of investments and returns”, *Journal of Management Studies*, Vol. 41, No. 3, pp. 335-61

6.2) Appendices

Appendix A: Reliability Test Result for the Survey

IC	Cronbach's Alpha
Human Capital	
1. You have the ability to solve technical and customer-related problems.	0.8252
2. Your talents and capability have increased from last year.	0.8426
3. Your organization is able to attract external assistance when needed.	0.8182
4. I can use basic computer programs to perform required tasks such as statistical analysis and information reports.	0.8406
5. Your organization offers useful training courses and subjects.	0.8309
6. You are satisfied about the knowledge and capability gained on the annual basis.	0.8268
7. You are more dedicated and committed to an organization.	0.8253
Innovation Capital	
1. Your organization always invests in new ideas and suggestions.	0.8449
2. Your organization always looks to build strong teams for new idea generations.	0.8407
3. Your organization always introduces new process improvement.	0.8240
4. Your organization always pays attention to what others are doing in production processes.	0.8234
Process Capital	
1. Your organization has effective document control systems.	0.8406
2. Your organization often communicates useful information and knowledge to all.	0.8294
3. Your organization constantly monitors productivity and quality.	0.8341
4. Your organization has essentially all production processes under control.	0.8287
Customer Capital	
1. Customers are generally satisfied with your products/services/ process management.	0.8238
2. Sales have increased as well as the prospective customers' interests.	0.8179
3. Serious complaints have become less common, especially dealing with the on-time delivery.	0.8235
4. Market outlook is improving.	0.8266
5. Existing customers always repeat their orders.	0.8240

Note: Cronbach's Alpha = 0.8370

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