Faculty of Manufacturing Engineering

CONCURRENT PRODUCT DEVELOPMENT PROCESS, PROJECT, AND PERFORMANCE OF MALAYSIAN CAR MANUFACTURER

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CONCURRENT PRODUCT DEVELOPMENT PROCESS, PROJECT, AND PERFORMANCE OF MALAYSIAN CAR MANUFACTURER

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DECLARATION

I declare that this thesis entitled "Concurrent Product Development Process, Project, and Performance of Malaysian Car Manufacturer" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

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ABSTRACT

New product development (NPD) has become more challenging with the increase in demand fluctuation, and technology advancement to cater to quality product performance, product customization and shorter lead time expectation. Thus, it is a norm for a manufacturer to establish its own formal NPD for these reasons. With concurrent engineering (CE), the manufacturer creates an enabling environment for effective and efficient NPD. The minor manufacturers are believed to have a different strategy of NPD from the major players in the automotive industry due to a limited pool of resources, and the target market. As such, the purpose of this study is to explore the NPD process and project of PROTON Sdn Bhd (PROTON) that is scant. Further, to have optimum NPD performance, the players in the automotive industry must overcome the moderate effect of project characteristics. For this, an investigation is done to identify how the formal NPD of PROTON mitigates the project characteristics. This study also considers the development of a measuring tool for NPD performance. Finally, analyses are carried out to verify the effect of formal NPD, CE best practices, co-development, and project characteristics on two NPD project goals: development time and cost. The findings obtained from scholarly articles enable the questionnaires for semi-structured personal and group interviews to be developed. Prior to the interviews, the questionnaires were pre-tested to confirm the intention of the questions being asked and avoid ambiguity. The findings from both interviews allow for the NPD process and project of PROTON to be outlined and defined. Besides, some variables were introduced and investigated through a survey, involving voluntary respondents. The investigation includes non-parametric statistical analyses in which the descriptive statistical analysis was used to investigate the influence of the selected variables on both project goals. Meanwhile, the associations between variables and their impact on the project goals were also investigated using inferential statistical analysis. The findings indicate that generally, the NPD process of PROTON is not that much different from the established NPD of other manufacturers in terms of the main development phases and tasks where the development tasks are executed in parallel by many related functions. As for the NPD project, there are five types of development projects that are normally done by PROTON. It is found that PROTON refers to the project characteristics based on the change contents of the vehicle and power train. In the meantime, the NPD performance matrix was successfully developed and tested through a feasibility study. It was named “Boejang Performance Matrix” (BPM) and enables the management to make a decision on specific NPD project performance. The effect of those selected variables on, and their association with the project goals are found to be according to the existing theories, except for the incremental innovation as for PROTON of which the research and development (R&D) capability is weak, the incremental innovation is actually not a significant threat to the project performance. Therefore, a formal NPD is crucial for both minor and major car manufacturers, and it helps to reduce the negative effects of project characteristics for optimum NPD performance and product success.

ABSTRAK

Pembangunan produk baru menjadi sangat mencabar disebabkan oleh ketidaktentuan permintaan pelanggan, dan perkembangan kemajuan teknologi yang didorong oleh kualiti produk yang tinggi, produk terlanggan, dan tempoh masa pembangunan yang pendek. Menjadi sesuatu yang normal kepada sesebuah pengeluar produk untuk membangunkan dan mengadaptasi proses pembangunan produk yang formal dan jitu. Melalui adaptasi strategi kejuruteraan serentak dalam pembangunan produk, pengeluar produk menyediakan pemangkin yang mampu menjadikan proses pembangunan produk lebih efektif dan efisyen. Pengeluar-pengeluar kecil kenderaan pastinya melaksanakan strategi berbeza bagi menghadapi kekangan akibat kekurangan sumber dan suasana pasaran yang berbeza. Justeru, tujuan kajian ini adalah untuk mengeksplorasi proses pembangunan produk yang diamalkan oleh pengeluar kecil kenderaan di Malaysia iaitu PROTON Sdn Bhd (PROTON). Di samping itu,untuk mendapatkan prestasi yang optimum pengeluar kenderaan mestilah mengatasi kesan dan cabaran dari ciri-ciri projek. Penyelidikan ini turut melibatkan pembangunan satu alat pengukuran bagi menilai prestasi proses pembangunan produk. Kajian ini turut bertujuan menganalisa kesan proses formal pembangunan produk, kejuruteraan serentak, dan penglibatan pembekal ke atas objektif-objektif projek pembangunan produk: jangka masa pembangunan dan kos. Berdasarkan kepada kajian literatur, soalan untuk tujuan kaedah temuduga secara individu dan juga berkumpulan telah dapat dirangka. Sebelum kedua-dua proses temuduga dijalankan, soalan-soalan temuduga telah diuji terlebih dahulu bagi memastikan kefahaman terhadap tujuan soalan dan mengelakkan kesamaran atau kekeliruan. Hasil dari sesi kedua-dua temuduga, prosess dan projek pembangunan produk baru telah dapat dikenalpasti. Beserta kajian ini, pengenalan kepada beberapa faktor-faktor baru turut dilakukan. Kajian meliputi kesan faktor-faktor ini terhadap objektif projek dan hubungkait di antara factor-faktor tersebut. Melalui analisis statistik, kesan dan hubungan antara faktor-faktor ini dengan objektif projek dapat dikenalpasti. Melalui kajian statistik juga didapati proses pembangunan produk yang dilaksanakan oleh PROTON tidak jauh berbeza dengan proses yang diamalkan oleh pengeluar kenderaan yang utama. Terdapat lima jenis projek pembangunan produk yang dilaksanakan oleh PROTON. Hasil kajian juga menunjukkan bahawa PROTON merujuk ciri-ciri projek pembangunan berdasarkan kepada kandungan perubahan yang melibatkan rekabentuk kenderaan dan enjin. Hasil penyelidikan ini juga satu alat bagi mengukur prestasi proses pembangunan produk dapat dibangunkan. Ianya dikenali sebagai "Boejang Performance Matrix". Ianya dapat membantu pihak pengurusan menilai prestasi proses pembangunan produk bagi projek tertentu.

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LIST OF ABBREVIATIONS

AFTA	-	ASEAN free trade area
AM	-	Additive manufacturing
AP	-	Approval permit
B.O.M	-	Build of materials
CAD	-	Computer aided design
CAE	-	Computer aided engineering
CAM	-	Computer aided manufacturing
CBU	-	Complete built-up
CE	-	Concurrent engineering
CKD	-	Completely knocked down
CNC	-	Computer numerical control
DFM	-	Design for manufacture
EC	-	Engineering consultant
GPS	-	Guideline for project scope and size
HICOM	-	Heavy industry corporation of Malaysia
IDT	-	Integrated development team
INO	-	Incremental innovation
LRPP	-	Long-range product planning
MF	-	Model fixed
MAA	-	Malaysia Automotive Association

MCP	-	Mule car program
MMC	-	Mitsubishi Motor Corporation
MyCC	-	Malaysia Competition Commissioner
NAP	-	National automotive policy
NCP	-	National car project
NPD	-	New product development
NPI	-	New product introduction
PMO	-	Project management office
PPC	-	Product – process complexity
PROTON	-	Perusahaan Otomobil Nasional Sdn. Bhd
R&D	-	Research and development
SI	-	Supplier involvement
SE	-	Simultaneous engineering
TMS	-	Top management support
TTM	-	Time-to-market

LIST OF PUBLICATIONS

Published Journal

1. Boejang, H., Hassan, M. Z., Mokudai, T., Ariff, H. and Esa, S., 2019. Measuring Effectiveness and Efficiency of a New Product Development Project Using Performance Matrix – The PROTON case. *IOP Conference Series: Material Science and Engineering*, 627(1), pp. 1-7. Scopus Indexed.

2. Boejang, H., Hambali, A., Hassan, M. Z., Esa, S. and Rauterberg, M., 2017. An Exploration of the New Product Development Process of Malaysian Small-Sized Automaker. *Journal of Advanced Manufacturing Technology*, 11(2), pp. 33–46. Scopus Indexed.

Submitted Journal

1. Boejang, H., Ariff, H., Hassan, M. Z., Esa, S. and Rauterberg, M. Dealing with Project Characteristics Through Concurrent Product Development by Malaysian Car Producer. *International Journal of Emerging Trends in Engineering Research*. Scopus indexed.

Copyright

1. Boejang Performance Matrix.

CHAPTER 1

INTRODUCTION

This chapter explains the context of the research work and the motive why this research is significant, particularly to the first Malaysian car manufacturer: Perusahaan Otomobil Nasional Sdn. Bhd. (PROTON). The discourse leads to the interest of the research and the research objectives. In addition, the research questions are also established in order to fulfill the objectives. Finally, the knowledge gap and the needs for this research are also established and discussed.

1.1 Research background

This research work focuses on the new product development (NPD) process and project at the firm level and internal and external performance outcomes: efficiency and effectiveness of a minor automaker in Malaysia. The research background is viewed from three perspectives which come from the scenario of the automotive industry worldwide, the importance of a well-defined NPD process, and the scenario of the Malaysia automotive industry. The motivation to conduct this research originates from the drastic intensification of the frequency of the new product introduction (NPI) that occurs between the year of 2000 until 2017, and the researcher's six years (1997 – 2003) working experience in the research and development (R&D) department at the automaker plant in Shah Alam, Selangor, Malaysia. This study focuses only on the completed development projects of PROTON that were launched between the year 2000 until the mid of 2017, before the acquisition of a 49.9% stake in PROTON by the Zhejiang Geely Holding Group. Figure 1.1 shows the product

development projects of PROTON since the 1980s until 2012, just to give an insight into the NPI frequency.

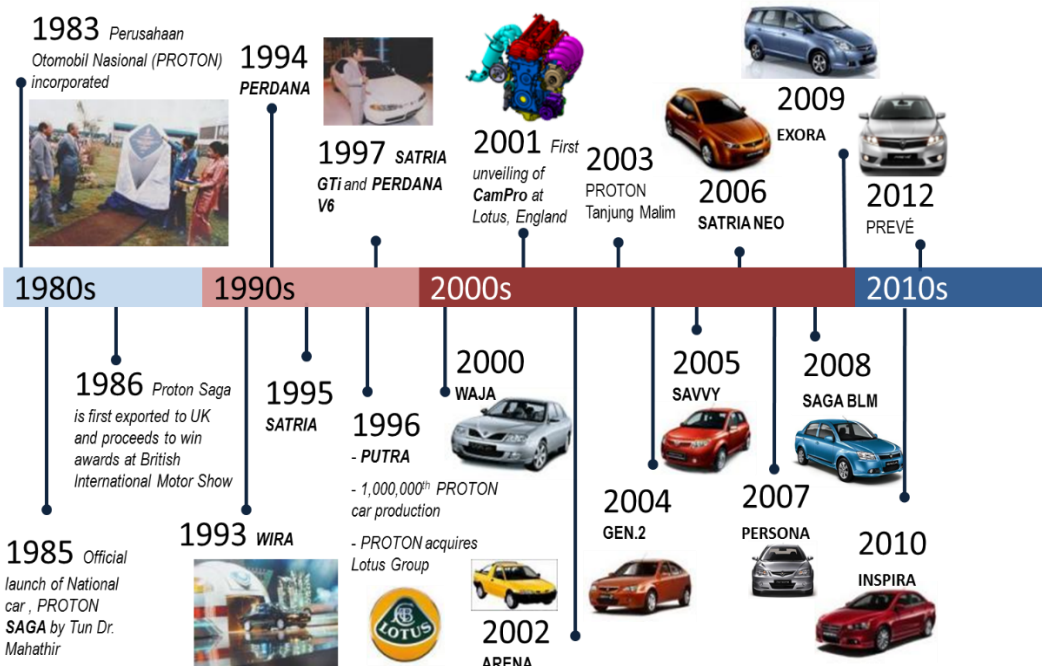

Figure 1.1: PROTON product development projects (Anonymous, 2018)

1.1.1 Impact of the automotive industry on the economy

The car industry has grown extensively since the first car invention a long time ago. Karl Benz invented the first car back in 1885 that was powered by a petrol engine (Biography.com Editors, 2014). However, the mass production of cars had only begun in 1900 in French as well as in the US. Later, Henry Ford introduced the Model T in the 20th Century, this had boosted the automotive industry in the US and finally the economy of the country. Thus, at the early age of the car industry, the car market was largely dominated by both the US and European manufacturers. However, the domination was fragmented when Japanese cars started entering the market in the late 1960s. Presently, more than 50 brands of cars commercially available across the globe, and about 14 of them are big players or manufacturers (Anonymous, 2019).

Of late, the automotive industry is continuously growing and has been described as the single largest industrial sector in the world economy (Turnbull et al., 1992). The International Organization of Motor Vehicle Manufacturers (OICA) reports that more than 70 million passenger cars alone were sold in 2018. In addition, the total number of vehicles sold including commercial and other types of vehicles is approximately about 95 million vehicles in the same year (Anonymous, 2019). Further, according to the German Association of the Automotive Industry (VDA), the automotive industry in 2017 such as in the US experience growth rate that was higher than the year before. Meanwhile, Japan's economy experienced its strongest growth in years as well as in Europe. The economy is now also visibly recovering in crisis-stricken countries, such as Italy and Greece. The emerging countries as well are posting positive growth. China's growth continues virtually unabated. India's catch-up has also continued apace. "Brazil and Russia have made significant steps to escape recession and should have put the worst of their economic woes behind them. Both economies benefited from rising raw materials prices" (Anonymous, 2017).

A single car that consists of 20,000 – 30,000 parts has made the automotive industry as an innovative industry that creates a business opportunity for car-related parts involving many business backgrounds such as after-sales and service, distribution and delivery, part supply, accessories, and product customization, used car, and at the same creates many job opportunities. For example, in Japan, 5.5 million people, or 8.7 percent of Japan's workforce are employed in automotive manufacturing and related industries. Auto parts manufacturing accounts for over 600,000 jobs in the sector and another 390,000 jobs are allocated to the production of raw materials and basic equipment used in automotive manufacturing (JAMA, 2017). This proves the significant impact of the industry on a nation's economic development and related businesses as well as the standard of living of the people of that country (Rosli, 2006)

1.1.2 The importance of product development in the automotive industry

To sustain its business and become competitive, a car producer must introduce a new product. According to Cusumano and Nobeoka (1992), there are at least two important factors that automaker needs to address in an NPD process and project: the frequency of the NPI, and the relation between existing and the newly developed product. The most challenging factor for car producers is not simply putting together thousands of components together but also planning numerous complex development tasks to manufacture cars. The research and study on the NPD projects that are executed using concurrent engineering are extensive, involving multi-industries, cross-nations, and multi-projects, covering various topics including engineering and technology, management and administration, business and finance. However, mostly the previous works have explored the NPD and its performance outputs for the big players in the auto industries i.e. Toyota, Honda, Mercedes Benz, BMW, Nissan, FORD, and many more. These players come from developed countries, having a wide range of products that penetrate 3 major markets across the world which classified as the US, Europe and Asia (Rugman and Collinson, 2004). The players have been in the industries for many years and have a comprehensive understanding of the auto industry and its market. Furthermore, some of them have outstanding achievements in many aspects related to auto industries. These include the development strategy and methods, technologies and innovation, product variants, market segment, and marketing strategy. On the other hand, there are quite significant numbers of automakers that originated from the late industrialization nations, for example; from Brazil, Spain, India, China, Thailand, and Malaysia (Mukherjee and Sastry, 1996). These car manufacturers are considered as small-sized car manufacturers, some of them just targeting mainly the domestic markets or countries of the emerging economies. The automotive industry which is driven by customer demands that are fluctuated and varies in terms of styling, safety, and efficiency, the ability

of car vehicle manufacturer to design and develop new cars, with low costs, and high quality while satisfying customer requirements is a must - regardless what category of the car manufacturer is?

1.1.3 Malaysian automotive industry

After its independence in 1957, Malaysia since the 60s has tried to improve its status from a poor country to a developing or industrializing country. The struggle continued until the 1980s, when, the Government brought up a new plan of the economy path of industrialization, and thereby transform the nation into a developing country. With its dream of becoming a manufacturing-oriented nation, the Malaysian Government introduced a big and significant industrialization project in 1983, namely as the National Car Project (NCP). The automotive industry in Malaysia is one of the most important and strategic industries in the development of Malaysia's economy and transforming Malaysia into an industrialized nation. Malaysia has four national automakers; they are Perusahaan Otomobil Nasional Sdn Bhd, known as PROTON, Perusahaan Otomobil Kedua Berhad (PERODUA), NAZA, and DRB-HICOM. These automobile companies are playing an important role in providing opportunities for employment, upgrading the development of technologies and industrial skills within the automobile manufacturing industry and improving the strength of the international competitiveness of Malaysia. The initial assembly plant of PROTON is located at the HICOM's Industrial Area in Shah Alam, Selangor. Completed in 1984, the plant, which used largely manual labor production techniques, boasted a capacity of 80,000 vehicles per year was aim to reduce the country's reliance on foreign-made import products. Initially, most of the industrialists and fellow Malaysians did not believe that Malaysia would able to build a car. However, with the commitment from the Government under the leadership of the Prime Minister at that time—Tun Dr. Mahathir Mohammad—the

Malaysians were so proud; having the first Malaysian car, the Proton Saga in 1985. Before the 1980s, there were only fifteen factories assembling foreign cars with a limited number of parts and sub-assemblies' suppliers. Most companies during this day were car assemblers of the European and Japanese brands. To accelerate the process of having its own car and car-manufacturing related enterprises, Malaysians took a short-cut through a partnership with Mitsubishi of Japan that allowed for re-batching of the Mitsubishi existing cars. In addition, for quick market share possession and protection of the national car project, the Government introduced the protective tariff barriers and other policies, resulting in PROTON domination of the domestic market up until the early 2000s. Circa 2000 PROTON has begun developing its own new product development process in partnership with its subsidiary Lotus Engineering of the U.K (Lotus). In the meantime, following the success of the PROTON, in 1993, the Government launched a second car project called the PERODUA with Daihatsu Japan. The protection and other policies for protecting national car manufacturers and the industry ended up in 2005 when the agreement known as ASEAN Free Trade Area (AFTA) was imposed. AFTA allows vehicle manufacturers and component suppliers from all over the world to establish factories in most ASEAN countries, focusing on the ASEAN and Chinese markets.

In 2009, both national car companies had a share of almost 60 percent of the Malaysian car market. Currently, there are approximately 800 local automotive suppliers within Malaysia, with 4 national vehicle manufacturers (2 car makers; 2 commercial vehicle manufacturers) and the industry has created employment for more than 300,000 peoples in various vehicle-related businesses. As for the Malaysian automotive market, the industry has grown rapidly, recovering from the financial crisis in 1999. It was reported in 2019, that between 2014 until mid of 2019 over three point two million vehicles were registered within Malaysia, with almost three million coming from the passenger car segment (Anonymous,

2019). In comparison, the ASEAN (Southeast Asian) market recorded slightly over ten million cars sold for the same period (Anonymous, 2019).

For Malaysian automotive industry, it is unique and promising as the industry: 1) being one of the dynamic industry in Malaysia, and a major contributor to the gross domestic product (GDP) growth, 2) having no history of the new product development process and projects and started through re-batch of its partner's products, and 3) being the third-largest market in ASEAN, 4) being protected by the Government throughout 1983 until 2005, and non-protected beyond 2005 after AFTA trade agreement.

Furthermore, as mentioned earlier, the new product development process offers great advantages to car companies in terms of decreasing lead times, improved quality, and reduced costs by using supplier knowledge about the product. Cusumano and Nobeoka (1992) insist on the importance of car manufacturers to increase the NPI frequency – meaning developing more new cars or their variances. There is a great deal of additional evidence concerning the success of car companies that have adopted a formal NPD in their product development programs. In the case of Malaysia, as there has so far been the insufficient study of an NPD of PROTON, there is an urgent need to understand current practices before any related improvement on NPD can be suggested or implemented. This study could also extend existing knowledge and thus may explore new knowledge of NPD within a unique and promising automobile industry, such as that of Malaysia. Therefore, the focus of this thesis is on understanding the NPD of Malaysian vehicle manufacturers.

1.2 Problem statement

In Chapter 2, the gap in existing knowledge will be explained through the literature review. The knowledge gap is not that hard to be established; most researchers of new product development practices have focused on the Japanese, US, and European automotive