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AN INVESTIGATION OF HAYES AND WHEELWRIGHT'S PRACTICES: EMPIRICAL EVIDENCE FROM THE INDONESIA'S OIL AND GAS INDUSTRY

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Abstract

The research extracts sixty seven Hayes and Wheelwright's practices from the Hayes and Wheelwright's six principles. These items formed the basis of a questionnaire sent to over 2800 managers at the SBUs level in the Indonesia's oil and gas companies. The empirical result indicates that All Hayes and Wheelwright's six principles collectively have positive impact on an overall construct that may be termed world-class company (WCC). Result also points out that Hayes and Wheelwright's six principles can be reduced into four meaningful factors) of world-class company—as operations strategies—for the Indonesia's oil and gas industry— Workforce skills and capabilities, Management technical competence, Competing through quality, and Workforce participation. These meaningful factors of WCC were shown to be reliable and valid, and offer new insights into the understanding of operations strategy implementation in an oil and gas industry.

Based on the oil and gas managers (the SBU level), operations strategies (four meaningful factors of WCC) can be viewed as the effective use of production and operations capability and technology for achieving business and corporate goals. Operations strategy, therefore, is to help a company's operations organization define the common ground where it can play a proactive and collaborative role with other company functions or cross-functional relationships (Hayes et al., 1996).

Oil and gas managers in Indonesia can use these meaningful factors in concert with other critical quality management practices to help them in there word-class company initiatives. Researchers can also use these factors to build structural model linking such factors to various organizational performance measures (i.e., Critical Success Factors of TQM, Operational Excellence, Six Sigma Quality Management, and Good Corporate Governance).

Keywords: *Hayes and wheelwright's six principles, Hayes and Wheelwright practices, World-Class Company.*

INTRODUCTION

Basu and Wright (1996) stated that in entering the global market environment, manufacturers must compete against world-class companies. It only follows that a manufacturer's ability to compete, and survive, will depend on its ability to create a consistent standard of excellence which transcends global boundaries or to achieve world-class performance in operations (Thorne and Machrey, 2000). To meet this need, a manufacture should develop an internal benchmarking approach that enable as a company to self-appraise against establish world-class manufacturing standards. It is called world-class company solution. World-class company solution is a systematic process of measuring all aspect of a manufacturing business through six pillars of world-class company solution (marketing and innovation, supply chain management, environment and safety, manufacturing facilities, procedures, and people).

The term "world-class manufacturing" was first used by Hayes and Wheelwright (1984) to describe organizations which achieved global competitive advantage through use of their manufacturing capabilities as a strategic weapon (Flynn *et al*., 1997). The concept of world-class manufacturing has been embraced, expanded and enhanced by a number of authors, who have reinforce some of Hayes and Wheelwright's ideas, added some new practices and ignored others (Flynn *et al*., 1999)

Hayes and Wheelwright developed their concept of world-class manufacturing based on in depth analysis of the practices implemented by Japanese and German firms, as well as U.S. firm, which had competed equally with the Japanese and German firms. The term "world-class manufacturing" was used because these firms were associated with outstanding performance in their global industries, resulting in their being described as "world-class". Hayes and Wheelwright found that there were many commonalities between these highly successful firms, arguing that the key to building competitive strength is related to six world-class manufacturing practices, summarized in Table 1 (Flynn *et al*., 1999).

This study developed the concept of world-class manufacturing (Hayes and Wheelwright, 1984) into world-class company for oil and gas industry. The concept of world-class company is based on the early work in the area, operationalizing the construct of world-class manufacturing suggested by Hayes and Wheelwright. Hayes and Wheelwright's practices were related to operations strategy. The Hayes and Wheelwright's concept was important to this study because the concept of world-class manufacturing was associated with excellence performance in the global industries (oil and gas industry), resulting in the industry being described as world-class company construct (Flynn *et.al*., 1999).

In this study, the researcher analyzes the foundation provided by Hayes and Wheelwright's work, to determine whether it remains relevant in the Indonesia's oil and gas industry. In addition to meet the future challenges of discovering new reserves, the oil and gas industry in Indonesia have restructured their companies into a Strategic Business Unit (SBU) organization towards achieving the World-Class Vision (to be recognized as world-class companies committed to operational excellence). The SBUs have already implemented TQM program to achieve this vision. Key elements of TQM program are: applying new recovery process; improving existing recovery techniques; applying existing technology to add two billion barrels of oil and gas equivalent to the companies' Proved, Probable, and Possible by the decade 2000s; continuing exploration and exploitation; improving cost management; and converting the target oil and gas into produce able reserves and discovering new reserves.

Table 1: Summary of Hayes and Wheelwright's Practices

Dimensions	Rationale	Practices
Workforce skills and capabilities	U.S. firms have neglected development of workforce skills and capabilities; this should not be left to the schools	• Apprenticeship programs • Cooperative arrangements with vocational technical institutes • Internal training institute • Extensive advanced training and retraining beyond entry level, focusing on skills, work habits and motivation
Management technical competence	U.S. firms experiences technical weakness among their managers	• Ensure a significant number of managers have engineering or technical degrees • Train potential managers, early in their careers, in a variety of technologies important to the firm • Rotate managers through various functions, to broaden their experience
Competing through quality	U.S. firms need to focus on what is important to customers	• Seek to align products and processes to meet need that are important to customers • Long-term commitment to quality • Strong attention to product design • Involvement of all function in product design and quality improvement
Workforce participation	Real participation is more than simply putting employees into teams	• Develop a culture of trust between workers in various departments and between workers and management • Routine, close contact between management and workers • Develop participation policies to ensure that 'We're all in this together'
Rebuilding manufacturing engineering	Unique capabilities of equipment cant be copied	• Invest in proprietary equipment • Bolster ability to perform sophisticated maintenance, process upgrades and continuous improvement of existing equipment
Incremental improvement approaches	Win the race by creating a constantly escalating standard	• Continuous improvement in small increments • Continually adapt to changes in customer needs

Adapted from Hayes and Wheelwright 1984, pp. 375-385

THE AIMS AND OBJECTIVES OF THE STUDY

The ultimate aim of this study is to identify world-class company dimensions underlying the Hayes and Wheelwright's Principles: empirical evidence from the Indonesia's oil and gas industry. In light of quantitative-deductive research approach, the objectives of the study are twofold:

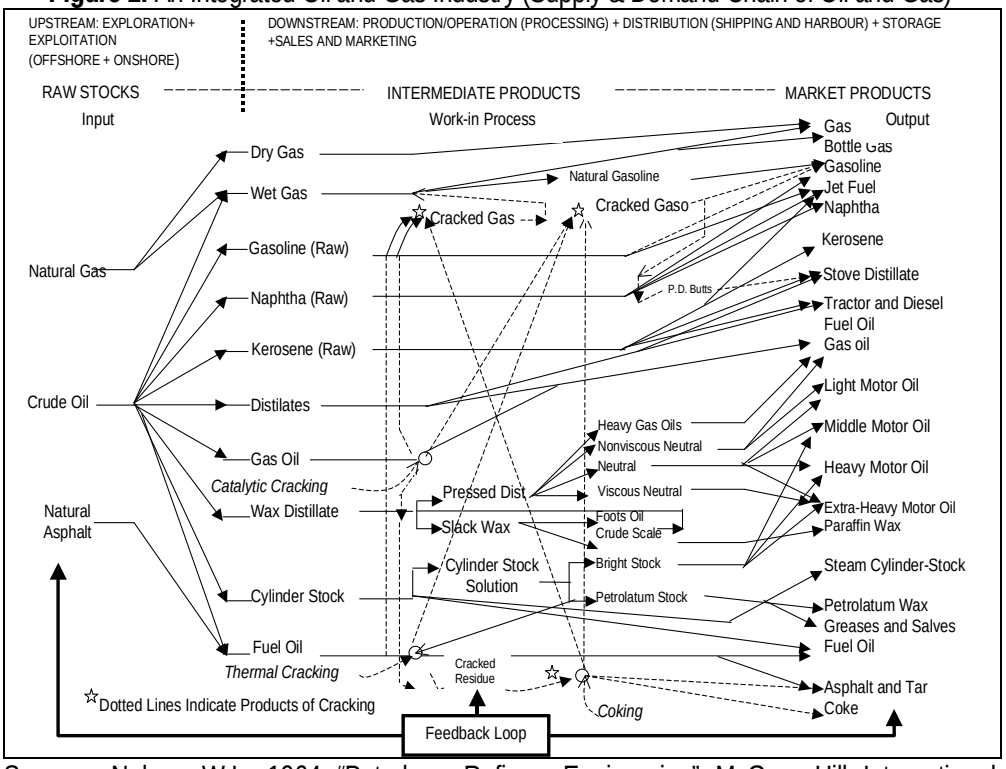
(1) To generate world-class company dimensions that is both substantively meaningful and statistically well-fitting for the Indonesia's oil and gas industry (a single industry); and

(2) To investigate managers' personal experiences in the field of operations strategy for achieving World-Class Company.

AN INTEGRATED OIL AND GAS INDUSTRY

The Indonesia's oil and gas industry is committed to adopting the following operations strategy principles in its journey to world-class company orientation: Quality Leadership, Stakeholders Focus, Integrated Business Strategy, Teamwork, Empowerment, Process Management, Asset Management, Continuous Improvement, Learning Organization, and Measurement of Company Performance. Although operations strategy has been implemented, the management oil and gas companies in Indonesia realized that to reach their vision to be world-class companies, they must fundamentally rethink their way of conducting business. The management oil and gas companies have encourage themselves to restructure the operations strategy related to other management philosophies such as world-class company underlying Hayes and Wheelwright's principles.

Figure 1: An Integrated Oil and Gas Industry (Supply & Demand Chain of Oil and Gas)



Source: Nelson, W.L., 1964, "Petroleum Refinery Engineering", McGraw Hill, International Book Company, Singapore

The oil and gas chain activities and an integrated oil and gas industry are shown in Figure 1. The raw stocks from the oil and gas fields are transformed in the upstream process of making the intermediate products and shipping them to the next customer (the downstream process). The intermediate products are converted into market products in the downstream process. The final outputs are the customer receiving the market products of oil and gas. An important aspect of the oil and gas process is a feedback loop. A feedback loop relates information about the market products (outputs) from any stage or stages back to another stage or stages so that an analysis of continuous improvement process can be made (Gitlow *et al*., 2005).

THE AMENDMENT OF LAW OF THE REPUBLIC OF INDONESIA CONCERNING OIL AND NATURAL GAS

The period of 2001 – 2005 is important transition years for Indonesia's Oil and Gas Industry, following passage of a new oil and gas law in October 2001. The Indonesian Parliament passed the oil law on October 23, 2001 (Law 22/2001). This new Law, which replaced the 1960 Oil and Gas Law and Law for State Owned Company 8/1971, required the upstream and downstream sectors to deregulate within four years (2001-2005). The amendment of law created two new governmental bodies: the Executive Body that takes over State Owned Company's upstream functions and the Regulatory Body that supervises downstream operations.

The Executive Body (Oil and Gas Upstream Implementing Body) was established on July 16, 2002 (Government Regulation No. 42/2002). It took over State Owned Company's upstream regulatory functions and management of oil and gas contractors. The Regulatory Body (Oil and Gas Downstream Regulatory Body) was established on December 30, 2002 (Government Regulation No. 67/2002). It has license downstream operators to assure sufficient natural gas and domestic fuel supplies and the safe operation of refining, storing, transport and distribution of petroleum products.

The oil and gas policy reform is necessary in order to maintain Indonesia's status as a net oil exporter and enhance efficient use of energy resources. To do so, the government must implement legislation and policies that will attract new private direct investment and rationalize use of Indonesia's energy resources (Embassy of USA, 2004). Based on the new law, there are three types of contracts: the Production Sharing Contract (PSC), the Technical Assistant Contract (TAC), and Enhance Oil Recovery (EOR) Contract. In addition to contracts that give bundles of right to explore and exploit, the participants in the PSC, TAC, or EOR may also enter into separate agreements. The objective of this agreement is to discuss how they are going to conduct petroleum operations. These are known as Joint Operating Agreements (JOA) and Joint Operating Bodies (JOB).

To support the oil and gas policy reform, Ministry of State Owned Enterprises will establish the Indonesia Quality Award (IQA). This award will be given to the

company to fulfill their vision to be recognized as World–Class Companies successfully. This award is not the end of the oil and gas companies' journey. It is only the beginning. The companies must continue to evolve and learn with perseverance.

LITERATURE REVIEW

The traditional operations value of managing processes, products/services, and systems involved controlling employees through hierarchies that coordinate stable, rationalized mass production and services delivery processes. The products/services are simplified and standardized toward the goals of maximum volume or minimized costs. Typically traditional systems seek a competitive edge, are national in focus, and function monolithically in pursuit of short-term plans. Alternatively, a world-class system empowers employee by reducing organization form, by destroying barriers, and by directing itself toward intuitive, adaptive, and integrated processes to produce complex and customized products or services designed toward customer needs. World-class systems are collaborative, global, and pluralistic in pursuit of long-term objectives (McCann, 1991 in Stonebraker and Leong 1994).

Table 2: From Traditional Operations to World-Class Operations Values

Traditional Operations Value Systems (A Mechanical Perspective)	***Transformation Process***	***World-Class Operations Value System (A Protoplasmic Perspective)***
I. Process Characteristics		I. Process Characteristics
a. Organize in hierarchies	---------->	a. Destroy form and barriers
b. Control employees	---------->	b. Empower employees
c. Use fixed technologies	---------->	c. Use flexible technologies
d. Rationalize processes	---------->	d. Intuit processes
e. Coordinate processes	---------->	e. Integrate processes
f. Stabilize production processes	---------->	f. Adapt Production processes
II. Product/Service Characteristics		II. Product/Service Characteristics
a. Maximize volume/minimize cost	---------->	a. Optimize response to customer
b. Standardize products/services	---------->	b. Customize products/services
c. Understand/accept complexity	---------->	c. Simplify design
III. System Characteristics		III. System Characteristics
a. Encourage individualism	---------->	a. Encourage teamwork
b. Define a national focus	---------->	b. Define a global focus
c. Pursue short-term plans	---------->	c. Pursue long-term plans
d. Function monolithically	---------->	d. Interact Pluralistically

Source: Stonebraker and Leong, 1994

Application Table 2 describes the makeover of an organization toward world-class value. The traditional value of operations is analogous to a mechanical and fixed process. It does not work well as a model for operations of the third millennium and beyond. The emerging world-class value system is much more comparable to a biological and protoplasmic process (Drucker, 1989 in Stonebraker and Leong 1994). Protoplasmic process is defined in biology as: a typically translucent, color-

less, semi-fluid, complex substance regarded as the physical basis of life, having the ability to sense and conduct stimuli and to metabolize. Management of a successful organization must transform itself so that it sees the organization as a protoplasmic organism, with the inherent ability to interact and self-energize.

According to Stonebraker and Leong (1994), there are six considerations in transforming an organization from a mechanical to a protoplasmic perspective.

1. *To examine the leadership processes*: Management must view employees as inherently competence and self-motivating. Management should and able employees with skills and knowledge and then empower them through responsibility and authority to use those skills and that knowledge.
2. *To define itself as a leader in the global market place*: Most businesses operate in markets where a significant portion of the business is in interaction with foreign producers and customers. The trend toward global market place will increase. To that end, the perspective of the corporation must include leadership in the global environment.
3. *To determine customer requirements:* Companies must identify the attributes of those requirements that add value, and then determine how operation can build to those specifications.
4. *To identify competitive niches:* As the global cost of manufacturing or services coverage, responsiveness to customers and a reputation for quality will secure business, and efficiency of process technology will define the key competitive niche in terms of cost or products/service differentiation.
5. *To design process flexibility:* There will be overall control of the process; each operation will have its own leadership, permitting specialization and internal process flexibility.
6. *To develop synchronous activities of teams and groups:* In the entire corporate value system, a changes of mindset from that of setting up and managing a system of stable gears to that of transforming protoplasm.

According to Flynn *et al*. (1999), Hayes and Wheelwright's work on world-class manufacturing is important to the field of operations strategy for several reasons. First, Hayes and Wheelwright were the first authors to use the term 'world-class manufacturing', laying the foundation for the work of countless future authors. This is particularly important due to the credibility associated with the work of Hayed and Wheelwright because of their seminal work in the area of operations strategy (Hayes and Wheelwright, 1979, 1984).

Second, Hayes and Wheelwright described world-class manufacturing as a set of practices, implying that the use of best practices would lead to superior performance. This practice-based approach to world-class manufacturing has been echoed by numerous authors since then. For example, Voss 1995 described world-class manufacturing as a subset of the 'best practices' paradigm of operations strat-

egy. Much of the study of Japanese manufacturing in recent years has also focused on the discernment and use of best practices.

Third, Hayes and Wheelwright were among the first authors in the operations management arena to address the issue of tradeoffs vs. synergies in manufacturing performance, building on the earlier work of Skinner 1969. They made a substantial contribution to this debate by arguing that it was important to have a clear set of priorities between the dimensions of competitive performance because it was potentially dangerous to try to achieve superior performance on multiple dimensions simultaneously. This debate continues to rage, particularly in the strategic management field.

More recent authors (Schonberger, 1996, 1990, 1996; Giffi *et al*., 1990) have developed their own descriptions of world-class manufacturing practices, often building on new manufacturing practices, such as total quality management and JIT. Schonberger (1996, 1990, and 1996) provided list of six principles of world-class manufacturing. Many of these correspond to Hayes and Wheelwright's practices, although not necessary directly. Compression of Hayes and Wheelwright prescriptions with Schonberger's principles is contained in Table 3. In addition, Flynn *et al*., 1998 considered the work of Giffi *et al*, 1990, who summarizes the attributes of world-class organizations or world-class companies. Those which are related to Hayes and Wheelwright's practices are also summarized in Table 3.

Table 3: Comparison of recent descriptions of world-class manufacturing with Hayes and Wheelwright's world-class manufacturing practices

Hayes and Wheelwright's world-class manufacturing practices	Corresponding Schonberger principles	Corresponding Giffi, Roth and Seal attributes
Workforce skill and capabilities	• Principle 8: Continually enhance human resources through cross-training, job and career-path rotation and improvements in health, safety and security • Principle 9: Expand the variety of rewards, recognition, pay and celebration-to match the expanded variety of employee contributions	• Promote and measure knowledge and skill development • Invest in people; develop a pattern for updating workforce skills and capabilities consistent with the evolution of technology within the organization • Seek ways to liberate the teams from traditional organizational controls, and reward and motivate, based upon ability to achieve meaningful goals
Management technical competence	• Principle 1: Team up with customer, organizing by families of customers of products what customers buy/use	• Identify the competitive advantage of the knowledge base that advanced technology can create; simultaneously implement new technology and develop the new knowledge base

Hayes and Wheelwright's world-class manufacturing practices	Corresponding Schonberger principles	Corresponding Giffi, Roth and Seal attributes
Competing through quality	• Principle 7: Operate close to customers' rate of use or demand	• Define quality in terms of the customers' needs. Make customer closeness the number one priority • Integrate the concept of customer closeness into the organization so that everyone in the organization has a customer, and everyone's goal is to provide quality product and service to his or her customer • Regard customers as the core of your existence
Workforce participation	• Principle 4: Frontline employee involved in change and strategic planning--to achieve unified purpose • Principle 11: Frontline teams record and own process data at the workplace	• Dissolve the boundaries between management and worker and between functionally segregated staff units, to create dynamic cross-functional teams charged with resolving both strategic and operational issues • Empower teams or workers to carry out the mission of the organization • Eliminate the teams 'supervisors' and 'supervision'. Develop leaders who can create and execute the strategic vision through the teams
Rebuilding manufacturing engineering	• Principle 14: improve present equipment and human work before considering new equipment and automation • Principle 15: Seek simple, flexible, movable, low-cost, readily available equipment and work facilities—in multiples, one for each product/customer family	• Develop an investment strategy for the continual enhancement of technology throughout the organization, based on a clearly defined vision of future competitive requirements • Carefully plan technological upgrades to be consistent with infrastructural upgrades. Benefits can be achieved only when the infrastructure is capable or integrating and exploiting the technology advantage offered
Incremental improvement approaches	• Principle 3: Dedicate to continual, rapid improvement in quality, response time, flexibility and value • Principle 5: Cut to the few best components, operations and suppliers • Principle 10: Continually reduce variation and mishaps	• Develop manufacturing operations that are flexible and able to respond rapidly to changes in product and market • Develop measurement systems that encourage continual learning • Evaluate the success of your human assets on the basis of their ability to learn, adapt to change, and improve performance within their areas of responsibility • Develop accelerated and integrative learning programs

Source: Flynn*, et.al*., 1999

THE STUDY

The intention of the cross-sectional study was to use the perceptions and experience of a range operations strategy practitioners from oil and gas industry (a single industry) as the basis for identifying the dimensions of world-class company underlying the Hayes and Wheelwright's principles. Their perceptions were to be measured using a questionnaire incorporating six principles of Hayes and Wheelwright. These principles were taken as the basis for this questionnaire since it is the best established and recognized sixty seven Hayes and Wheelwright's practices (Flynn *et al*., 1999).

The study concerns the context of justification (theory-driven research) and a quantitative-deductive (explanatory) approach. This study addresses two key research questions that enable us to understand the dimensions of world-class company for the Indonesia's oil and gas industry.

Research Questions

1. Do Hayes and Wheelwright's principles individually and collectively comprise reliable and valid instrument for measuring World-Class Company (WCC)?
2. Can Hayes and Wheelwright's principles be reduced into a smaller set of meaningful factors for the Indonesia's oil and gas industry?

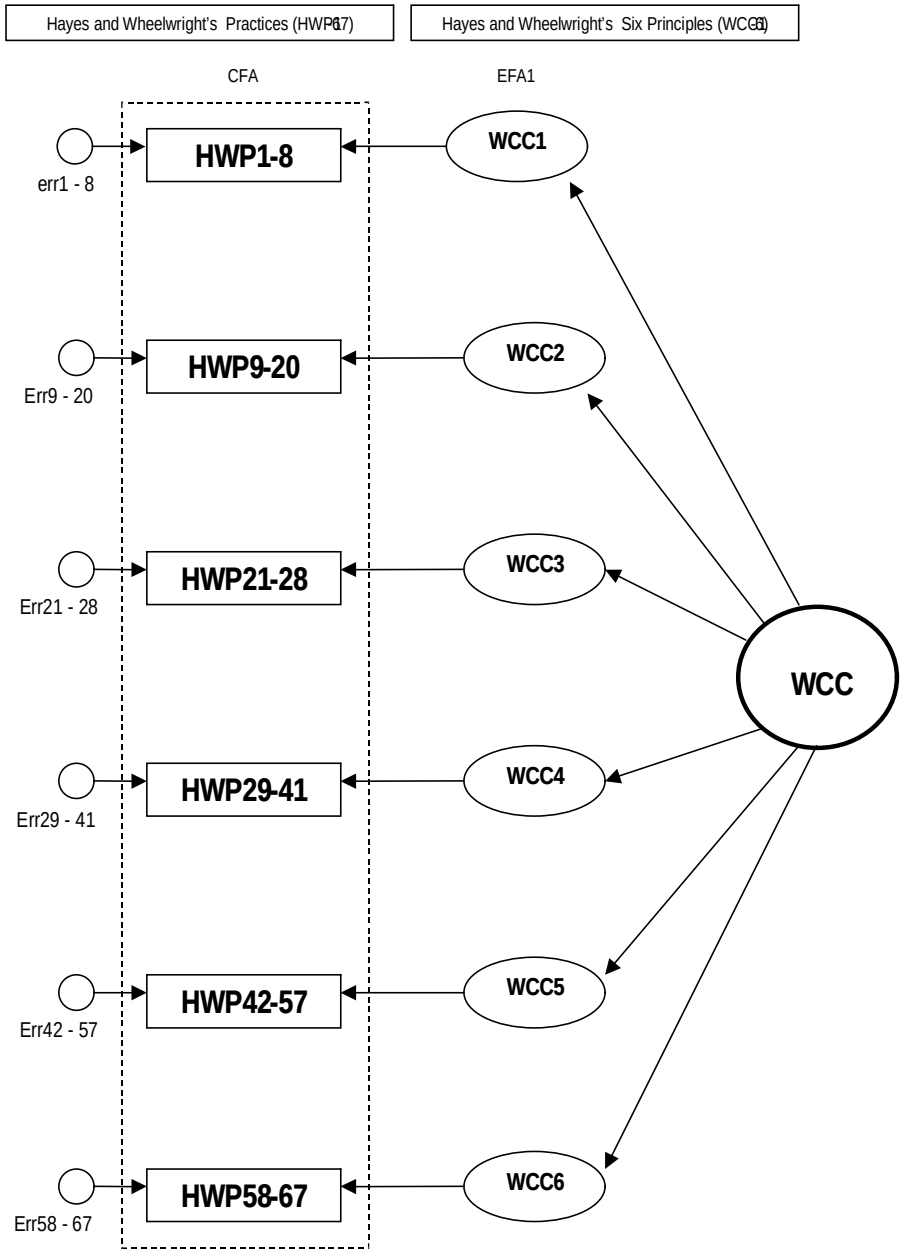
Research Hypotheses

The quantitative-deductive (explanatory) research hypotheses include the following two hypotheses.

1. **H1:** Hayes and Wheelwright's principles individually and collectively comprise reliable and valid instrument for measuring World-Class Company (WCC).
2. **H2:** Hayes and Wheelwright's principles can be reduced into a smaller set of meaningful factors for the Indonesia's oil and gas industry.

The hypothesized overall models are portrayed in Figure 2.

Figure 2: A Research Framework World Class Company



Sampling Method

Empirical data for this study were collected from seven group companies of the integrated oil and gas industry in Indonesia (based on the new law of oil and gas number 22/2001); containing 49 oil and gas companies and 140 strategic business units. Forty six of which were privately owned and two of which were in the public sector (state owned) companies.

The primary unit of analysis for empirical validation is the individual Strategic Business Unit (SBU) level. The SBU organizational structure is chosen in this study because of three reasons. First, the Indonesia's oil and gas companies have realized that SBUs allow corporate management to delegate authority for the strategic management of distinct business entities—the SBUs (Hakim, 1996 and Pearce and Robinson, 2005). In addition the SBUs are profit centers, which facilitates accurate assessment of profit and loss. The second important reason of choosing the SBU as unit of analysis is that the advantage of the SBU to meet the increased coordination and decision-making requirements that result from increased diversity and size (Pearce and Robinson, 2005). Third, the SBU is the level of implementation for most world-class company programs.

Furthermore, studies have shown (e.g. Yamashina, 2000) that basic requirements for world-class manufacturing are: (1) to be outstanding in applied research, production engineering, improvement capability, and detailed shopfloor know-how involving good maintenance; and (2) to integrate them as a system.

Two thousand and eight hundred (2800) questionnaires were distributed to the participating oil and gas companies in a qualified sample of 140 SBUs. An initial sample of 200 SBUs operating in Indonesia was drawn at random from the directory of Directorate General of Oil and Gas, Republic of Indonesia. Each SBU was contacted by telephone and e-mailed web system to establish that individuals with primary responsibilities for the three level of management position were identifiable. It was not possible to contact 12 SBUs because of incorrect contact details. A further 48 SBUs were either unable or unwilling to identify individual managers with the required responsibilities. Each qualified sample of 140 SBUs received 20 questionnaires. Only responses and answered completely on of the research constructs were used. The effective response rate is calculated as follows (Bryman & Bell, 2003):

$$\textbf{Response Rate} = \frac{\textbf{Number of useable questionnaires}}{\textbf{(Total samples-unsuitable or uncontactable numbers of the samples)}} \textbf{ x 100}$$

A total of 1,332 individual usable questionnaires were returned thus qualified for analysis, representing an effective response rate of 50,19 percent. Of these, 354 were from high level managers, 447 from middle level managers, and 531 from low level managers. At least 6 questionnaires were returned by qualified sample of 140 SBUs, with 62 SBUs returning more than 10 questionnaires of 20 questionnaires

distributed. All 140 SBUs returned questionnaires from their high level manager, middle level manager, and low level manager. An assessment of non response bias was made by using the extrapolation approach recommended by Armstrong (1979). Each individual questionnaire type (high, middle, and low level managers) was categorized by the date the completed questionnaire was received. Tests revealed no significant differences between early and late responders on any of the quality management practices.

Research Instrument

The survey instrument (questionnaires development) was based on a replica of previous assessing the dimensions of world-class company or WCC (Flynn *et al*., 1999). The questionnaire contained sixty seven questions of Hayes and Wheelwright practices. The questionnaire asked the managers at the SBU level to respond to a set of sixty seven Hayes and Wheelwright practices, synthesized from Hayes and Wheelwright's principles of their establishments on a five-point interval scale (1 = not at all true; 2 = slightly true; 3 = somewhat true; 4 = mostly true; and 5 = completely true).

DATA ANALYSES

To test the hypotheses (hypotheses 1 & 2), the researcher used confirmatory factor analysis (CFA) and exploratory factor analysis (EFA). The researcher used CFA to measure the research constructs. Then, the researcher used EFA to identify the underlying the Hayes and Wheelwright's principles. The SPSS 11.0 (Coakes and Stead, 2003) were used to the quantitative data analyses.

Sixty seven (67) questionnaire items of Hayes and Wheelwright's practices used in this study. After reversed scores were adjusted, items representing the quality Hayes and Wheelwright's practices was subjected to reliability and validity tests.

Rigorous statistical analysis is required in order to meet professional standards of validity and reliability. This approach would enable items to be retained or removed based on multivariate statistical analysis such as factor analysis/principle component procedure. According to Samson and Terziovski (1999) this has not been done with any statistical rigor based on a large and selected sample (n > 1000). Previous studies have been generally based on between about 20 and 200 observations (i.e. in this study 140 Strategic Business Units and 1332 respondents).

Reliability of measures

Cronbach's alpha coefficients were computed to estimated the reliability of each scale (observed variable or indicator). Item to total correlation was used to refine the measures and eliminate items whose inclusion resulted in lower alpha coefficients. Items with item to total correlation coefficients less than 0.50 were eliminated. However, items with item to total correlation coefficients less than 0.50 were retained

if eliminating those items would result in lower Cronbach's alpha coefficient of the related scale (Hair *et al*., 1998). The Cronbach's alpha of the measures are ranging from 0.8350 to 0.9270, which, according to DeVellis (1991), are respectable to very good. Table 4 shows the reliability of the measures. Table 5 informs the number of items retained of the constructs.

Table 4: Reliability Coefficients (Cronbach's Alpha) of the Constructs

Construct	Number of Items in the Questionnaire	Number of Items Retained	Cronbach's Alpha
WCC	6 Items	4 Items	0.8475
WCC1	8 Items	6 Items	0.8350
WCC2	12 Items	9 Items	0.8750
WCC3	8 Items	5 Items	0.8370
WCC4	13 Items	9 Items	0.8730
WCC5	16 Items	15 Items	0.9170
WCC6	10 Items	10 Items	0.9270

Table 5: Number of Items Retained of the Constructs

Construct's Name	Construct Item Code	Sub Construct Item Code
World-class Company (WCC)	HWP1	Hayes-Wheelwright dimensions: 51,54, 55, 56, 57, 58
	HWP2	Hayes-Wheelwright dimensions: 59,60,62,63,64,65,66,67,68
	HWP3	Hayes-Wheelwright dimensions: 72,73,74,75,76,78
	HWP4	Hayes-Wheelwright dimensions: 80,82,83,84,85,88,89,90,91

Validity of measures

After the scales had met the necessary levels of reliability, the scales were assessed for validity. Confirmatory factor analysis was to assess the validity of each scales, which consisted of the retained items or manifest indicators. All loadings (path coefficients or regression weights) from a latent construct to their corresponding manifest indicators were significant (critical ratio values > 1.96). Thus provided evidence of convergent validity.

This study also assessed the discriminant validity of the latent constructs. Discriminant validity is the degree to which two conceptually similar constructs are distinct. According to Anderson and Gerbing (1988), when the confidence interval of ± two standard errors around a correlation estimate between two factors (constructs) does not include the value 1, that is evidence of discriminant validity for the two constructs. None of the confidence intervals in this study includes one.

Construct Reliability (α)

The composite reliability of each latent construct (α) measures the internal consistency of the construct indicators, depicting degree to which they indicate the common latent (unobserved) construct. High reliability of measures provides the re-

searcher with greater confidence that the individual indicators consistently measure the same measurements (see Table 6). The threshold value for acceptable reliability is 0.70. (Hair *et al*., 1998).

Fixing the Error Terms and the Lambdas

Single indicators measured latent constructs of this study; however, in each case, the indicator was a multiple-item scale. It is unlikely that a single indicator perfectly measures a construct; therefore, this study estimated the measurement error terms. The measurement error terms were fixed at $(1- \alpha)\ \sigma^2$ and the corresponding lambdas—the loading from a latent construct to its corresponding indicator—were fixed at $\alpha^{1/2}\ \sigma$ (Howell, 1987). For the non-latent (observed) variables, the error terms were fixed at 0 and the corresponding lambdas were fixed at 1.

The measure of this study consists of indicators five latent variables measured on a 5 point scale. Therefore, before fixing the error terms and the lambdas for the samples, the study converted those latent variables into standard scores (Z scores) by subtracting the mean and dividing by the standard deviation for each variable. Using standardized variables eliminates the effects due to scale differences (Hair *et al*., 1998). Table 6 provides the reliability of the constructs, lambdas, and error terms.

Table 6: Construct Reliability

Construct	ε	ƛ	α
ή1 (WCC: HWP1-6), Before deleted components 5 & 6	0.0217	0.7866	0.9661
ή1 (WCC: HWP1-4), After deleted components 5 & 6	0.0379	0.8186	0.9465

EFA for World-Class Company (WCC) Construct

An exploratory principle components factor analysis was conducted to determine whether the Hayes and Wheelwright's six dimensions (HWP 1-6) load collectively overall constructs that may be termed as World-Class Company (WCC). All Hayes and Wheelwright's six dimensions (HWP 1-6) were extracted that accounted for 60.436% of the total variation in the observed variable and all of the 6 component matrix value above 0.5. All Hayes and Wheelwright's six principles (HWP 1-6) collectively have positive impact on World-Class Company (WCC). Hayes and Wheelwright Principles 5 and 6 with total initial eigenvalues that fall below the acceptable level of 0.4 should be excluded from the WCC construct (Nunally, 1967). Table 7 shows the result of Exploratory Factor Analysis: World-Class Company or WCC.

Table 7: The Result of Exploratory Factor Analysis: World-class Company (WCC)
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Component Matrix
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Component 1
1	3.626	60.436	60.436	3.626	60.436	60.436	0.792
2	0.710	11.835	72.272				0.859
3	0.558	9.298	81.570				0.701
4	0.494	8.226	89.796				0.800
5	0.317	5.279	95.075				0.822
6	0.295	4.925	100.000				0.674

Extraction Method: Principal Component Analysis
1. Component Extracted: only one component was extracted. The solution cannot be rotated
Components 5 & 6 should be deleted, because the total initial eigenvalues are < 0.4 (Nunnally, 1967)

DISCUSSION

The study points out that (1) the Hayes and Wheelwright's six principles load collectively an overall constructs that may be termed as World-Class Company (WCC); (2) Hayes and Wheelwright's six principles can be reduced into four meaningful factors of WCC for the Indonesia's oil and gas industry—Workforce skills and capabilities, Management technical competence, Competing through quality, and Workforce participation.

The results of the study determined the Hayes and Wheelwright's six principles as the important of operations strategies for achieving world-class company. It has been observed that for operations strategies collectively affect world-class company. The workforce skills and capabilities was the most meaningful factor of operations strategies for the Indonesia's oil and gas industries, followed by management technical competence, competing through quality, and workforce participation. Based on the oil and gas managers (the SBU level), operations strategies (four meaningful factors of WCC) can be viewed as the effective use of production and operations capability and technology for achieving business and corporate goals. Operations strategy, therefore, is to help a company's operations organization define the common ground where it can play a proactive and collaborative role with other company functions or cross-functional relationships (Hayes *et al*., 1996).

CONCLUSION

In this study, an attempt was made to simplify Hayes and Wheelwright's six principles into a smaller set of meaningful factors of world-class company to help oil and gas managers in their operations strategy efforts. For this purpose, exploratory

factor analysis was applied to a set of 67 Hayes and Wheelwright's practices that were synthesized from Hayes and Wheelwright's six principles were extracted which were interpreted, respectively, as Workforce skills and capabilities, Management technical competence, Competing through quality, and Workforce participation. These extracted factors accounted for 60.436% of the total variation among Hayes and Wheelwright's sixty seven practices.

It is important to note that the potential limitation of this study stems from the use of a cross sectional analysis. Cross sectional analysis only give us portrayed at a particular point of time. The researcher cannot examine the dynamic nature of trade-off, which is changing over time (Silveira and Slack, 2001). In addition the researcher encourages to think about whether the model of the study effects vary over time, either because other time the constructs are theoretically important or because the theoretical effect is unstable for some reason.

Next research should be conducted longitudinally to observe the progress of improvement efforts (i.e., by developing ABC Analysis→ Antecedents, Behavioral, Consequences; or MTMM → Multitrait-Multimethod Measurement Model framework or Triangulation Method). Recommendations can be made to implement a set of meaningful factors of WCC (operations strategies) categorized by different classes and sizes of industry; these will be a significant contribution to the literature on operations strategy (Ahmed & Montagno, 1996).

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