CHAPTER II

Literature Review

2.1 New Product Development

New Product Development is defined as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale (Ulrich and Eppinger, 2000; Agouridas *et al.*, 2007). It is obvious in many of the literature reviews that during the past decade, new product development becomes important to the business. It could either help the company differentiate itself from others or can be included in the business survival plan. Various models have been proposed for new product development and could be grouped into linear, recursive and chaotic frameworks according to McCarthy *et al.* (2006). The most popular process used by international companies is Stage Gate process and its modification schemes which use project management methods to seek appropriate outputs on time and within cost.

Table 3: Linear, recursive, chaotic frameworks of New Product Development (McCarthy *et al.*, 2006)

NPD Framework	Descriptive Interpretation	Benefits/Limitations
Linear	A process with relatively fixed, discrete and sequential stages. The connections, flows, and outcomes of the process are comparatively deterministic.	Provides a simple and effective representation of the structural logic and flows. Suited to incremental innovation activity with relatively reliable market push or strong market pull forces. Does not consider the dynamic behaviors and relationships associated with agency, freedom, and resulting innovations.
Recursive	A process with concurrent and multiple feedback loops between stages that generate iterative behavior and outcomes that are more difficult to predict.	Represents the dynamic and fluid nature of the process. Suited to more radical innovations with push-pull market force combinations. Assumes similar behavior across the whole process and does not represent the structural and behavioral instabilities of the process.
Chaotic	A process where the linkages and flows are greater during the initial stages, resulting in different degrees of feedback across the process. The initial stages exhibit chaotic dynamics and outcomes that appear to be random and unpredictable, whereas the latter stages are relatively stable and certain.	Recognizes different system behaviors across the process and acknowledges the effects of highly cumulative causation. Suited to the search and exploration aspects of very radical innovations or really new products. Focuses on differences between the stages and presupposes that the overall process configuration is fixed (i.e., does not consider process adaptability).

Time passed and the environment becomes more complex and uncertain. The increase of globalization, rapid introduction of technology innovations, changing of customer needs and shorter product life cycle make companies seek for modification of the linear stage gate method to support the delivery of high quality product efficiently (Buyukozkan *et al.*, 2004; Ulrich and Eppinger, 2000; Agouridas *et al.*, 2007). As suggested by McCarthy *et al.* (2006) the new NPD process still passes a series of stages but with overlaps and feedback loops as well as not to focus only on the process efficiency itself. Flexibility, informality and feedback are added into the process to promote innovations. The model proposed is called Complex Adaptive System (CAS), characterized the nonlinearity, self-organization and emergence process. Tested in 3 companies, they find that despite the market-focused, project controlled and relatively sequential nature of each NPD process, it was possible to identify nonlinear behaviour in all 3 companies. Additionally, they imply that there's no fixed NPD for all products and that the NPD successfully used with one product might not yields high performance on the other especially when new technology and innovation is involved. Mayer and Vambery (2008) and Ettlie and Elsenbach (2007) similarly stated that a continuous improvement in NPD should be done as the process is within a dynamic environment boundary.

Detailing into the NPD processes, they required good attention and support from senior management as

- It involves many decision making stages which according to McCarthy *et al.* (2006) can be specified into strategic decisions[1], review decisions[2] and in-stage decisions[3]

[1]Strategic decisions: highest decision level related to the market and product strategy, decisions made by high level management team

[2]Review decisions: decisions at milestones usually engage with concept development, product design and testing which has significant effect to the NPD lead time, decisions made by middle management.

[3]In-stage decisions: decisions usually made by working members

- It is accompanied by high cost and risks (Ahn *et al.*, 2006)
- It could differentiate the company to the others
- Quality, cost and timing is mostly defined at the strategic decision gate way and effects the whole following processes (Verworn *et al.*, 2006)

Measurements of the NPD performance can be done in both financial and non-financial terms. It was also found that companies using more formalized NPD processes have a more aggressive new product introduction history. Ettlie and Elsenbach (2007) and Ahn *et al.* (2006) proposed that the business performance measurement should be added with knowledge performance as creation of knowledge is the core theme of NPD process.

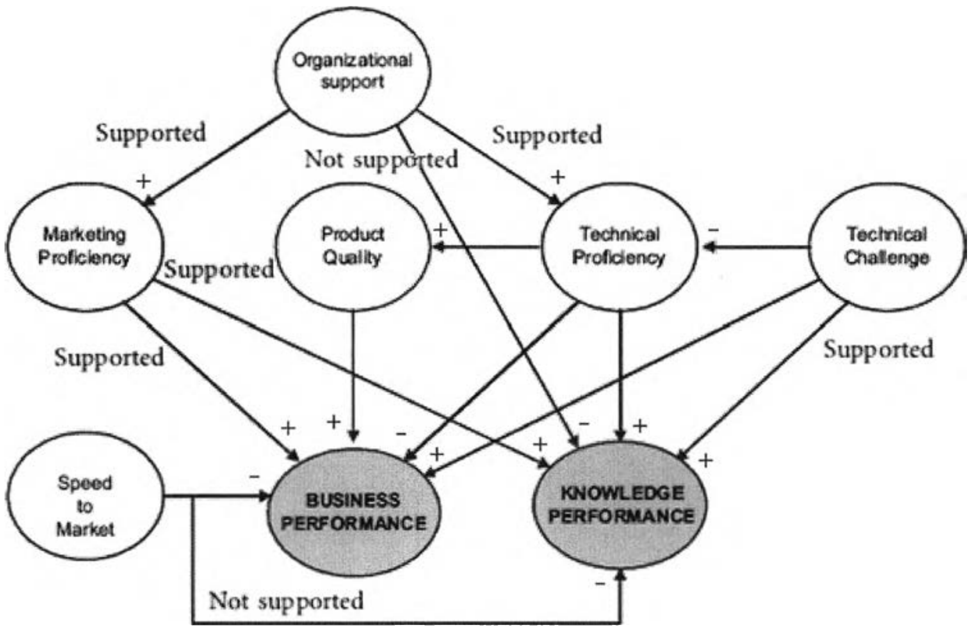
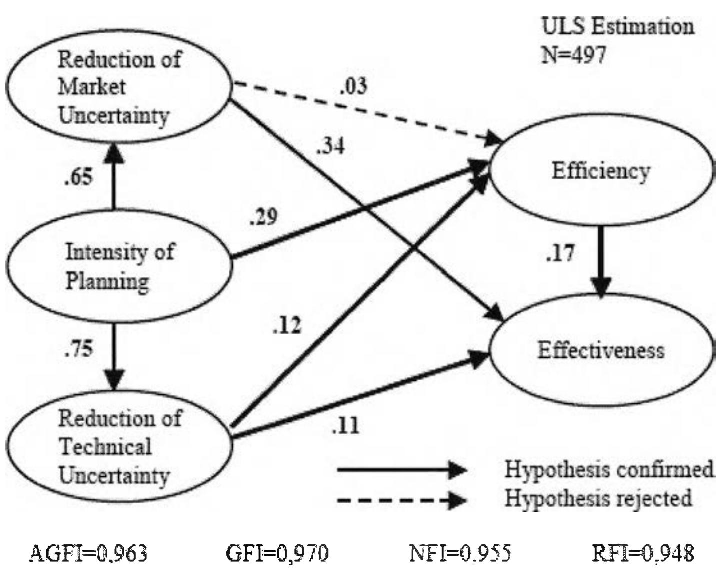


Figure 14: Conceptual study and the hypothesis result of the factors related to business and knowledge performance of a company (Ahn *et al.*, 2006)

In order to improve NPD performance, many sub-processes and methods are introduced. Mostly, those methods will refer to the beginning or front end steps which give highest effects to the decisions followed and the success of the product. Verworn *et al.* (2006), studied Japanese NPD and its fuzzy front end on information-processing perspective, suggested that there should be an early reduction of market and technical uncertainty and a draft initial planning prior to development. Agile characteristics and concurrent design (a systematic approach to the integrated, concurrent design of products and their related processes including manufacturing and support) is also well-known (Buyukozkan *et al.*, 2004). Collaborative engineering tools are allowing substantial improvement of the stage gate process as well (Ettlie and Elsenbach, 2007). PLM (Product Life Cycle Management, a strategic business approach for the effective management and use of corporate intellectual capital) is another approach used by Sudarsan *et al.* (2005) in their study of product family modelling. Troy *et al.* (2001) illustrates the centralization of market information as it helps increases new product ideas generated by work group. There are also evidences that outsourcing NPD processes and/or the early involvement of suppliers and customers also enhances the NPD performance especially in automotive industry where increases R&D are pushed toward inter-firm NPD partnership (Ettlie and Pavlou, 2006). The research find that superior NPD partnership dynamic capability, company's higher technology context and good IT support used in NPD formulates a better result of new product success rate and superior product commercialization. However, there are still negative effects of doing so as well. The offer might deteriorate company's product innovation and as a result Intellectual Property tension has been increased in the auto industry in recent years. Note that primary, outsourcing R&D is a mean to cut cost.



Source: own depiction.

Figure 15: Results of the structural equation model between efficiency and effectiveness and their input factors (Birgit *et al.*, 2006)

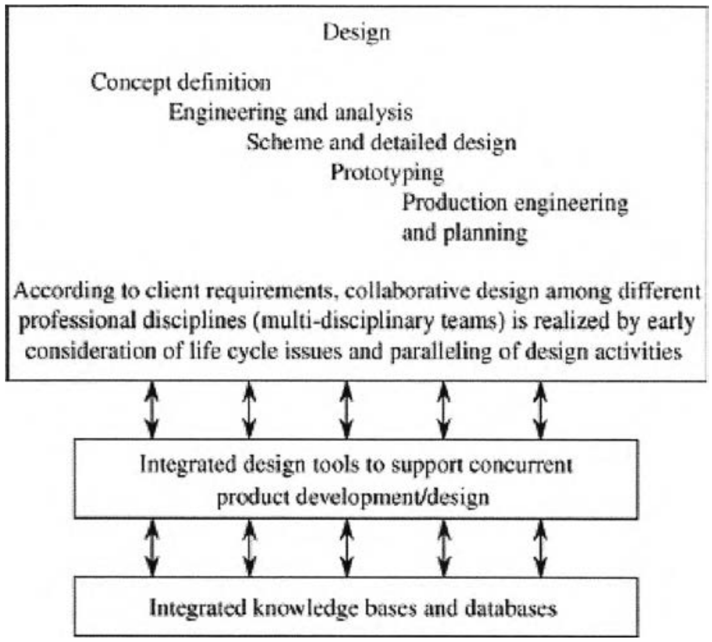


Figure 16: Methods and tools of concurrent new product development

(Gulcin *et al.*, 2002)

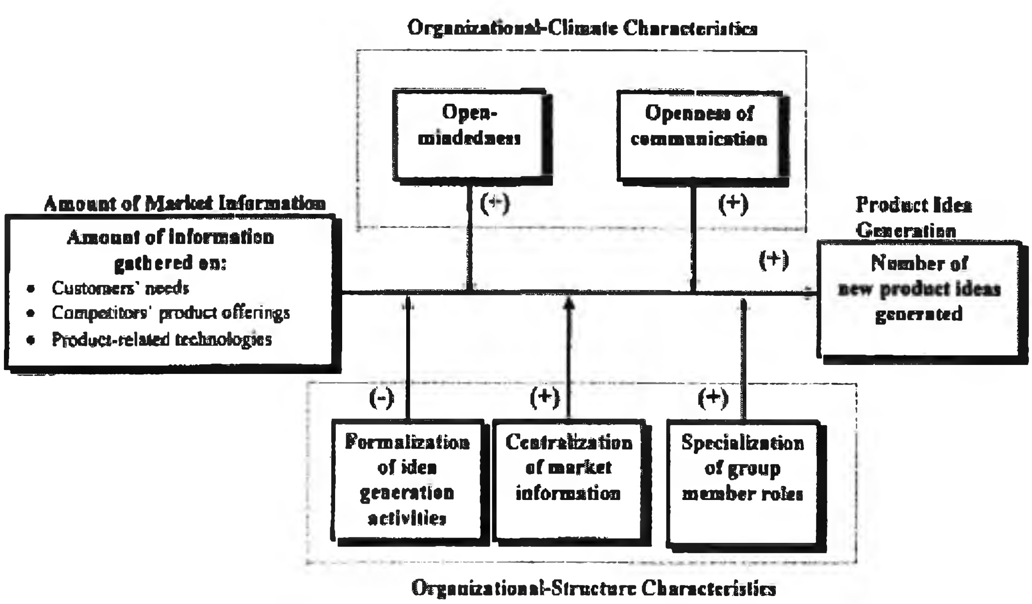


Figure 17: The effect of organizational and environmental characteristics that effects on

product idea generation (Troy *et al.*, 2001)

Another popular performance enhancement method is "Lean NPD" which focuses on eliminating wastes.

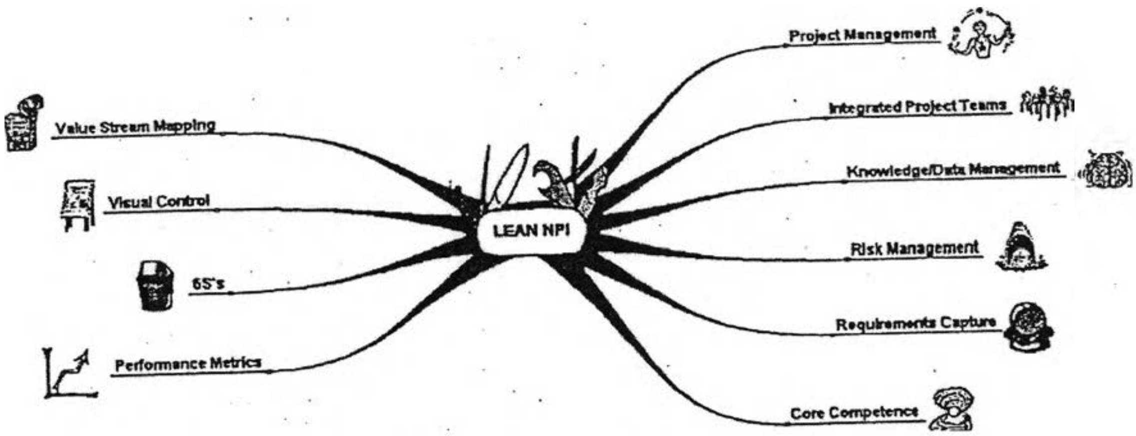


Figure 18: Lean NPI tools and techniques (Warwick, 2008)

There are quite a number of tools which can be used in managing a lean NPD process. Some can be adapted from lean manufacturing process such as

- QFD (quality function deployment) which helps for quality planning, output required by customer identification and output tracing and control
- FMEA (Failure Modes and Effects Analysis) which helps to list all potential sources of failure, weight, expected frequency and the likelihood to be able to detect the failure and its severity
- Six sigma, a management tool to control the quality range of product or process output
- 5S which helps to improve the working environment as well as better organization work culture change

Some can be identified from studies (mostly construction businesses) and implementation of sample companies such as

- Process re-engineering, a work simplification and method improvement process for improving productivity, product quality and greater customer satisfaction
- Concurrent engineering (synchronized) in Product Design Management, to improve team's communication and avoid duplication or misuse of information

- Implementation of data management software (transparency, flow, alignment) to shorten time to market and retain organization knowledge
- An optimized stage gate process to ensure effectiveness of the process

As company's performance depends upon the entire system optimization, it is important to look into the process and its impact to the whole organization when implementing a lean project. The choice of tool and technique depends on the company, industry standard, best practices and peer experience (Miller and Coker, 2008).

2.1.1 Stage gate process

As mentioned earlier, stage gate process is well known by both researchers and companies in its widely used. The stages consist of a set of parallel activities and ends at gates where output of each stage is evaluated (Cooper and Edgett, 2006). In this thesis, gate 2 to 3 (product selection) will be focused.

Gate 1: Idea screen

Stage 1: preliminary investigation: a quick investigation and scoping of the project, market assessment, technical assessment and preliminary business assessment.

Gate 2: Second screen

Stage 2: detailed investigation: includes market research, detail technical and manufacturing assessment, detail financial and business analysis and leads to a business case.

Gate 3: Product/project selection and business approval

Cooper (2006) recently introduced seven NPD principles (lean, rapid, profitable) for high productivity business practices to be applied into the stage gate process with statistical support from APQC. He also mentioned that product innovation and team accountability is also crucial to the success of business NPD process.

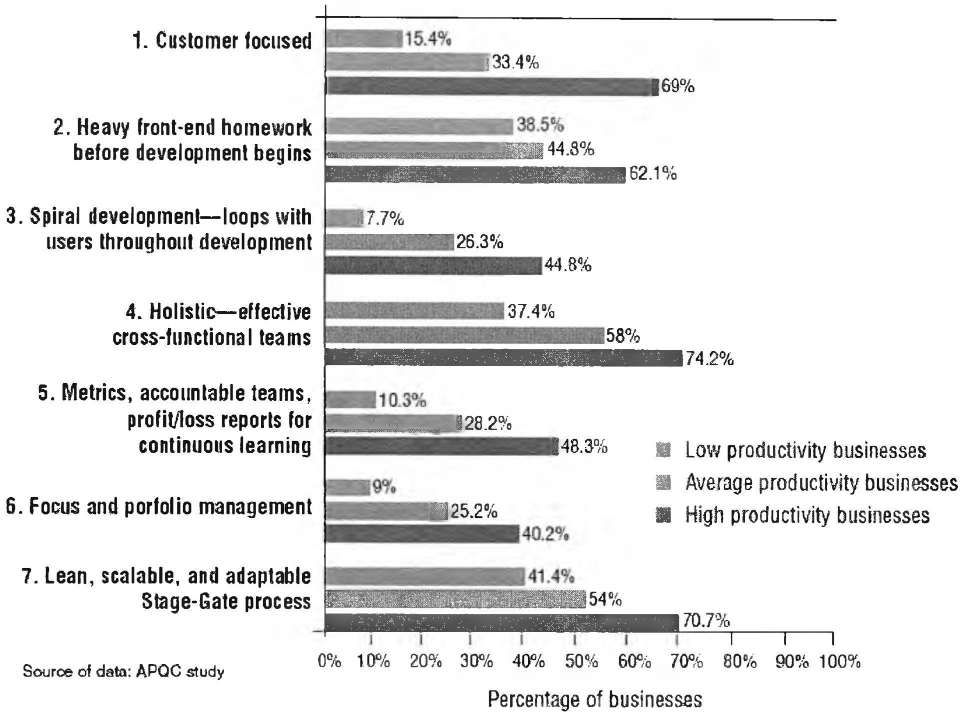


Figure 19: Productivity level and business practice, the seven NPD principles (Cooper, 2006)

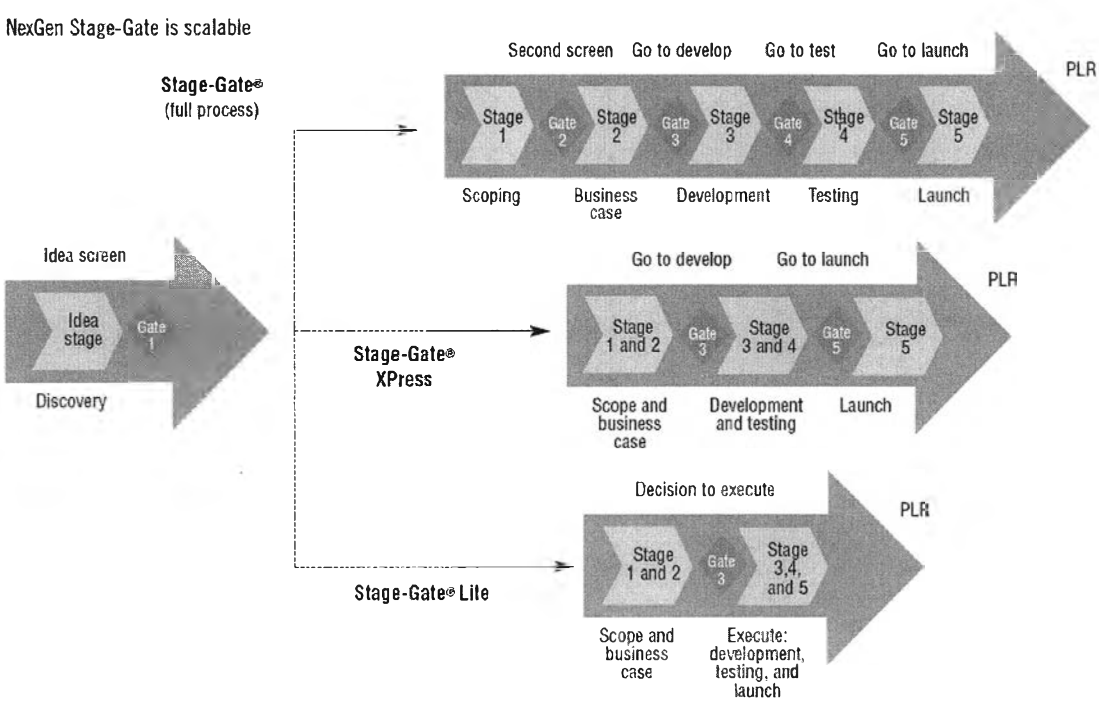


Figure 20: Stage Gate process and its modification process (Cooper, 2006)

Another modified stage gate model is introduced by Ettlie and Elsenbach (2007) with supported data from auto companies who usually applied stage gate into their product development processes. Although the study did not show how stage gate is modified and fit with the firms, the model indicates overlapping of stages where back tracking is possible. The modified stage gate uses virtual team, has adopted collaborative, virtual new product development software tools, used structured process to guide the NPD process as well as has formalized strategies in place.

Another important thing very few study mentioned is the cost management in the stage gate system. Ibusuki (2005) elaborates that all the processes (initial phase, product concept, product requirement specification (include decision to make or buy), decision of style and others) should include cost management considerations within the process as well as at the gates.

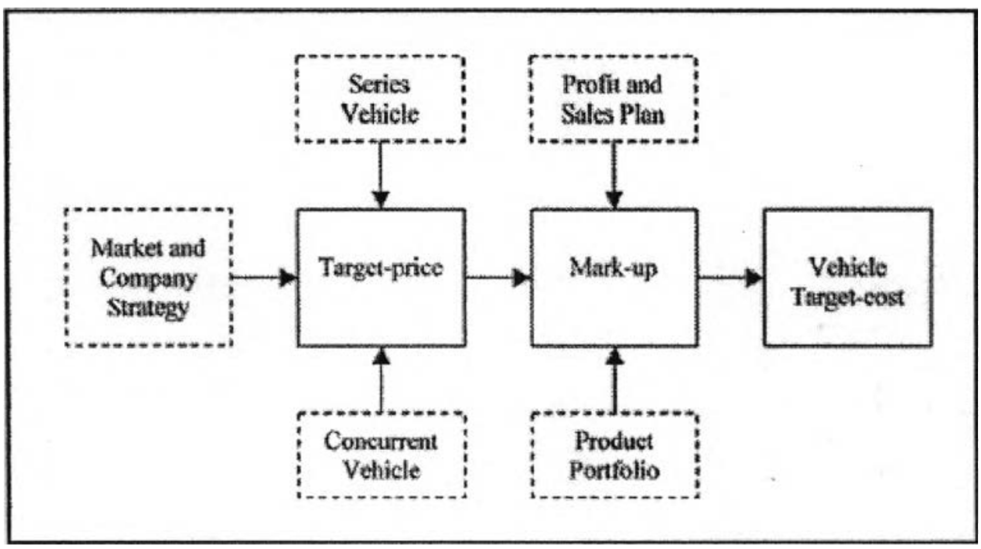


Figure 21: Cost management should be controlled through every stage and gates (Ibusuki, 2005)

2.1.2 <u>Product Planning</u>

The first phase in NPD which ranges from idea generation, initial screening, preliminary evaluation and concept evaluation to either its approval or termination is considered the "product planning" phase. Many studies show that this first phase is the most important phase in NPD as it could help a company to strategically plan its current and future product platforms (Shil and Allada, 2007) and determine the program cost and resource allocation for the rest of the development process (Ulrich and Eppinger, 2000). Watson (2005) identified in a Ford's published study that the 5% design costs of the total life cycle costs actually contributes an affect to 80% of the total product cost. Geraldi and Jayashankar (2006) added that as the marginal cost of remanufacturing decreases, the value of making new products in the first period increases. Once price of OEM is set, the after markets can only hope to attract customer that consider the OEM's price too high. However, there's not yet any fixed method to optimize the estimations and assumptions used in this early development stage. Product planning is a significant source of uncertainty (Stockstrom, 2008) which Cooper (1988) identified this as a "fuzzy" front end.

Even though, the product planning process provided by Ulrich and Eppinger (2000) is in a sequential manner, in practical, it could be overlapped as well as iteration when necessary. The plan could be different depend on the type of product and need a good decision-making tool to include uncertainties (technical uncertainty, market uncertainty and implementation uncertainty) and incorporate the needed flexibility in the decision making process (Shil and Allada, 2007).

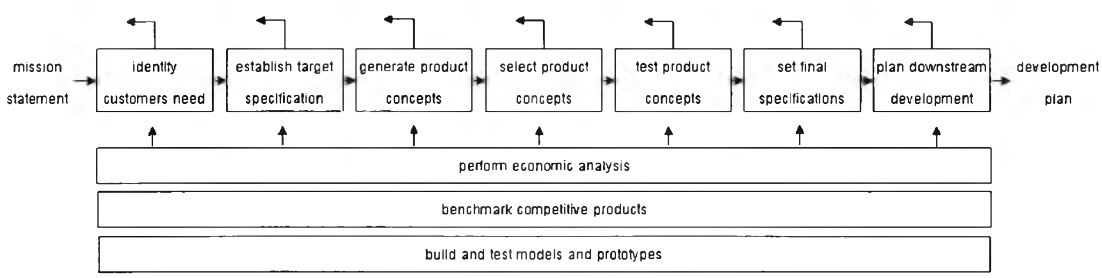


Figure 22: Front end process defined by Ulrich and Eppinger (2000)

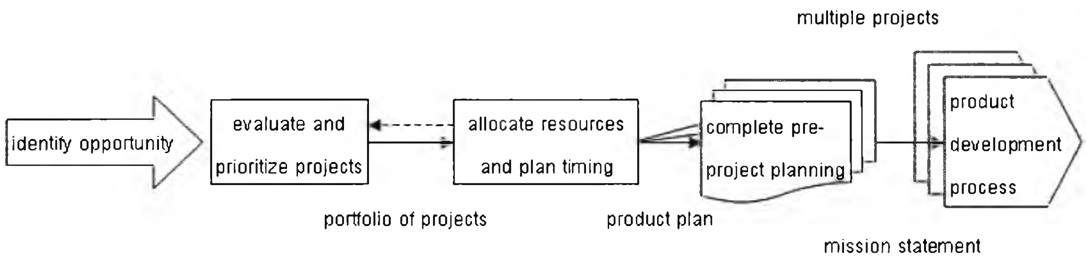


Figure 23: The product planning process (Ulrich and Eppinger, 2000)

Critical factors in product planning process are the optimization between engineering approach (bottom-up) and marketing approach (top-down), the cooperation between the parties and the practice to maintain the process live (Agouridas *et al.*, 2007; Michalek *et al.*, 2005; Shil and Allada, 2007; Whalen, 2007; Arturo, 2005). It is company's challenge to improve the product planning process to reduce development risk, time and cost and to be able to response not only to customer's need and their delighted but also fit to the engineering capability and make profit for the company. Current issues found in the product planning processes are lack of effective design support tool, miscommunication of language used between parties, relationship amongst requirements and the traceability of the requirements (key to systems engineering)

To improve the process, Michalek *et al.* (2005) proposed a mathematical model used to optimize both engineering and marketing targets and then coordinate them together; they called it the Analytical Target Cascading model. The advantage of the model is that the information can be focused and provided a communication and linkage method to the firm's overall objective where necessary. Fang *et al.* (2007) proposed the involvement of supplier proactively from the beginning of the process to reduce cost and improve product's performance from supplier's effort. Customer's participation also can improve the planning process as the key product design objective could become clearer. However, the participation can also lead to conflicts or dysfunctional. An advanced product planning process introduced by Cagan and Vogel (2000) in Vassilis *et al.* (2007)'s study is interesting as it describes the front end detailed step processes clearly.

Output of planning process is to get a brief description of the product, key business goal, target markets, assumptions and constraints that guide the development effort (manufacturing, service, and environment) and stakeholders' commitment to begin designing the new product. The output will also need to justify both financial (variable cost, fixed cost, target price, project life cycle) and non-financial aspects (ability to manufacture, distribute, market and sell of the product). Mentioned by Baker (1995), products which are clearly and precisely specified before the start of development have three times the chance of succeeding than those that do not.

General principles of good product planning defined by Collier (1995) are as below

- A good plan should be rooted in reality
- The plan should be very clear in its objectives
- Strategy thinking should be clear, complete and purposeful
- The product or brand plan should be a working document for the organization
- Good planning should be a learning process
- Leave a room for negotiation

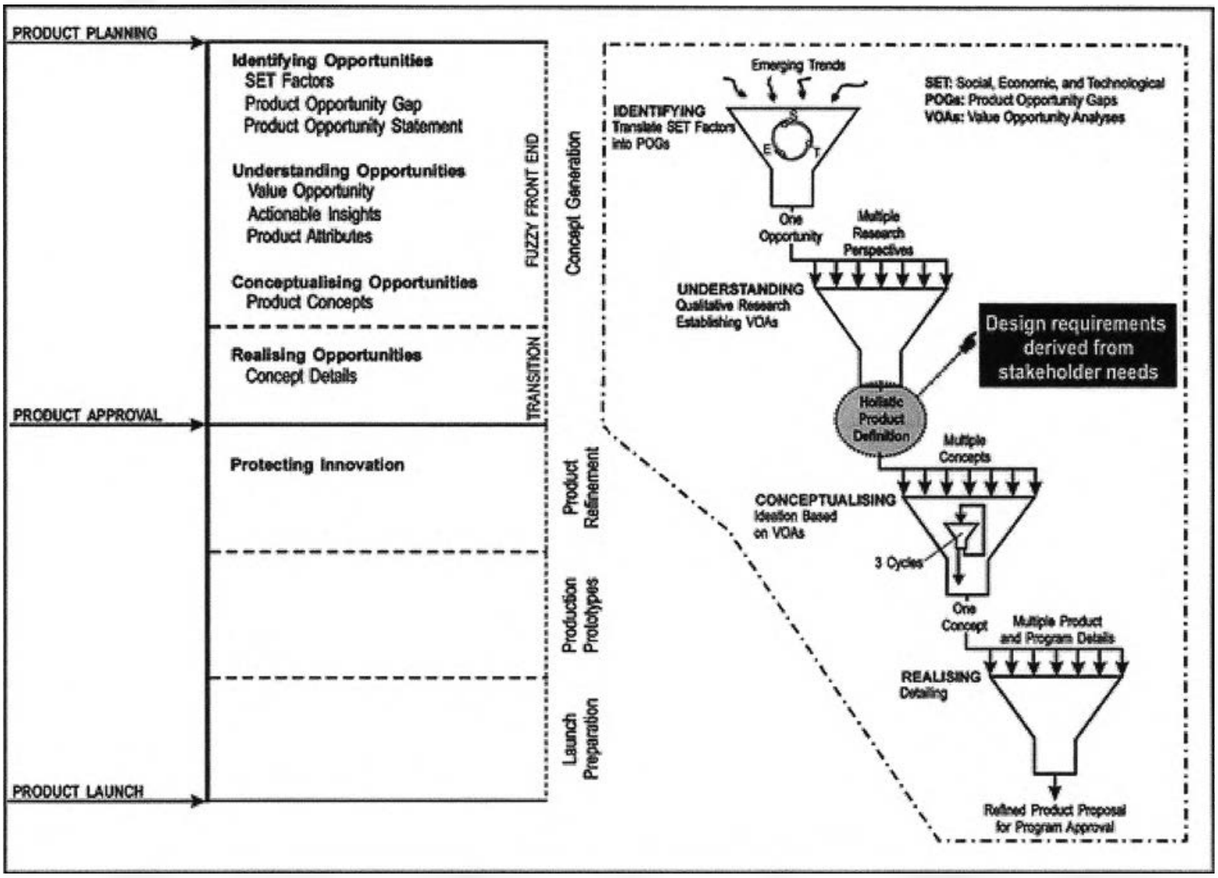


Figure 24: Advanced product planning process (Agouridas *et al.*, 2007)

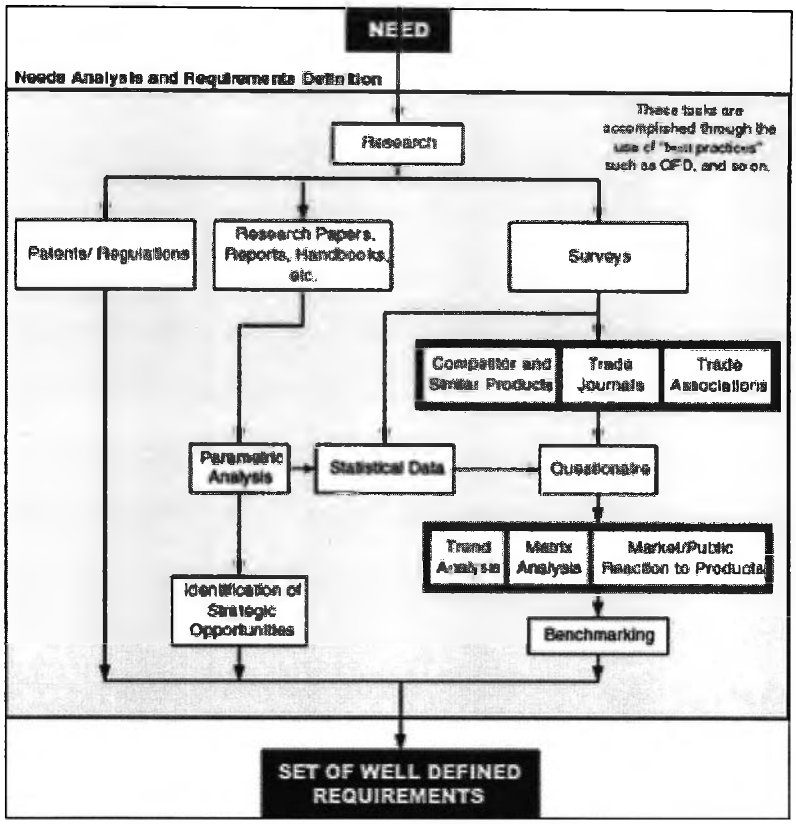


Figure 25: Customer's need analysis (Agouridas *et al.*, 2007)

Marketing Product Planning Subproblem

maximize	**Profit**, and
minimize	**Deviation** from engineering design
with respect to	Price and product characteristic targets,
where	Profit depends on price, demand, and cost, and Demand is predicted using discrete choice analysis and conjoint data.

Product characteristic targets ↓ ↑ Engineering design responses

Engineering Design Subproblem

minimize	**Deviation** from product characteristic targets set by marketing
with respect to	Design decisions
subject to	Engineering constraints
where	Product characteristics depend on the design decisions.

Figure 26: Sub problems of the product planning and engineering design

(Michalek *et al.*, 2005)

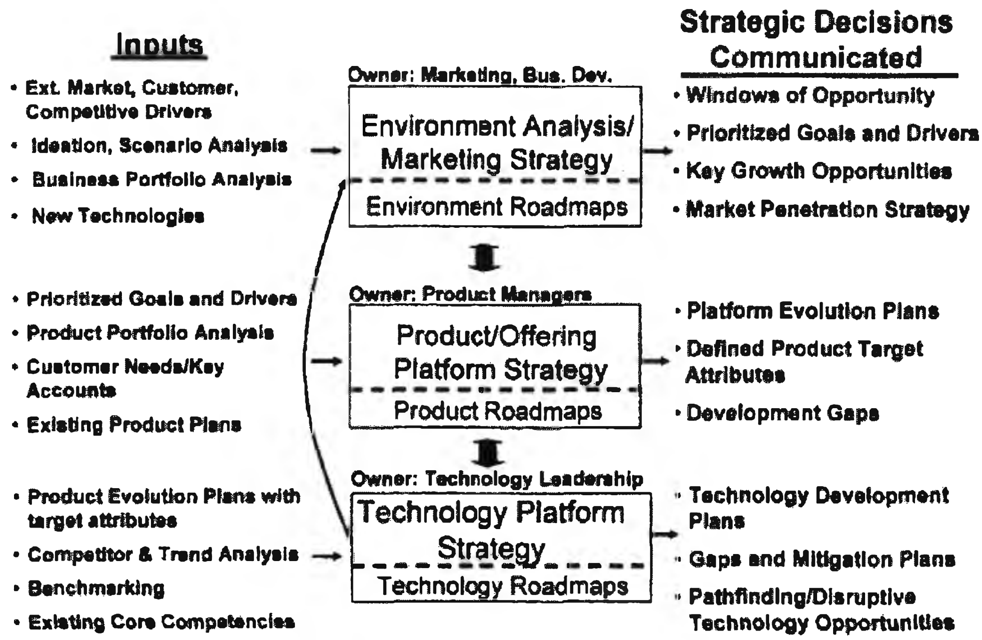


Figure 27: Information required from each business function for general planning process (Whalen, 2007)

2.1.3 <u>QFD</u> (Quality Function Deployment)

Customer focus is the most important constraint when designing a new product or modifying existing product. QFD is one of the model that helps to drive the effectiveness of customer requirement interpretation into product functions and through to manufacturing. Definition of QFD provided by Ford Motor Company is "a system for translating customer requirements into appropriate company requirements at each stage of the product development cycle from research and product development to engineering and manufacturing, sales and distribution". (Ginn and Zairi, 2005 in Miguel, 2007)

QFD was developed in Japan by Akao in the 1960s and 1970s and is a classic tool under TQM (Total Quality Management) umbrella (Al-Mashari *et al.*, 2005; Sanford, 2005; Shiu *et al.*, 2007). QFD was proved to be an easy-to-use and highly systematic qualitative soft method with clear and measurable milestones. It was combined with other tools (supply chain management, Kano model, benchmarking, AHP (analytical hierarchy process) and planning matrix) to fulfil all decision making processes and improves NPD value in all fields and subjects including non-profit organization framework, military service, etc, (Mezey, 2008; Zokaei and Hines, 2007; Bayraktaroglu and Ozgen, 2008; Kumar *et al*., 2006; Jalham and Abdelkader, 2006; Hung Liu and Hung Wu, 2007). QFD approach is provided to control implementation and self-document to facilitate the review, corrective action and organization learning. However, the model requires a huge effort, enforces a linear thinking (Miguel, 2007) and uses a lot of symbols. To quantify imprecise and subjective customer information inherent in the product planning process, Sharma and Rawani (2007) proposed the change of symbols to numerical method. And in the case a company would like to design or modify products that yields most value while minimize resource usage, Kumar *et al*. (2006) suggests QFD integration with bench marking.

2.1.4 Concurrence engineering and collaborative design

As the industry moves toward agile product development and manufacturing, companies have to increase the flexibility and responsiveness of their product design and manufacturing operations while maintain their processes effectiveness. These could be done by a good planning with suppliers, partners and customer involvement in product design, product plan and through the concept design stages (Wu *et al*., 2007; Flavia *et al*., 2005). According to Han and Do (2006), it was called CPDM (collaborative product development management). Johnson and Filippini (2009) thinks a little bit different, they supports the idea of collaborative design and concurrence approach and added that internal integration affects time and product performance differently to external integration (supplier and customer). While external integration can result in less waste and re-work in the supply chain making a faster time to market, internal integration is more focus, effective and safer when developing new products especially with new technologies. Early involvement is encouraged.

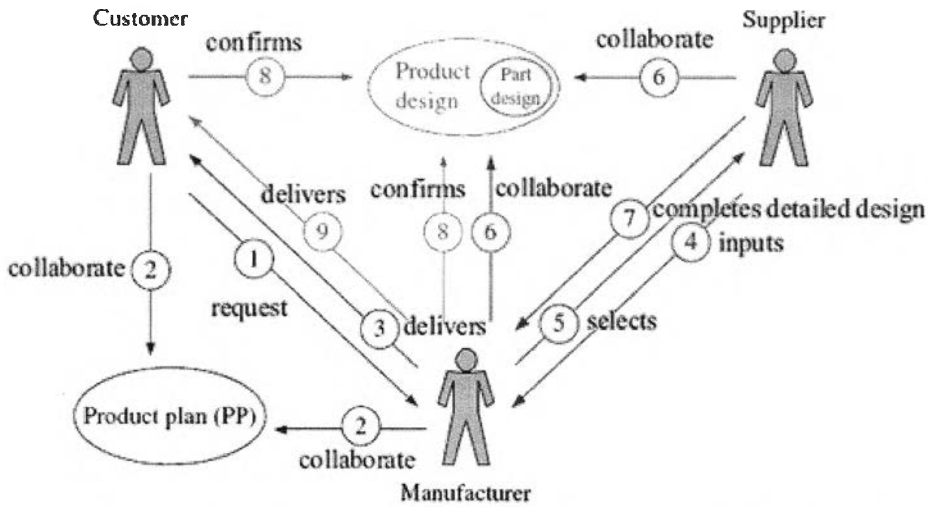


Figure 28: Proposed interaction in collaborative design chain (Wu *et al.*, 2007)

Concurrence engineering and collaborative design importance is obvious when there're studies as well as tools introduced to aid the collaborative processes. One of the common known tools is PLM (Product Life Cycle Management) and the use of CAD/CAM/CAPP (Computer Aided Process Planning) (Siller *et al.*, 2008). PLM could help the integration of process on the engineering side but it could not be linked easily with other functions in the company such as finance, quality control, purchasing, etc. which according to Alisantoso *et al.* (2006) should also been taken into account to the design specification and constraints.

2.1.5 New Product Introduction from marketing point of view

Companies know that new product introduction is very important for them to be able to compete and sustain their position in the market. However, not all products introduced in the markets are successful. Kotler (2000) summarize marketing factors that can destroy products success, they are; high level executives push on favourite idea in spite of negative market research findings, overestimation of market size, bad design products, the product is incorrectly positioned in the market with a non effective advertisement, development cost is higher than expected making product overpriced and the fight back of competitors. According to Kotler (2000), there are also other factors that companies might not be able to control such as, social and governmental constraints and trade barriers, fragmented market, shorter than expected of product life cycle due to customer behaviour changes, fierce competition in the market place which makes the company required shorter development and product introduction process, etc. By these factors, Czinkota (2001) suggested two options to pursue new product development, standardization or adaptation. Standardization can increase economy of scale of production, R&D and marketing while product adaptation suits more to the different customer behaviour pattern and local competition. In the case of high influences of government and regulatory, it is suggested that the company follows product adaptation strategy.

Factors usually included in new product development decisions are

- Product characteristics (brand, packaging, function and feature, durability and quality, installation, maintenance and after sales service and country of origin)
- Company's considerations (profitability, market opportunity, cost of adaptation, policies, resource constrains and organization structure)

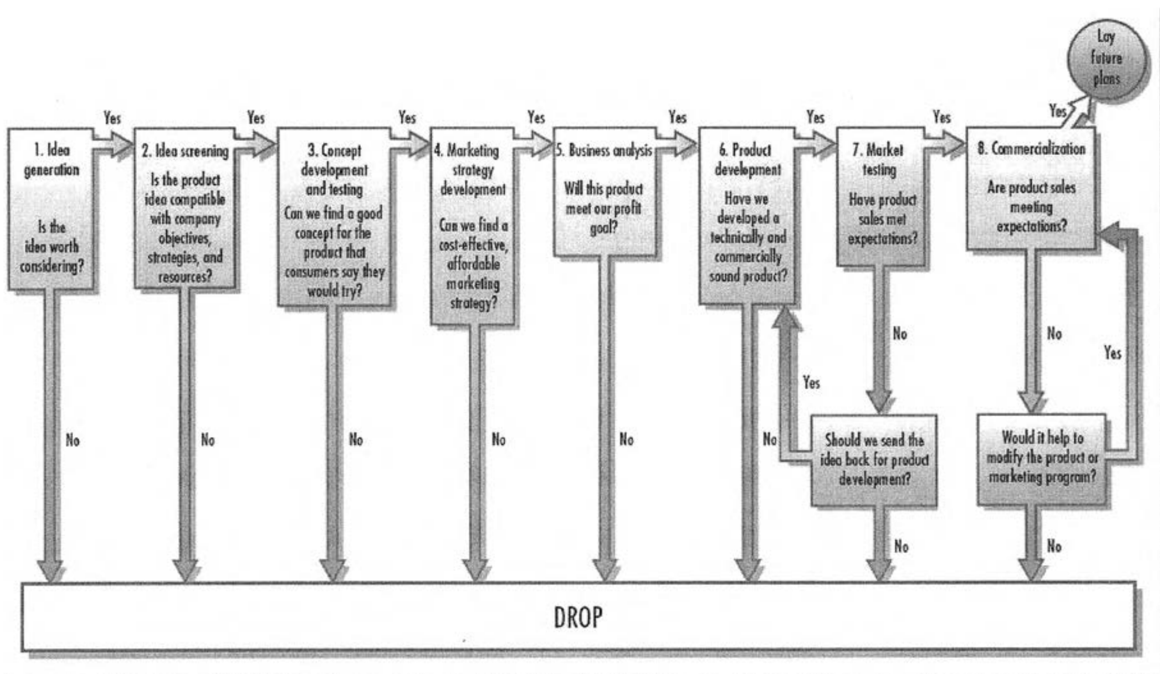


Figure 29: New product development decision process (Kotler, 2000)

2.2 Decision making process

As stated by Harris (1980) in Fulop (unknown), decision making is the study of identifying and choosing alternatives based on the values and preference of the decision maker. From alternatives, the best fit solution with the goal, objective or desire value will be selected. A general decision making process is define as follow.

Define problem

↓

Determine requirements

↓

Establish goals

↓

Identify alternatives

↓

Develop evaluation criteria

↓

Select a decision making tool

↓

Evaluate alternatives against criteria

↓

Validate solution against problem statement

Figure 30: A general decision making process (Adapted from Baker *et al.*, 2001 and Fulop, unknown)

Gates and decision making is one of the most important but difficult to manage part of NPD. The ability to make a sound decision is very important to the success of the project. Schuyler (in Al-Harbi, 2001) makes it a skill that is certainly near the top of the list of project management skills. Decision making is the science of choosing the best alternative within particular constraints (Page *et al.*, 2006). In each situation, choosing criteria can be different, the number of detail steps in the decision making process can also be different. Decision is strongly related to the comparison of different points of view, some in favour and some against a certain decision which means that decision is intrinsically related to a plurality of points of view, which can roughly be defined as criteria (Figueira *et al.*, 2005). Decision making process varies from three steps of problem formulation and objective setting, identification and generation of alternative solutions, and analysis of a feasible alternative (Cyert and March, 1963 and Mintzberg *et al.*, 1976 in Nooraie, 2008) to the five steps suggested by Fredrickson (1984) in Nooraie (2008) as situation diagnosis, alternatives generation, alternatives evaluation, selection, and integration or eight steps general decision making process as stated earlier. The decision maker or gate keeper is important that he or she should have the capability, experience, professionalism as well as able to recognize the opportunity and threats (Page *et al.*, 2006). Imperfect knowledge from uncertain, imprecise, poorly understood, state of context at the time the decision is implemented, the fuzzy or incomplete, unstable system, and others can be considered problems when formulate decision process. (Roy B. in Figueira *et al.*, 2005). Roy's recommendation is to delimiting a domain of reasonable instantiation values for various data and parameters and to build a set of scenarios for different possible future contexts or eliciting a set of weight vectors within the nature of the overall evaluation model. Preference or nearest possible solution is the goal of the decision making process.

Example of factors usually included in the decision making process are customer requirements, market trend, regulatory, resource allocation feasibility, technological innovation and technology road map, competitor analysis, company's strategic requirement, financial performance, market incentives and risks, cost effectiveness of the project, etc. (Cooper, 2009; Johal *et al.*, 2007; Millett, 2006; Cohen *et al.*, 1998)

Mentioned by Saunders *et al.* (2005), the initial screening is not set up to eliminate projects but to allow as many possible projects to have the chance to move to the next NPD stage. Then the later stages, looking into more detail criteria, should be able to evaluate and eliminate those unsuccessful projects before they incur excessive costs. Generally, decision making is done by a group of management, so it could be called a group decision making according to Yahaya and Abu-Bakar (2007). Advantage of having a group decision is that a greater array of ideas and options will show up. However, sometimes, the decision was driven by plausibility rather than accuracy.

Not only that the project selection (first to third gates in NPD), considered an investment, is critical, project prioritization, right project mixed and balance of resource are also key issues to gates management (Cooper *et al.,* 2004). A study by Nooraie (2008) indicates that a better quality decision which yields to better final result can be achieved when a company has rational decision making process especially when the project impacts the organization's strategic plan. A disciplined decision making process will provide a structure approach to complex problems, a rationale and consistency of decision making as well as a good documentation for repeatable, reviewable and easy to understand (Baker *et al.*, 2001). Additionally, gates should be flexible enough to allow adaptation when conditions and situation change. They should also fit with a combination between "deliberate" and "emergent" strategic planning (Dibrell *et al.,* 2007; Samra *et al.,* 2008). (Deliberate approach to strategic planning describes as top-down, rigid, mechanistic and efficient plan while emergent is informal, flexible and empowering). Potential problems restricting successful strategic decision making was studied by Taslak (2004). They are conflicts and poor communication, inadequate training, skill and characteristics of the decision maker, mission and goal uncertainty, lack of participation, uncertainty from external forces and insufficient information. Yahaya and Abu-Bakar (2007) agree with the idea that decision making depend on the reliability of the source data and the disciplines of the gate keeper.

There are several ways to go through gates process; the company can use a score card, house of quality (QFD process) or complicated mathematical model. A model proposed by Ritcher and Schmidt (2005) and Panagiotou (2008) is shown below.

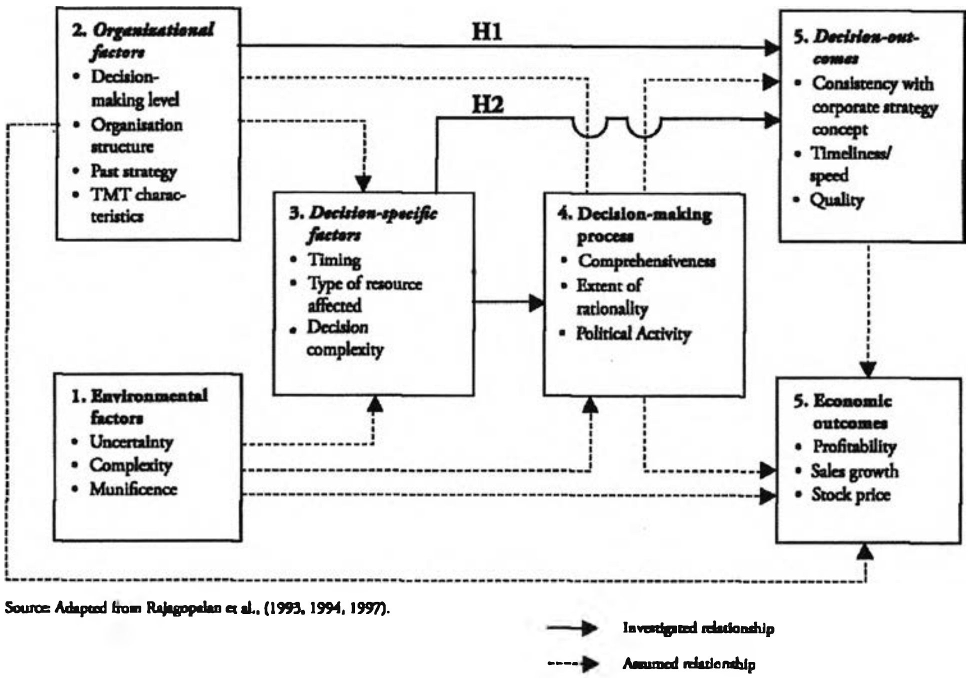


Figure 31: Scope of quantitative analysis within strategic decision-making model

(Ritcher and Schmidt, 2005)

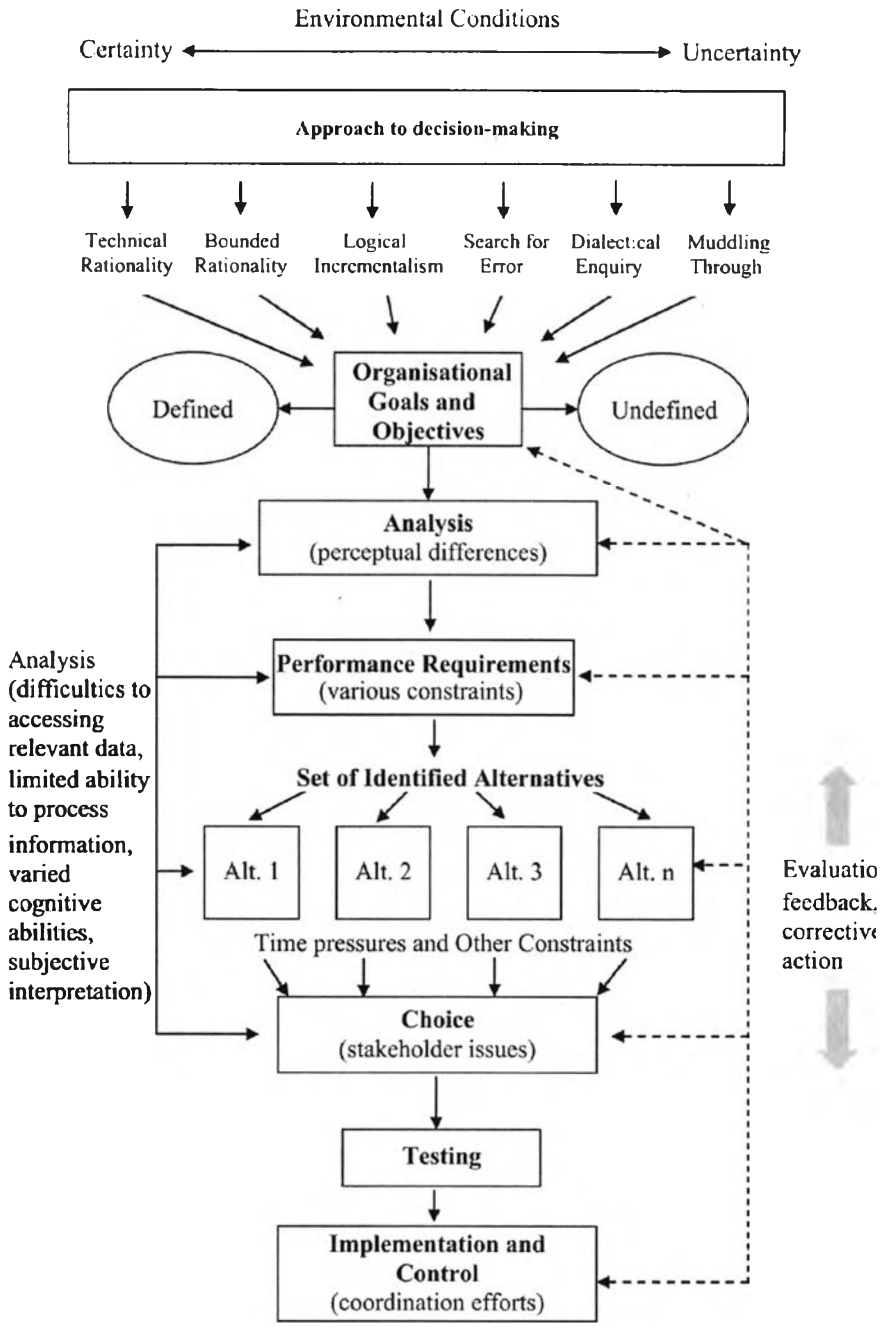


Figure 32: A holistic framework of decision making process (Panagiotou, 2008)

2.2.1 Multi-Criteria Decision Making method

Most of the time, more than one criteria/factor are used to define the decision making process and constraints where optimal strategy is required. An MCDM (Multi-Criteria Decision Making) method is introduced as a model to be used when intuitive decision making is not enough for several reasons: because of the conflicts between criteria or because of disagreement between decision makers about relevant criteria or their importance and about acceptable alternatives and preferences (Sharifi *et al.*, 2006).

Peniwati (in Saaty *et al.*, 2006) stated that a successful analysis depends on the faithfulness of judgment elicitation, psychophysical applicability and the depth of analysis. She provides useful information on what criteria to consider when choosing decision making method, her comparison study considered group maintenance, problem abstraction, structure, analysis, fairness, applicability, validity and truthfulness of decision making methods. Her summary is shown in table 4.

Two of the most popular methods are MAUT (Multi-attribute Utility Theory) and AHP (Analytic Hierarchy Process). The MAUT method according to Fulop (unknown) and Baker *et al.* (2001) is a utility function that transform raw performance value of alternatives against diverse criteria, both factual (objective, quantitative) and judgemental (subjective, qualitative) to a common dimensionless scale that aggregate preferences. There are two types of method in this category; they are Weight Sum Method (WSM) and Weighted product method (WPM). The difference is that the WSM should be used when decision criteria are in identical units while WPM usually is a dimensionless analysis, however, in many real life MCDM problems, criteria maybe expressed in different dimension units as well (Triantaphyllou and Sanchez, 1997). Baker *et al.* (2001) describe that the AHP method is a pair wise comparison of alternatives based on the basis that humans are more capable of making relative judgement than absolute judgements. For complex decisions with multiple criteria and alternatives, MAUT, which additional alternatives can be freely added, is more flexible comparing to AHP.

Table 4: Comparison of Group Decision Making Methods (Peniwati in Saaty *et al.*, 2006)

Method	Group Maintenance		Problem Abstraction		Structure		Analysis	
	Leadership Effectiveness	Learning	Scope	Development of Alternatives	Breadth	Depth	Faithfulness of Judgments	Breadth and Depth of Analysis (What if)
Structuring								
Analogy, Association	Low	Medium	Medium	Low	NA	NA	NA	NA
Boundary Examination	Medium	Medium	High	Low	NA	NA	NA	NA
Brainstorming/Brainwriting	Low	Low	Low	Medium	NA	NA	NA	NA
Morphological Connection	Low	Medium	High	Very High	NA	NA	NA	NA
Why-What's Stopping	Medium	Medium	High	Very High	High	High	NA	NA
Ordering and Ranking								
Voting	Low	Low	NA	NA	Low	Low	Low	Low
Nominal Group Technique	Medium	Medium	Medium	High	Low	Low	Low	Low
Delphi	Medium	Medium	Medium	High	Low	Low	Low	Low
Disjointed Incrementalism	Medium	High	Medium	Medium	High	Low	Medium	Medium
Matrix Evaluation	Medium	Medium	Medium	Low	High	Low	Medium	Medium
Goal Programming	Low	Low	Medium	Low	High	Low	Very High	Medium
Conjoint Analysis	Low	Low	Medium	Low	Low	Low	Very High	Medium
Outranking	Medium	High	Medium	High	High	Low	Medium	High
Structuring and Measuring								
Bayesian Analysis	Medium	High	Medium	Low	Low	Low	Very High	Medium
MAUT/MAVT	Medium	High	Medium	High	High	Low	High	High
AHP	High	Very High	Medium	Very High	High	High	Very High	Very High
ANP	High	Very High	Medium	Very High	High	Very High	Very High	Very High

NA = Not Applicable

Table 4 (continue): Comparison of Group Decision Making Methods (Peniwati in Saaty *et al.*, 2006)

	Fairness			Applicability, Validity, and Truthfulness				
Method	Cardinal Separation of Alternatives	Prioritizing Group Members	Consideration of Other Actors and Stakeholders	Scientific and Mathematical Geneality	Applicability to Intangibles	Psychophysical Applicability	Applicability to Conflicy Resolution	Validity of the Outcome (Prediction)
Structuring								
Analogy/Association	NA	NA	NA	NA	NA	NA	NA	NA
Boundary Examination	NA	NA	NA	NA	NA	NA	NA	NA
Brainstorming/Brainwriting	NA	NA	NA	NA	NA	NA	NA	NA
Morphological Connection	NA	NA	NA	NA	NA	NA	NA	NA
Why-What's Stopping	NA	NA	NA	NA	NA	NA	NA	NA
Ordering and Ranking								
Voting	Low	Low	NA	Medium	NA	NA	NA	Low
Nominal Group Technique	NA	NA	NA	Medium	NA	NA	NA	Low
Delphi	NA	NA	NA	Medium	NA	NA	NA	Low
Disjointed Incrementalism	NA	NA	Medium	Low	Low	Low	NA	Medium
Matrix Evaluation	NA	NA	Medium	Low	Low	Low	NA	Medium
Goal Programming	High	NA	Low	Medium	Medium	NA	NA	Low
Conjoint Analysis	High	NA	NA	Medium	Medium	NA	NA	Low
Outranking	High	High	Low	Medium	Medium	Medium	NA	Medium
Structuring and Measuring								
Bayesian Analysis	High	NA	Low	High	Medium	Low	NA	Medium
MAUT/MAVT	High	High	Medium	High	Medium	Medium	Medium	Medium
AHP	High	Very High	High	High	Very High	Very High	High	High
ANP	Very High	Very High	High	High	Very High	Very High	High	High

NA = Not Applicable

There are also many commercialized software available for companies to choose from. However, they may not always fit into all business settings and usually management considerations which should be absorbed in the model are not included (Kwak *et al.*, 2005) MCDM model is widely used through industries and government sectors. An example of the used of the model is for strategic vendor selection by Shyur and Shih (2005). Shyur and Shih (2005)'s study formulates a vendor evaluation process by combining multi-criteria decision making (MCDM) with a five-step hybrid process incorporates the technique of an analytic network process (ANP), an extension of analytic hierarchy process (AHP), in order to obtain a set of suitable weights of the criteria. Shyur and Shih (2005) added that AHP only valuable when decision-making framework has a unidirectional hierarchical relationship among decision levels. It is not practically usable if the number of alternatives and criteria is large, since the repetitive assessments may cause fatigue in decision making. However, in the real world, criteria are usually interdependent on each other.

In regional planning of aquaculture development paper presented by El-Gayar and Leung (2001), an MCDM framework is used to seek a desirable allocation of resources and activity levels while balances various development goals. They mentioned two MCDM techniques in finding target values to support the decision making model. The techniques and considerations are as follow.

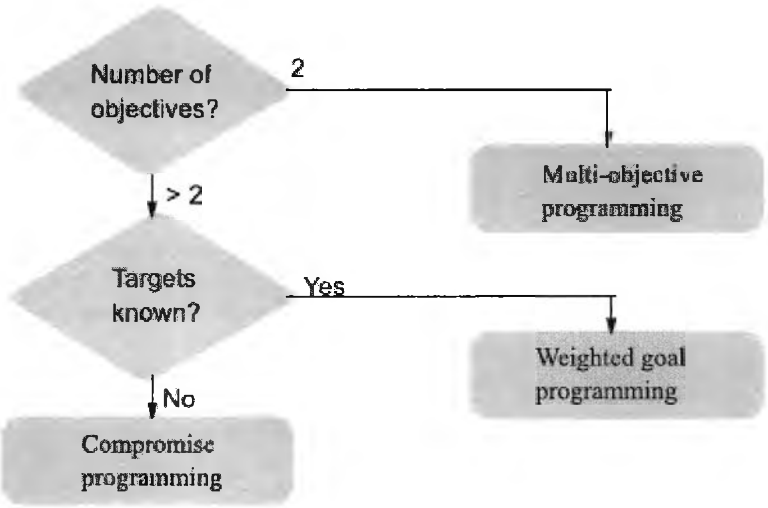


Figure 33: MCDM techniques (El-Gayar and Leung, 2001)

Another sample of MCDM's use incorporating AHP process is the AHP application in project management by Al-Harbi (2001). AHP aims at quantifying relative priorities for a given set of alternatives on a ratio scale. It is based on the judgment of the decision maker, and stresses the importance of the intuitive judgments of a decision maker as well as the consistency of the comparison of alternatives in the decision making process. Al-Harbi (2001) added that brain storming and sharing ideas and insights often leads to a more complete representation and understanding of the issues and the criteria to be used in making decisions.

2.2.2 <u>Sensitivity Analysis</u>

Biases and estimations can discredit the confidence of the model's outcome. It is often found that model parameters are unavailable but populated by expert opinion or best guesses. Sometimes the results may also be contrary to the expectations. A way to check whether or not the model result is reasonable and robust is to conduct sensitivity analysis which is considered a deterministic tool. (Shaw and Zachry, 2002, Wallace, 2000). Sensitivity analysis can be carried out to study the model's sensitivity to both parameter value and model structure. In this thesis parameter value will be focused. A conventional sensitivity analysis can be done by varying a model parameter while observing the result variation. In the case that there's a reasonable range of parameter value that makes a consistent result, the strategy seems to be robust. However, conventional sensitivity analysis also has limitations. According to Shaw and Zachry (2002), conventional sensitivity analysis is difficult to interpret and present in graphical form, alternative values used in order to vary the parameters can also create a potential selection bias and by varying one parameter at a time did not account potential parameter interactions. They suggest the use of Monte Carlo simulation instead.

Only a small change in weight can change the optimal alternative to change and decision maker can calculate the switchover or break even points or what is the smallest change on weight criterion such that the alternative changes occur. (Barron and Schmidt, 1988 and Ven and Edwards, 1986 in Triantaphyllou and Sanchez, 1997)

Butler *et al.* (1996) uses a high dimensional sensitivity analysis to conduct sensitivity analysis on weights applied to decision model parameters. According to them, there are three techniques decision maker can use. Random weighting where weights are completely random, Rank order weights where random weights but consider the importance of attributes rank as restricted domain and Response distribution weights where weights are randomly assigned in the interval given by the decision maker. These assessed weights are subjected to response error.

Another recent study in improving a multi-criteria decision model using integrated sensitivity analysis to the model is proposed by Chen *et al.* (2009). They used MATLAB program to help explore the dependency of model output on input parameters and show the impact of changing criteria weight in spatial dimensions.

Triantaphyllou and Sanchez (1997) mentioned that one of the major problems of sensitivity analysis is how to determine the most critical criterion which doesn't need to be the highest weight criterion but the weight that has the highest effect on the alternative rank changes. They also found that the sensitivity importance of any weight reduces gradually as the number of decision criteria in the problem increases and the number of alternatives has very minor practical influences.

2.3 Regionalization and Globalization

A global industry is an industry in which the strategic positions of competitors in major geographic or nation markets are fundamentally affected by their overall global positions. A global firm is a firm that operated in more than one country and captures R&D, production, logistical, marketing, and financial advantages in its costs and reputation that are not available to purely domestic competitors, Kotler (2000). Global strategy involves global market participation, product standardization, uniform marketing, integrated competitive move and coordination of value adding activities, (Shaoming, 1994).

Despite the media hype about global brands and global business, the world economy is fundamentally regional (Cayla and Eckhardt, 2007). There are many theories introduced about regionalization, Porter's theory of cluster, Krugman's new economic geography, Piore and Sable's theory of collaborative economies, etc. The regionalization marketing and production advantages become obvious when Europe introduced a "single market" strategy in 1990s. Some of the advantages are, the economy of scales to produce high-quality products at lower cost, quick and larger capital investment and worldwide distribution system sharing (Shaoming, 1994). There were also evidences that the regionalization tends to expand from and to advance countries first (Collier, 1995). Furthermore, studies between established markets (North America/Europe/Japan) and new markets (East Europe/India/China) are different and sometimes are not comparable or compatible (Fleischmann *et al.,* 2006; Condo, 2000). However, with internet and global communication network, the lag between lead country and the followers are reduced and thus make the port folio management easier (Mayer and Vambery, 2008).

The main challenge of economic development of region (or country) according to Rucinska (2007) is to create conditions for fast and sustainable growth of productivity. Porter (1998) also supported this argument and insists that competitiveness actually means productivity and that almost everything does matters for competitiveness. He also mentioned that a company usually grows from a factor-driven economy (focus on input cost) to investment-driven economy (focus on efficiency) then to innovation-driven economy (focus on unique value)

According to Collier (1995), factors that influence the decision for regionalization or globalization of markets are

- Customer basic needs and requirements (technology/fashion) have to be fairly homogeneous
- There has to be some economic or corporate rationale for companies to want to do
- The company must be able to operate this way (there are barriers such as national standards or approval procedures, tariff or quota restrictions, language, culture and traditions)

- Home market and the person managing the plan is important (true international managers often the key to international marketing success)

Most people think of Asian region, becoming a major economic centre, as a one-market. Conversely each country is completely different (Cayla and Eckhardt, 2007). Even though globalization trends seem to be emerging into Asia, the cultures and ways of living are still different especially outside of big cities. It is then companies' challenges in pursuing regionalization plan in Asia. According to Cayla and Eckhardt (2007)'s study in regional branding, two major challenges in Asia are the negative country of origin perception (low price - low quality) and the regional positioning being inherently fragile. The recommendations are either to focus on modernity, to capitalize Asian pride and confidence or to use western stamps of approval to signal to Asians the viability of the brand. Achieving a balance between global consistency and local relevance which requires enormous amount of change in the routines and structures of the organization is never easy but can be done (Wills *et al.,* 1991; Chetty and Campbell, 2004).

An issue of being regional or global is the ability and resource availability of a company to do so. A transparent strategy and good team (creating mutual trust) is important (Karandikar and Nidamarthi, 2006). Here, middle management has critical role to play in managing the processes of knowledge management and resource allocation flexibility across time-zones, multi-cultural, intellectual property protection and many more. Cost can be a temporary advantage but can not be the sole basis of a long term strategy for distributing engineering effort.

As innovation of a company becomes important, the process of internationalisation or regionalization has to support innovation as well. Park (2002) proposed five policy in promoting innovation and regional competitiveness. They are promoting region-specific clustering, building habitats for innovation and entrepreneurship, collective learning processes and innovation networks, building a stock of social capital and promoting local and global networks. Companies anchored in such clusters can yield, on average, high productivity than isolated companies and also benefit from greater innovative strength (Schiele, 2008).

Interesting study by Chetty and Campbell (2008) founds that internationalisation is not always a forward progression and firms in fact, leapfrog into internationalisation rather than doing so gradually which is contrasted to the traditional four stages to internationalisation. They also stressed the importance of time management in internationalisation and the knowledge management in two ways, the acquired of knowledge from new market a company expanded to and the knowledge and experiences a company wanted to adapt to the new market. Additionally, it was found that (Chetty and Campbell, 2004) global firms are more ready to identify and exploit new opportunity than regional firms as they are more experienced and structured. Firms can also improve their competitiveness by learning from the country they expanded to as well.

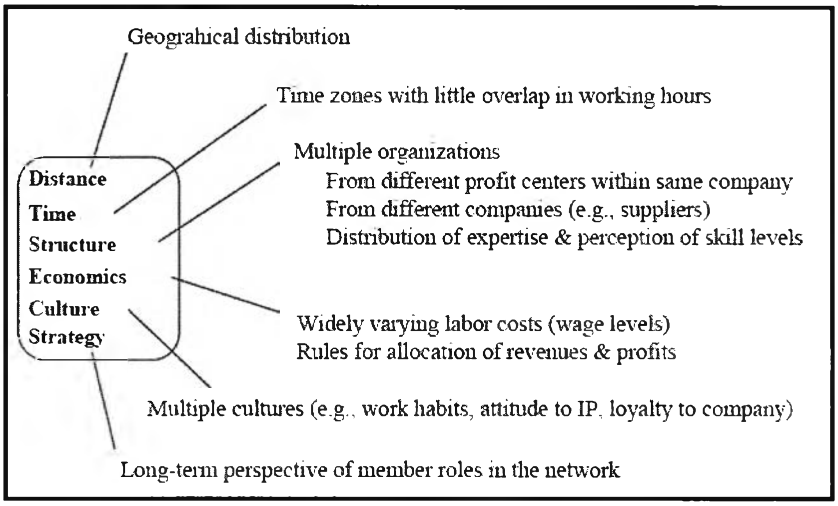


Figure 34: Factors related to regionalization plan (Karandikar and Nidamarthi, 2006)

In making corporate regional strategy, Porter (1998) suggests the company not to abandoned local competitiveness. He mentioned innovating to offset local factor disadvantages is better than outsourcing, developing domestic suppliers and buyers is better than relying solely on foreign ones as company will not sustain the competitive advantage in the long run. The correct approach according to Porter for globalization is to tap selectively into sources of advantage in other nations.

An example of Porter's approach is Honda's globalization strategy which has 3 steps, (Porter, 1998), first they turn market preference to the characteristics of its own products and away from competitors, and then they sustain the growth by enticing customers with the upper level of its product line. Lastly, it explores the economy of scale through both centralized manufacturing and logistics.