CHAPTER 8

VERIFICATION AND VALIDATION OF KBLVAM MODEL

8.1 Introduction

This chapter describes the detail verification and validation processes of the KBLVAM Model. The verification and validation of the KBLVAM model uses data from actual industrial case study and published data. The process is to ensure that the developed KBLVAM model represents expertise in this area and is capable of identifying and suggesting the areas that need to be improved. *Verification* is concerned with the consistency and accuracy of the input and output data, information, knowledge, and justification of the KBLVAM model (Hvala et al., 2005). On the other hand, *validation* is concerned with the level of knowledge the model incorporates to solve a problem, in a similar manner as the human experts (Min et al., 2010). Both verification and validation processes require expert involvement to evaluate the effectiveness of the KBLVAM model (Wong and Li, 2010). The confidence in the model assessment process is closely related to the amount and quality of the expert input (Jiang and Mahadevan, 2009).

As mentioned in the introduction (Chapter 1), there is no available KBLVAM model which makes the verification and validation process difficult. Therefore, the focus of this chapter is more about the verification and refinement of the KBLVAM model. The validation process can only be conducted for the *Financial Analysis* and *Market Analysis* modules, where much published data is available. This is because the information needed for these modules is standardised and readily available from the manufacturer's annual report.

The real industry case study is from two automotive manufacturers in Malaysia, who have been selected for the verification of the KBLVAM model. The first manufacturer is the Malaysian national car manufacturer, whereas the second manufacturer is the Malaysian main car body parts manufacturer. For the validation of the KBLVAM model, two published data from Proton and Toyota are analysed to support the validation processes.

8.2 Industry Verification Process

In the verification process, two automotive manufacturers in Malaysia were involved in the study. Proton and Miyazu Malaysia were selected since they are the biggest automotive manufacturer and car body parts components manufacturer in Malaysia, respectively. The verification processes for these manufacturers were done separately in July 2011. The verification involved the users applying the KBLVAM System for their LVAM environment, and thereafter comparing the results and decisions of the KBLVAM with their own expert conclusions. Given below are brief descriptions of the manufacturers that participated in the verification processes.

8.2.1 Perusahaan Otomobil Nasional Sdn. Bhd (Proton)

Perusahan Otomobil Nasional Sdn. Bhd (Proton) was incorporated in May 7, 1983 to become the national car manufacturer (Proton, 2011b). It was the brainchild of the then Malaysian Prime Minister, Mahathir Mohamed to manufacture, assemble and sell motor vehicles and related products, including accessories, spare parts and other components. Proton Saga was Malaysia's first car launched on July 9, 1985.

Proton has two plants in Shah Alam and Tanjung Malim, with capacities of 240,000 and 150,000 vehicles per year, respectively. Besides these two plants, Proton has a total of 11 subsidiaries and 11 associate companies, which are involved in manufacturing, research and development, sales and service activities. For the export market, Proton cars are now being exported to 50 countries including the United Kingdom and continental European markets. Currently the Proton's market share in Malaysia is around 30%, with annual turnover of £1.8 billion and the number of employees of more than 12,000 people.

Tanjung Malim plant is also known as Proton City, and comprises of the state-of-the-art £360 million Proton car assembly plant and a township with industrial, commercial and residential activities spread over 4,000 acres. Proton City aims to be a self-contained, eco-sensitive intelligent city which provides superior technological and educational capabilities.

The developed KBLVAM model was verified by the Stamping Engineering *Lead Engineer,* Ir. Kamal Rusulan Mohamed (17 years working experience); Production Engineering *Engineer*, Armaizon Abdullah (18 years working experience); and Group Corporate Planning *Manager*, Huszeine Hussain (20 years working experience), all three are considered to be experts in their fields. They verified all Levels of the KBLVAM model except for Level 1 (*Financial Analysis* module), which was validated using Proton Annual Report.

8.2.2 Miyazu (Malaysia) Sdn. Bhd.

Established in 1991 as a tooling shop, Miyazu was managing the in-house stamping operations of the Proton factory (Miyazu, 2011). In 2003, the company's

growth potential increased when Proton Holdings, Miyazu Seisakusho and Sojitz Corporation, Japan invested in the company to become Miyazu Malaysia Sdn Bhd. The newly formed company specialised in automotive tooling engineering, design and manufacturing services, and is currently the leading die tools provider for Proton cars. Miyazu has two tooling plants in Shah Alam and Tanjung Malim with over 250 personnel.

The developed KBLVAM model for Miyazu was verified by the Manufacturing *Head of Department*, Mr. Noresam Mahat (17 years working experience). He was assisted by the Quality Control engineer and technical supervisor to verify the quality aspects of the Company.

8.2.3 The Relationship and Profile of the Manufacturers

The relationship between Proton and Miyazu is illustrated in Figure 8.1. It shows that Proton is the Original Equipment Manufacturer (OEM), while Miyazu is the 1st Tier Supplier.

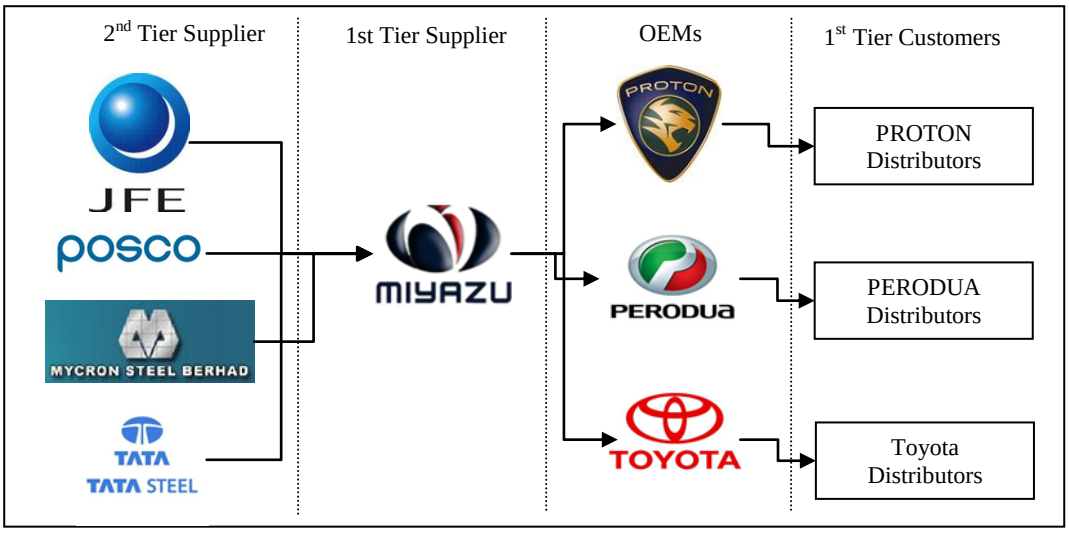

Figure 8.1: Relationship of the manufacturers in the Malaysian automotive industry

Part of being the Proton main car body parts provider, Miyazu also supports Perodua and Toyota. The main suppliers for Miyazu are JFE, Japan; Posco, Korea; Mycron Steel Berhad, Malaysia; and Tata Steel, India. The profiles of Proton and Miyazu can be summarised as shown in Table 8.1.

Table 8.1: Summary of Proton and Miyazu profiles

	PROTON	**MIYAZU**
Position in Supply Chain	OEM	1st-Tier Supplier
Established	1983	1991
Number of employees	> 12000	> 150
Annual Turnover (approx.)	£1,883.68 million	£20 million
Number of Plants and Locations	2: Shah Alam and Tanjung Malim	2: Shah Alam and Tanjung Malim
Products	Passenger Cars	Body panels, metal parts, and stamping components
Markets	Local and Global	Local and Global

8.3 Verification and validation of KBLVAM Model Based on the Industry Data

The KBLVAM System consists of six levels perspectives: one pre-requisite perspective (Level 0 – *Manufacturer Environment* Perspective) and five main perspectives (Level 1 to Level 5), as shown in Figure 5.5, Chapter 5. Each of the perspectives is tested, verified and validated by both Proton and Miyazu users. The detailed inputs, outputs and analysis of Proton are used in this chapter to show the KBLVAM capability during modules verification and validation process. The Miyazu analysis is presented as a summary of results in this chapter while the detailed inputs and outputs are shown in Appendix C. Hence, the following Sections 8.3.1 to 8.4.1 are the KBLVAM results from the Proton Company.

8.3.1 Level 0 - *Manufacturer Environment* Perspective

The *Manufacturer Environment* Perspective is used to identify the existing condition of the company by gathering information related to general information and background of the manufacturer as shown in Figure 8.2.

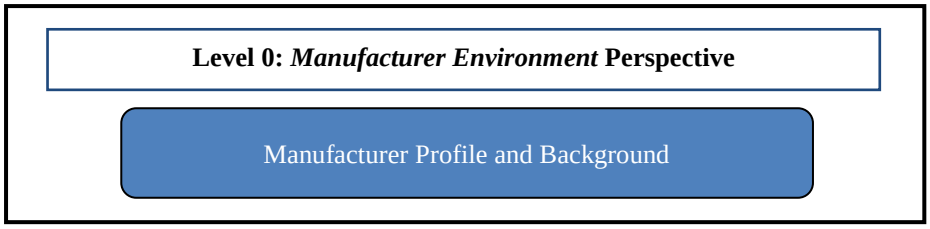

Figure 8.2: *Manufacturer Environment* perspective

Level 0 of the KBLVAM model requires the user to provide general information as the input to the KB System as shown in Table 8.2.

Table 8.2: Inputs of *Manufacturer Environment* perspective for Proton

Variables Description	**Data**		
Name of user (the interviewee)	Kamal Rusulan Mohamed		
Post	Lead Engineer		
Department	Stamping Engineering, Production Engineering		
Organisation	Perusahaan Otomobil Nasional Sdn. Bhd.		
Address of Organisation	HICOM Industrial Estate, Batu 3, P.O. Box 7100, 40918 Shah Alam, Selangor Darul Ehsan.		
Annual Sales	> £1,883.68 billion		
Number of Employees	> 12000		
Branch	2		
Position in Automotive Industry	Original Equipment Manufacturer (OEM)		
Products	Passenger Cars Manufacturing		
Age of Organisation	28 years (1983)		
	Age of Relationship		
	< 5 years	**5 – 10 years**	**> 10 years**
Number of Suppliers	> 200	> 200	> 200
Key Market - Local	All classes	All classes	All classes
Key Market - Global	Asean, Europe, Middle East, Australia	Asean, Europe, Middle East, Australia	Asean, Europe, Middle East, Australia
	(1-5 Years)	**(6-10 Years)**	**> 10 years**
LVAM Capabilities:			
Car Body Parts Design	Capable	Capable	Capable
Car Body Parts Manufacturing	Capable	Capable	Capable
Car Body Assembly	Capable	Capable	Capable

Subsequently, the KB System has produced the output as shown in Table 8.3, based on the Knowledge (Rule-Based) stored in the KBLVAM model.

Table 8.3: Output/results of *Manufacturer Environment* perspective for Proton

Category	Description
Size of Manufacturer	Large
Stage in Business Cycle	Harvest stage
Relationship with Suppliers	Good and stable
Relationship with Customers	Good and stable
Strategic improvement	Yes
LVAM activities	Capable for all activities

Based on the input from the user, the KBLVAM System categorised PROTON as a large manufacturer, in the harvest stage of the business cycle, having good and stable relationships with suppliers and customers, has taken strategic improvements, and has the capability of LVAM environment. In order for the KBLVAM to determine the output, the knowledge contained in the KB System must have the sales of annual turnover, age of the manufacturer, age of suppliers and customer relationship, strategic steps, and the essential LVAM activities.

In summary, for Level 0, the KBLVAM System requires the basic information and general profile of the manufacturer as the input to the System. Based on the gathered input, the System will generate the competitive level of the manufacturer in terms of size, stage in the business cycle, relationships with suppliers and customers, and LVAM capabilities.

8.3.2 Level 1 - *LVAM Manufacturer Business* Perspective

The first level of the KBLVAM Model is the *LVAM Manufacturer Business* Perspective, which is used as the beginning point to analyse the company competitiveness. It consists of two modules, which are *Financial Analysis* and *Market Analysis* as shown in Figure 8.3.

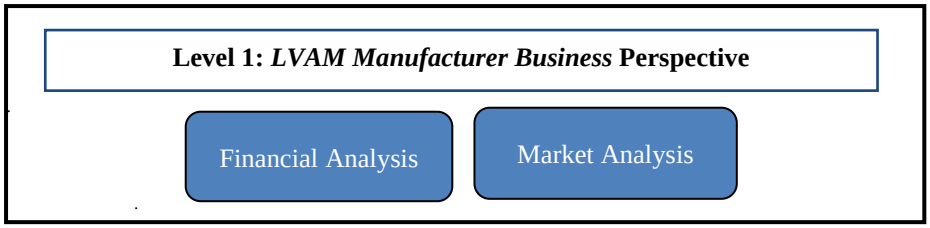

Figure 8.3: *LVAM Manufacturer Business* perspective

Income Statement, *Balance Sheet* and *Cash Flow Statement* are the three financial reports required as inputs to the *Financial Analysis* module to calculate various financial ratios. The financial report contains all the relevant financial information, and it is presented in different accounting and legal standards depending on countries and commercial regions (Ramnath et al., 2008). The financial data for all companies in the world is available through the annual reports of the companies (Wibisono, 2003). These three reports are shown in Tables 8.4, 8.5 and 8.6 respectively.

Table 8.4: Income Statement of Proton (An exchange rate of £1.00 = RM4.9)

INCOME STATEMENT			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Net Sales	1,368.95	1,727.65	1,883.68
Cost of goods sold	1,290.51	1,550.37	1,675.95
Other expenses	91.60	123.90	164.64
Depreciation	97.63	93.87	90.70
Net Interest	-3.02	-2.54	-2.88
Tax	-3.65	8.82	12.35

Table 8.5: Balance Sheet of Proton

BALANCE SHEET			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Assets			
Cash & short term securities	195.11	351.94	275.71
Receivables	219.58	193.62	261.79
Inventories	292.97	257.71	253.49
Other current assets	95.68	72.22	76.94
Long term assets			
Land, plant & equipment	593.69	551.12	531.28
Other long term assets	7.64	7.75	-
Current liabilities			
Payables	151.52	184.34	189.27
Short term debt	50.93	25.73	71.82
Other current liabilities	59.93	62.69	65.50
Long term liabilities			
Long term debt & capital leases	10.96	6.22	2.04
Other long term liabilities	4.56	7.83	3.23
Common shareholders' equity	1,071.32	1,119.93	1,135.41

Table 8.6: Cash Flow Statement of Proton

CASH FLOW STATEMENT			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Cash From Operations	53.13	271.76	33.37
Cash From Investing	-127.28	-81.94	-142.23
Cash From Financing	21.74	-37.74	23.92
Foreign Exchange Rate Adjustments	-5.12	-3.65	2.52
Net Income in Cash	**-57.53**	**148.43**	**-82.42**

KBLVAM Model uses its internal rules to produce the output as shown in Table 8.7 based on the data of *Income Statement*, *Balance Sheet*, and *Cash Flow Statement*.

Table 8.7: Output of *Financial Analysis* for Proton

FINANCIAL PERFORMANCE RESULTS							
As of:	**Mar 31, 2009**		**Mar 31, 2010**		**Mar 31, 2011**		**Trend**
	Ratio	Category	Ratio	Category	Ratio	Category	
Leverage Ratio							
Debt Ratio	0.01	Good	0.01	Good	0.00	Good	Improved and in Good category
Liquidity Ratio							
Current Ratio	3.06	Good	3.21	Good	2.66	Good	Fluctuating and in Good category
Quick Ratio	1.58	Good	2.00	Good	1.65	Good	Fluctuating and in Good category
Profitability Ratio							
Net Profit Margin (%)	-7.61	**Bad**	-2.71	**Bad**	-3.03	**Bad**	Fluctuating in Bad category **(PC-1)**
Sales to Total Assets	0.97	Good	1.20	Good	1.35	Good	Improved continuously
Inventory Turnover	0.01	**Bad**	2.82	Fair	3.28	Fair	Improved continuously
Return on Total Assets (%)	-7.41	**Bad**	-3.26	Fair	-4.08	Fair	Fluctuating in Bad category **(PC-1)**
Return on Equity (%)	-9.72	**Bad**	-4.18	**Bad**	-5.03	**Bad**	Fluctuating in Bad category **(PC-1)**
Cash Flow	-£57.53 million		£148.43 million		-£82.42 million		Fluctuating and making loss
Profit Values							
Gross Profit	£78.44 million		£177.28 million		£207.73 million		Improved continuously
Net Profit	-£104.12 million		-£46.77 million		-£57.08 million		Fluctuating and continuously making loss

Table 8.7 presents various financial ratios of Proton in terms of leverage, liquidity, and profitability. All the financial ratios are then to be classified into three categories: *Good, Fair* or *Bad* based on the KB rules embedded in the KBLVAM model (Wibisono, 2003). The KB System also provides indications of the trend for the financial ratios in the last three years, to show whether it has improved, deteriorated, fluctuated or remained the same. Table 8.7 shows that Proton has an improved in *Debt Ratio* as well as maintaining at the *Good category* in the last three consecutive years. In terms of liquidity, the *Current Ratio* and *Quick Ratio* performance has fluctuated for both categories for the past three years, but have been in the good category. In the *Profitability Ratio* category, the performance of Proton has increased continuously in the past three years in the areas of *Sales to Total Assets* and *Inventory Turnover*. The *Sales to Total Assets Ratio* has shown a trend of continuous improvements which increased from 0.97 in 2009 to 1.2 in 2010 to 1.35 in 2011. However, the *Return on Total Assets* and *Return on Equity* have been fluctuating. *Net Profit Margin* for Proton has fluctuated from -7.61% (loss) in 2009 to -2.71% (loss) in 2010 to -3.03% (loss) in 2011.

The KBLVAM System has also indicated that the cash flow of Proton is fluctuating (Table 8.7), which has increased for the 2010 financial year (£148.43 million) but decreased for the 2011 financial year (-£82.42 million). This indicates that Proton is having a financial problem. The KBLVAM System has also concluded that Proton's net profit performance has fluctuating and continuously making loss over the period of the last three years, with the worst performance of £104.12 million net loss in 2009.

The next module in the *LVAM Manufacturer Business* Perspective is the *Market Analysis* module. The purpose of this module is to obtain the information

about the market competition and its share in local, regional and global markets. The analysis of this module is very important for a company like Proton in order to strategise the programmes for future improvements. The inputs for market competition and market share of Proton are recorded in Table 8.8 and the outputs processed by the KBLVAM System are shown in Table 8.9.

Table 8.8: Inputs of *Market Analysis* for Proton

Main Product: **Passenger Cars**			
Market Competition	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Local	< 5 companies	< 5 companies	< 5 companies
Regional	5-20 companies	5-20 companies	5-20 companies
Global	> 20 companies	> 20 companies	> 20 companies
Market Share	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Local	25.9 %	27.6 %	28 %
Regional	No information	No information	No information
Global	No information	No information	No information

Table 8.9: Output of *Market Analysis* for Proton

Aspect	Area	Trend	Remarks
Market Competition	Local	Steady for 3 years	Good Point
	Regional	Steady for 3 years	Good Point
	Global	Steady for 3 years	Good Point
Market Share	Local	Steady for 3 years	Good Point
	Regional	No information	Need to measure – indicates Bad Point **(PC-1)**
	Global	No information	Need to measure – indicates Bad Point **(PC-1)**

Based on the inputs from 2011 Annual Report (Proton, 2011a), Proton managed to secure an average of 27 % of the local market share in the past three years (2009 - 2011). The trend shows that the market share is improving for the local market. However, there is no data available for regional and global shares mainly because the figures are too small compared to the world Total Industry Volume (TIV) of 58 million (OICA, 2011). This indicates that measurement is required in order to benchmark with the world class LVAM manufacturer, and is considered as PC-1. The KBLVAM analysis also revealed that Proton has steady market

competition for the last three years in all areas (local, regional, and global). The output from the KBLVAM suggests that Proton has only focused in improving the local market share. Failure to have the regional and global market share information is considered as PC-1. Hence, the KB System recommends that the future planning of Proton should not only be to become the local champion, but also to increase the regional and global market shares.

In summary, for the Level 1, the KBLVAM System has recorded that financial and market performances of Proton have been fluctuating and continuously making loss for the past three years, which is the true scenario at Proton. Hence, the KBLVAM System suggested that Proton needs to improve the financial and market performances in achieving LVAM.

8.3.3 Level 2 - *LVAM Manufacturer Resources* Perspective

The *LVAM Manufacturer Resources* Perspective consists of three modules, which are *Human Resource*, *Technology Resource*, and *Financial Resource* as shown in Figure 8.4. In *LVAM Manufacturer Resources*, the KB System assesses these resources capability of the manufacturer in dealing with the processes and operations of LVAM environment.

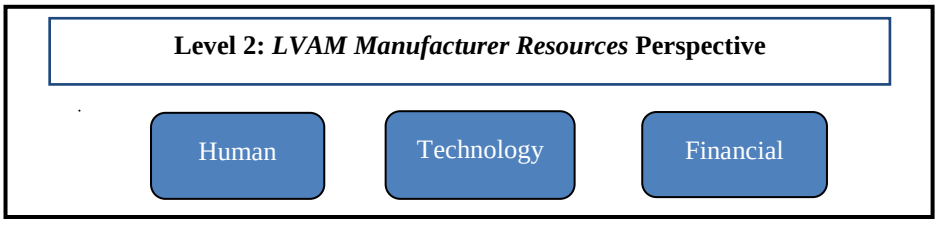

Figure 8.4: *LVAM Manufacturer Resources* perspective

As discussed in Chapter 6, *Human Resource* activities involved *Development*, *Culture*, and *Benefits.* In *Technology Resource* module, there are three sub-modules to be evaluated, which include *Technology Management*, *Manufacturing Technology* and *Information and Communications Technology.* Finally, *Financial Resources* assesses the manufacturer on the level of financial resources for *Human*, *Technology* and *LVAM Development*.

Based on the response from the user (Proton), the KBLVAM System summarised the GAP Analysis Results of *Resources* Perspective between the existing practice and the benchmark practice as shown in Table 8.10. A total of 123 questions have been asked in this module which also contains the number of Good Points (GP), the number of Bad Points (BP), together with the Problem Categories (PC) of the BP. The GAP analysis optimisation technique suggests that only the BP are categorised into a PC in order to identify the necessary pre-requisites that are required to achieve the LVAM. Out of 123 questions, 91 have been categorised as GPs whereas 32 have been considered as BPs. The System finalised these 32 BPs into Problem Categories, (3 PC-1, 6 PC-2, 1 PC-3, 1 PC-4, 4 PC-5, 3 PC-6, and 14 PC-7) and which need to be improved to achieve benchmark implementation of LVAM.

In the *Human Resource* module, the KBLVAM has identified a major problem area in *Development* sub-module with 5 BPs (3 PC-2, 1 PC-3, and 1 PC-4). It is the priority for Proton to resolve the problems from category PC-2 (3 BPs) before rectifying the other 2 PCs (1 PC-3, and 1 PC-4). In the *Technology Resource* module, *Manufacturing Technology* sub-module was found to have 3 BPs (3 PC-7), which just indicate minor problems to the system. Finally, the KB System has also recorded that *Financial for Technology* sub-module which has 9 BPs (4 PC-5, 5 PC-

7) is the most problematic area in *the Financial Resource module*, but they are all minor problems to the system.

Table 8.10: Summarised GAP analysis results of Level 2: *Resources* perspective for Proton

Level 2: *Resources* Perspective	**No of Questions**	**GAP Analysis**										
		GP	BP	Problem Category (PC)								
				1	2	3	4	5	6	7	8	9
Human Resource												
Development	31	26	5	0	3	1	1	0	0	0	0	0
Culture	14	11	3	3	0	0	0	0	0	0	0	0
Benefits	11	8	3	0	3	0	0	0	0	0	0	0
Sub-total	**56**	**45**	**11**	**3**	**6**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
Technology Resource												
Technology Mgmt	11	11	0	0	0	0	0	0	0	0	0	0
Mfg Technology	15	12	3	0	0	0	0	0	0	3	0	0
ICT	11	11	0	0	0	0	0	0	0	0	0	0
Sub-total	**37**	**34**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**
Financial Resource												
Financial for Human	9	3	6	0	0	0	0	0	0	6	0	0
Financial for Tech	9	0	9	0	0	0	0	4	0	5	0	0
Financial for Devmt	12	9	3	0	0	0	0	0	3	0	0	0
Sub-total	**30**	**12**	**18**	**0**	**0**	**0**	**0**	**4**	**3**	**11**	**0**	**0**
Total	**123**	**91**	**32**	**3**	**6**	**1**	**1**	**4**	**3**	**14**	**0**	**0**

The KBLVAM System uses the above GAP analysis results to produce the AHP analysis to determine which aspect should be prioritised for improvement. As a starting analysis, the embedded AHP in the KBLVAM System will determine the weight of Priority Vector (PV) values for sub-modules in *Human Resource*, sub-modules in *Technology Resource*, and sub-modules in *Financial Resource*. Tables 8.11, 8.12, and 8.13 illustrate the PV values for each of the elements in each of the sub-modules.

Table 8.11: AHP analysis with PV for *Human Resource* module for Proton

Human Resource	Development	Culture	Benefits	PV
Development	1	1/4	1/3	0.1199
Culture	4	1	3	**0.6080**
Benefits	3	1/3	1	0.2721

Table 8.11 indicates the PVs for *Human Resource* module. The PV values for *Development*, *Culture*, and *Benefits* are 0.1199, **0.6080**, and 0.2721 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Culture* (KB System highlighted team building was the major issue that needs to be tackled) before attempting the sub-modules *Benefits* and *Development.*

Table 8.12: AHP analysis with PV for *Technology Resource* module for Proton

Technology Resource	Technology Management	Mfg Technology	ICT	PV
Technology Management	1	1/2	1	0.2500
Mfg Technology	2	1	2	**0.5000**
ICT	1	1/2	1	0.2500

Table 8.12 indicates the PVs for *Technology Resource* module. The PV values for *Technology Management*, *Mfg Technology*, and *ICT* are 0.2500, **0.5000**, and 0.2500 respectively. Therefore, the priority for PROTON to focus in this module is by improving the sub-module *Mfg Technology* (KB System highlighted the effectiveness of the Computer Integrated Manufacturing implementation was the major issue that needs to be tackled), before attempting the sub-modules *Technology Management* and *ICT* (both have equal PV).

Table 8.13: AHP analysis with PV for *Financial Resource* module for Proton

Financial Resource (FR)	FR for Human	FR for Technology	FR for Development	PV
FR for Human	1	1/2	2	0.3119
FR for Technology	2	1	2	**0.4905**
FR for Development	1/2	1/2	1	0.1976

Table 8.13 indicates the PVs for *Financial Resource* module. The PV values for *Financial Resource for Human*, *Financial Resource for Technology*, and *Financial Resource for LVAM Development* are 0.3119, **0.4905**, and 0.1976

respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Financial for Technology* (KB System highlighted the lack of budget allocation for information technology improvement was the major issue that needs to be tackled), before attempting the sub-modules *Financial for Human* and *Financial for Implementation.*

The next analysis is to find the PV at the modules' stage of *Human Resource, Technology Resource,* and *Financial Resource* by using the same AHP process. The summary of the PV values for these modules is presented in Table 8.14. The PV values for *Human Resource*, *Technology Resource*, and *Financial Resource* are **0.5889**, 0.1592, and 0.2519 respectively. Therefore, the priority for Proton to focus on this *Resources* Perspective is by improving the module *Human Resource*, followed by the module *Financial Resource* and finally the module *Technology Resource*. Similar procedures of performance assessment are conducted for Level 3, Level 4, and Level 5. The assessment results for Miyazu are shown in Appendix C.

Table 8.14: AHP analysis with PV for Level 2: *Resources* perspective for Proton

Aspect	**Human**	**Technology**	**Financial**	PV
Human	1	3	3	**0.5889**
Technology	1/3	1	1/2	0.1592
Financial	1/3	2	1	0.2519

Table 8.15 provides the summary of the AHP PVs for each of the sub-modules and modules for Level 2 (*Resources* Perspective). The analysis by the KBLVAM System proposes that Proton should concentrate firstly to improve the *Human Resource* elements due to the highest PV of 0.5889. The KB System also requires Proton to improve its *Culture* sub-module which has PV of 0.6080.

The KB System also proposes that Proton should then focus to improve *Financial Resource* module (PV 0.2519) before continuing the improvement process

for *Technology Resource.* In the *Financial Resource* module, Proton needs to pay attention more on *Financial for Technology* aspect (PV of 0.4905) whereas in the *Technology Resource* activity, Proton needs to concentrate more on the *Manufacturing Technology* aspect (PV 0.4905).

Table 8.15: Summary of AHP results for Level 2: *Resources* perspective for Proton

Level 2: *LVAM Manufacturer Resources* Perspective			
Module	**Priority Vector**	**Sub-module**	**PV**
Human Resource	**0.5889**	Development	0.1199
		Culture	**0.6080**
		Benefits	0.2721
Technology Resource	0.1592	Technology Management	0.2500
		Manufacturing Technology	**0.5000**
		ICT	0.2500
Financial Resource	0.2519	Financial for Human	0.3119
		Financial for Technology	**0.4905**
		Financial for Development	0.1976

In summary, for the Level 2, the KBLVAM System has recorded the GAP Analysis of 32 BPs from 123 questions asked, which suggested that Proton's performance is 26 % lower than the benchmark standard. In order to achieve LVAM environment, the KBLVAM concluded that Proton needs to take actions to improve the *Culture* element in the *Human Resource* module.

8.3.4 Level 3 - *LVAM Manufacturer Capability Car Body Parts Manufacturing* Perspective

The *LVAM Manufacturer Capability Car Body Parts Manufacturing* Perspective module consists of three modules, which are *Car Body Design Development*, *Car Body Parts Manufacturing Process*, and *Car Body Assembly Process* as shown in Figure 8.5.

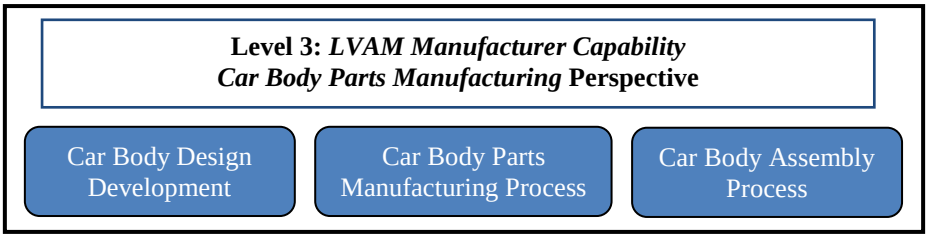

Figure 8.5: *LVAM Manufacturer Capability - Car Body Parts Manufacturing* perspective

As discussed in Chapter 7, *Car Body Design Development* module consists of three sub-modules which include *Car Body Design Concept*, *Conceptual Design Analysis* and *Car Body Design Development Assessment. Car Body Parts Manufacturing Process* module consists of sub-modules *Design of Dies and Checking Fixtures* and *Design of Manufacturing Process.* Finally, *Car Body Assembly Process* module consists of sub-modules *Design of Assembly Tools* and *Design of Assembly Process*.

Table 8.16 recorded the summarised GAP Analysis Results of *Car Body Parts Manufacturing* Perspective. A total number of 189 questions have been asked, with 135 have been categorised as GPs whereas 54 have been considered as BPs. The System finalised these 54 BPs (7 PC-1, 7 PC-2, 4 PC-3, 0 PC-4, 19 PC-5, 0 PC-6, 11 PC-7, 9 PC-8, and 2 PC-9) that need to be improved to achieve benchmark implementation of LVAM. In the *Car Body Parts Manufacturing* Perspective, the KBLVAM has identified major problem activities for all modules of *Car Body Design Development*, *Car Body Parts Manufacturing Process*, and *Car Body Assembly Process. In* The *Car Body Design Development* module, the KB System found 47 BPs with 6 BPs are under PC-4. These 6 BPs are identified in Design Concept sub-module (3 PC-1), and Design Assessment sub-module (1 PC-2, 2 PC-3). The other 41 BPs are considered as not serious problems since all of them are above PC-4.

Table 8.16: Summarised GAP analysis results of Level 3: *Car Body Parts Manufacturing* perspective for Proton

Level 3: *Car Body Parts Manufacturing* Perspective	**No of Questions**	**GAP Analysis**										
		GP	BP	Problem Category (PC)								
				1	2	3	4	5	6	7	8	9
Car Body Design Development												
Design Concept	57	13	44	3	0	0	0	19	0	11	9	2
Design Analysis	19	19	0	0	0	0	0	0	0	0	0	0
Design Assessment	20	17	3	0	1	2	0	0	0	0	0	0
Sub-total	**96**	**49**	**47**	**3**	**1**	**2**	**0**	**19**	**0**	**11**	**9**	**2**
Car Body Parts Mfg Process												
Design of Dies & CF	31	28	3	3	0	0	0	0	0	0	0	0
Design of Mfg Proc	18	17	1	1	0	0	0	0	0	0	0	0
Sub-total	**49**	**45**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Car Body Assembly Process												
Design of Assy Tools	26	25	1	0	0	1	0	0	0	0	0	0
Design of Mfg Proc	18	16	2	0	1	1	0	0	0	0	0	0
Sub-total	**44**	**41**	**3**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Total	**189**	**135**	**54**	**7**	**2**	**4**	**0**	**19**	**0**	**11**	**9**	**2**

In the *Car Body Parts Manufacturing Process* module, the KB System found that the problems are critical that needs to be rectified because it has 4 PC-1 which indicates a very serious problem to Proton. These 4 PC-1 problems are found to be related to sub-modules *Design of Dies & Checking Fixture* (3 PC-1) and *Design of Manufacturing Process* (1PC-1). The KB System also discovered 3 BP (1 PC-2, 2 PC-3) in the *Car Body Assembly Process* module. These 3 BP are related to the Design of Assembly Tools (1 PC-3), and Design of Manufacturing Process (1 PC-2, 1 PC-3) which also indicates serious problems to Proton.

The KBLVAM System uses the above GAP analysis results to produce the AHP analysis to determine which aspect should be prioritised for improvement. The embedded AHP in the KBLVAM System will determine the weight of Priority Vector (PV) values for sub-modules in *Car Body Design Development*, sub-modules in *Car Body Parts Manufacturing Process*, and sub-modules in *Car Body Assembly*

Process. Tables 8.17, 8.18, and 8.19 illustrate the PV values for each of the elements in each of the sub-modules.

Table 8.17: AHP analysis for Proton's *Car Body Design Development* module

Aspect	Design Concept	Design Analysis	Design Assessment	PV
Design Concept	1	3	2	**0.5390**
Design Analysis	1/3	1	1/2	0.1638
Design Assessment	1/2	2	1	0.2973

Table 8.17 indicates the PVs for *Car Body Design Development* module. The PV values for *Design Concept*, *Design Analysis*, and *Design Assessment* are **0.5390**, 0.1638, and 0.2973 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Design Concept* (KB System highlighted the design innovation was the major issue that needs to be tackled), before attempting the sub-modules *Design Assessment* and *Design Analysis.*

Table 8.18: AHP Analysis for Proton's *Car Body Parts Manufacturing Process* module

Aspect	Design of Dies & CF	Design of Mfg Process	PV
Design of Dies & CF	1	2	**0.6667**
Design of Mfg Process	1/2	1	0.3333

Table 8.18 indicates the PVs for *Technology Resource* module. The PV values for the *Design of Dies & CF*, and *Design of Mfg Process* are **0.6667**, and 0.3333 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Design of Dies & CF* (KB System highlighted the lack of design of dies & CF monitoring hour was the major issue that needs to be tackled), before attempting the sub-module *Design of Mfg Process*.

Table 8.19: AHP analysis for Proton's *Car Body Assembly Process* module

Aspect	Design of Assembly Tools	Design of Mfg Process	PV
Design of Assembly Tools	1	1/2	0.3333
Design of Mfg Process	2	1	**0.6667**

Table 8.19 indicates the PVs for *Car Body Assembly Process* module. The PV values for the *Design of Assembly Tools*, and *Design of Mfg Process* are 0.3333, and **0.6667** respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Design of Mfg Process* (KB System highlighted the laser welding method unavailability was the major issue that needs to be tackled), before attempting the sub-module *Design of Assembly Tools*.

The next analysis is to find the PV at the modules' stage of *Car Body Design Development*, *Car Body Parts Manufacturing Process*, and *Car Body Assembly Process* by using the same AHP process. The summary of the PV values for these modules is presented in Table 8.20. The PV values of *Car Body Design Development*, *Car Body Parts Manufacturing Process*, and *Car Body Assembly Process* are 0.3119, **0.4905**, and 0.1976 respectively. Therefore, the priority for Proton to focus on this *Car Body Parts Manufacturing* Perspective is by improving the module *Car Body Parts Manufacturing Process*, followed by the module *Car Body Design Development* and finally the module *Car Body Assembly Process*.

Table 8.20: AHP analysis for Proton's Level 3: *Car Body Parts Manufacturing* perspective

Aspect	Car Body Design Development	Car Body Parts Mfg Process	Car Body Assy Process	PV
Car Body Design Development	1	1/2	2	0.3119
Car Body Parts Mfg Process	2	1	2	**0.4905**
Car Body Assy Process	1/2	1/2	1	0.1976

Table 8.21 provides the summary of the AHP PVs for each of the sub-modules and modules for Level 3 (*Car Body Parts Manufacturing* Perspective). The analysis by the KBLVAM System proposes that Proton should concentrate firstly to improve the *Car Body Parts Manufacturing Process* elements due to the highest PV of 0.4905 together with its *Design of Dies & Checking Fixtures* sub-module which has PV of 0.6667.

Table 8.21: Summary of AHP results for Level 3: *Car Body Parts Manufacturing* perspective for Proton

Level 3: LVAM Manufacturer Capability Car Body Parts Manufacturing Perspective			
Module	**Priority Vector**	**Sub-module**	**PV**
Car Body Design Development	0.3119	Car Body Design Concept	**0.5390**
		Conceptual Design Analysis	0.1638
		Car Body Design Development Assessment	0.2973
Car Body Parts Manufacturing Process	**0.4905**	Design of Dies & Checking Fixtures	**0.6667**
		Design of Manufacturing Process	0.3333
Car Body Assembly Process	0.1976	Design of Assembly Tools	0.3333
		Design of Assembly Process	**0.6667**

The KB System also proposes that Proton should then focus to improve the *Car Body Design Development* module (PV 0.3119) before continuing the improvement process in the *Car Body Assembly Process* (PV 0.1976). In the *Car Body Design Development* module, Proton needs to pay attention more on *Car Body Design Concept* aspect (PV 0.5390) whereas in the *Car Body Assembly Process* activity, Proton needs to concentrate more on the *Design of Assembly Process* aspect (PV 0.6667).

In summary, for the Level 3, the KBLVAM System has recorded the GAP Analysis of 54 BP from 189 questions asked, which suggested that PROTON's performance is 29 % lower than the benchmark standard. In order to achieve LVAM environment, the KBLVAM concluded that Proton needs to take actions to improve

the *Design of Dies & Checking Fixtures* element in the *Body Parts Manufacturing Process* module.

8.3.5 Level 4 - *LVAM Manufacturer Capability Competitive Priorities* Perspective

The *LVAM Manufacturer Capability Competitive Priorities* Perspective consists of five modules, which are *Quality*, *Cost*, Delivery, *Flexibility*, and *Supply Chain* as shown in Figure 8.6.

Figure 8.6: *LVAM Manufacturer Capability - Competitive Priorities* perspective

As discussed in Chapter 7, the related sub-modules that are contained under *Quality* module involved *Supply Quality Audit*, *Main Production Quality Audit* and *Customer Quality Audit* sub-modules. Furthermore, three aspects are considered in *Cost* module; *Supply Cost*, *Main Production Cost*, and *Resources Cost.* For *Delivery*, the sub-modules that relate to this module are *Supply Timing*, *Main Production Timing*, and *Delivery Timing.* Three areas that correspond to dimensions of flexibility are assessed by the KB System, and these are sub-modules *Flexibility in Supply*, *Flexibility in Main Production* and *Flexibility in Delivery.* Finally, efficient logistics planning play important roles in improving the LVAM supply chain, which include *Location* and *Logistics* sub-module.

Table 8.22 shows the summarised GAP Analysis Results of *Competitive Priorities* Perspective for Proton. A total number of 202 questions have been asked in this module. The assessments of the KBLVAM System for the *Competitive*

Priorities perspectives have also highlighted major non-compliances in their modules, and sub-modules. In the *Quality* module, the *Customer QA* sub-module is the most problematic area with 5 BPs (5 PC-1). The KB System has discovered that *Supply QA*, and *Main Prodn QA* sub-modules are practising to the benchmark standard. In the *Cost* module, there are 6 BPs (1 PC-1, 3 PC-2, and 2 PC-4) revealed by the KB System.

Table 8.22: Summarised GAP analysis results of Level 4: *Competitive Priorities* perspective for Proton

Level 4: *Competitive Priorities* Perspective	**No of Questions**	**GAP Analysis**										
		GP	BP	Problem Category (PC)								
				1	2	3	4	5	6	7	8	9
Quality												
Supply QA	18	18	0	0	0	0	0	0	0	0	0	0
Main Prodn QA	20	20	0	0	0	0	0	0	0	0	0	0
Customer QA	19	14	5	5	0	0	0	0	0	0	0	0
Sub-total	**57**	**52**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cost												
Supply Cost	17	17	0	0	0	0	0	0	0	0	0	0
Main Prodn Cost	15	14	1	1	0	0	0	0	0	0	0	0
Resource Cost	12	7	5	0	3	0	2	0	0	1	0	0
Sub-total	**44**	**38**	**6**	**1**	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Delivery												
Supply Timing	11	1	10	4	0	2	1	3	0	0	0	0
Main Prodn Timing	11	1	10	4	0	0	3	3	0	0	0	0
Delivery Timing	11	1	10	4	0	0	3	3	0	0	0	0
Sub-total	**33**	**3**	**30**	**12**	**0**	**2**	**7**	**9**	**0**	**0**	**0**	**0**
Flexibility												
Supply Flexibility	10	5	5	3	2	0	0	0	0	0	0	0
Main Prod Flexibility	15	12	3	1	2	0	0	0	0	0	0	0
Delivery Flexibility	11	11	0	0	0	0	0	0	0	0	0	0
Sub-total	**36**	**28**	**8**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Supply Chain												
Location	15	11	4	2	0	0	0	2	0	0	0	0
Logistics	17	14	3	1	0	0	0	1	0	0	0	1
Sub-total	**32**	**25**	**7**	**3**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**1**
Total	**202**	**146**	**56**	**25**	**7**	**2**	**9**	**12**	**0**	**0**	**0**	**1**

The key priorities needed to achieve benchmark implementation are the *Main Prodn Cost* (1 PC-1) and *Resource Cost (*3 PC-2, and 2 PC-4) sub-modules. Furthermore, the KB System has discovered the major non-compliances in *Delivery* module with 30 BPs (12 PC-1, 2 PC-3, 7 PC-4, and 9 PC-5), which are 91% of this module's question. Therefore, Proton must improve the areas of PC-4 and below in

the sub- modules *Supply Timing* (4 PC-1, 2 PC-3, 1 PC-4), *Main Prodn Timing* (4 PC-1, and 3 PC-4), *and Delivery Timing* (4 PC-1, and 3 PC-4).

In *Flexibility* module, only sub-modules *Supply Flexibility* (3 PC-1, and 2 PC-4), and *Main Prod Flexibility* (1 PC-1, and 2 PC-4), need to be rectified. Finally for *Supply-Chain* module, the areas that need to focus are *Location* (2 PC-1) *and Logistics* (1 PC-1) sub-modules.

The KBLVAM System uses the above GAP analysis results to produce the AHP analysis to determine which aspect should be prioritised for improvement. The embedded AHP in the KBLVAM System will determine the weight of Priority Vector (PV) values for sub-modules in *Quality*, sub-modules in *Cost*, sub-modules in *Delivery,* sub-modules in *Flexibility* and sub-modules in *Supply-Chain*. Tables 8.23, 8.24, and 8.25 illustrate the PV values for each of the elements in each of the sub-modules.

Table 8.23: AHP analysis for Proton's *Quality* module

Aspect	Supply Quality Audit	Main Production Quality Audit	Customer Quality Audit	PV
Supply Quality Audit	1	1	1/6	0.1250
Main Production Quality Audit	1	1	1/6	0.1250
Customer Quality Audit	6	6	1	**0.7500**

Table 8.23 indicates the PVs for *Quality* module. The PV values for *Supply Quality Audit*, *Main Production Quality Audit*, and *Customer Quality Audit* are 0.1250, 0.1250, and **0.7500** respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Customer Quality Audit* (KB System highlighted the QFD implementation was the major issue that needs to be improved),

before attempting the sub-modules *Supply Quality Audit*, and *Main Production Quality Audit* (which have the same priority).

Table 8.24: AHP analysis for Proton's *Cost* module

Aspect	Supply Cost	Main Production Cost	Resource Cost	PV
Supply Cost	1	1/3	1/4	0.1199
Main Production Cost	3	1	1/3	0.2721
Resource Cost	4	3	1	**0.6080**

Table 8.24 indicates the PVs for *Cost* module. The PV values for *Supply Cost*, *Main Production Cost*, and *Resource Cost* are 0.1199, 0.2721, and **0.6080** respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Resource Cost* (KB System highlighted the material cost was the major issue that needs to be improved), before attempting the sub-modules *Main Production Cost* and *Supply Cost.*

Table 8.25: AHP analysis for Proton's *Delivery* module

Aspect	Supply Timing	Main Prodn Timing	Delivery Timing	PV
Supply Timing	1	2	3	**0.5390**
Main Prodn Timing	1/2	1	2	0.2972
Delivery Timing	1/3	1/2	1	0.1638

Table 8.25 indicates the PVs for *Delivery* module. The PV values for *Supply Timing*, *Main Prodn Timing*, and *Delivery Timing* are **0.5390**, 0.2972, and 0.1638 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Supply Timing* (KB System highlighted the late delivery from suppliers was the major issue that needs to be improved), before attempting the sub-modules *Main Prodn Timing*, and *Delivery Timing.*

Table 8.26: AHP analysis for Proton's *Flexibility* module

Aspect	Supply Flexibility	Main Prodn Flexibility	Delivery Flexibility	PV
Supply Flexibility	1	1/3	1	0.2000
Main Prodn Flexibility	3	1	3	**0.6000**
Delivery Flexibility	1	1/3	1	0.2000

Table 8.26 indicates the PVs for *Flexibility* module. The PV values for *Supply Flexibility*, *Main Prodn Flexibility*, and *Delivery Flexibility* are 0.2000, **0.6000**, and 0.2000 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Main Prodn Flexibility* (KB System highlighted the volume flexibility was the major issue that needs to be improved), before attempting the sub-modules *Supply Flexibility* and *Delivery Flexibility* (which have the same priority).

Table 8.27: AHP analysis for Proton's *Supply Chain* module

Aspect	Location	Logistics	PV
Location	1	3	0.7500
Logistics	1/3	1	0.2500

Table 8.27 indicates the PVs for *Supply Chain* module. The PV values for *Location*, and *Logistics* are **0.7500**, and 0.2500 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Location* (KB System highlighted the geographical environment in selecting suppliers was the major issue that needs to be improved), before attempting the sub-module *Logistics*.

The next analysis is to find the PV at the modules' stage of *Quality*, *Cost*, *Delivery*, *Flexibility* and *Supply-Chain* by using the same AHP process. The summary of the PV values for these modules is presented in Table 8.28. The PV values for *Quality*, *Cost*, *Delivery*, *Flexibility* and *Supply-Chain* are 0.0617, 0.0641,

0.6259, 0.1389, and 0.1094 respectively. Therefore, the priority for Proton to focus on this *Competitive Priorities* Perspective is by improving the module *Delivery*, followed by the modules *Flexibility*, *Supply-Chain*, *Cost*, and finally the module *Quality*.

Table 8.28: AHP analysis for Proton's Level 4: *Competitive Priorities* perspective

Aspect	Quality	Cost	Delivery	Flexibility	Supply Chain	PV
Quality	1	1	1/7	1	1/2	0.0617
Cost	1	1	1/8	1/3	1/2	0.0641
Delivery	7	8	1	6	7	**0.6259**
Flexibility	1	3	1/6	1	2	0.1389
Supply Chain	2	2	1/7	1/2	1	0.1094

Table 8.29 provides the summary of the AHP PVs for each of the sub-modules and modules for Level 4 (*Competitive Priorities* Perspective). The analysis by the KBLVAM System proposes that Proton should concentrate firstly to improve the *Delivery* elements due to the highest PV of 0.6259 together with its *Supply Timing* sub-module which has PV of 0.5390.

Table 8.29: Summary of AHP results for Level 4: *Competitive Priorities* perspective for Proton

Level 4: *LVAM Manufacturer Capability Competitive Priorities* Perspective			
Module	**Priority Vector**	**Sub-module**	**PV**
Quality	0.0617	Supply Quality Audit	0.2000
		Main Production Quality Audit	**0.6000**
		Customer Quality Audit	0.2000
Cost	0.0641	Supply Cost	0.1199
		Main Production Cost	0.2721
		Resource Cost	**0.6080**
Delivery	**0.6259**	Supply Timing	**0.5390**
		Main Prodn Timing	0.2972
		Delivery Timing	0.1638
Flexibility	0.1389	Supply Flexibility	0.2000
		Main Prod Flexibility	**0.6000**
		Delivery Flexibility	0.2000
Supply Chain	0.1094	Location	**0.7500**
		Logistics	0.2500

The KB System also proposes that Proton should then focus to improve the *Flexibility* module (PV 0.1389) before continuing the improvement processes in the *Supply-Chain* (PV 0.1094), *Cost* (0.0641) and finally the *Quality* (0.0617). In the *Flexibility* module, Proton needs to stress more on *Main Prod Flexibility* aspect (PV 0.6000). Whereas in the *Supply-Chain*, *Cost*, and *Quality* activities, Proton needs to concentrate more on the *Location* aspect (PV 0.7500), *Resource Cost* aspect (PV 0.6080), and *Main Production Quality Audit* aspect (PV 0.6000) respectively.

In summary, for the Level 4, the KBLVAM System has recorded the GAP Analysis of 56 BPs from 202 questions asked, which suggested that Proton's performance is 28 % lower than the benchmark standard. In order to achieve LVAM environment, the KBLVAM concluded that Proton needs to take actions to improve the *Supply Timing* element in the *Delivery* module.

8.3.6 Level 5 - *LVAM Manufacturer Capability Lean Process Optimisation* Perspective

The *LVAM Manufacturer Capability - Lean Process Optimisation* Perspective consists of three modules, which are *Employee Involvement*, *Waste Elimination*, and *Kaizen* as shown Figure 8.7.

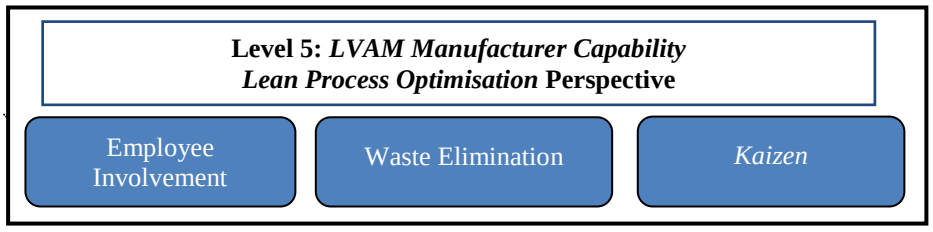

Figure 8.7: *LVAM Manufacturer Capability - Lean Process Optimisation* perspective

As discussed in Chapter 7, the implementation levels of lean processes optimisation are identified by the KB System on how the LVAM manufacturer benchmarks, assesses, measures, analyses and plans an action.

Table 8.30 shows the summarised GAP Analysis Results of *Lean Process Optimisation* Perspective for Proton. A total number of 183 questions have been asked in this module. In the *Lean Process Optimisation* Perspective, the *Employee Involvement* module is the most problematic area with 18 BPs (1 PC-1, 6 PC-2, 2 PC-3, 8 PC-4 and 1 PC-5). The important areas need to be rectified are for the *Analyse* sub- module; with 3 BPs (1 PC-1, 1 PC-2, 1 PC-3), *Benchmark;* 3 BPs (2 PC-2, and 1 PC-3), *Measurement*; 3 BPs (2 PC-2, and 1 PC-4), *Action*; 3 BPs (1 PC-2, 1 PC-4, and 1 PC-5), and *Assessment*; 6 PC-4.

Table 8.30: Summarised GAP analysis results for Level 5: *Lean Process Optimisation* perspective for Proton

Level 5: *Lean Process Optimisation* Perspective	**No of Questions**	**GAP Analysis**										
		GP	BP	Problem Category (PC)								
				1	2	3	4	5	6	7	8	9
Employee Involvement												
Benchmark	15	12	3	0	2	1	0	0	0	0	0	0
Assessment	10	4	6	0	0	0	6	0	0	0	0	0
Measurement	12	9	3	0	2	0	1	0	0	0	0	0
Analyse	12	9	3	1	1	1	0	0	0	0	0	0
Action	12	9	3	0	1	0	1	1	0	0	0	0
Sub-total	**61**	**43**	**18**	**1**	**6**	**2**	**8**	**1**	**0**	**0**	**0**	**0**
Waste Elimination												
Benchmark	15	12	3	0	2	0	1	0	0	0	0	0
Assessment	10	4	6	0	0	2	1	2	0	1	0	0
Measurement	12	11	1	0	0	0	0	1	0	0	0	0
Analyse	12	12	0	0	0	0	0	0	0	0	0	0
Action	12	9	3	0	0	0	1	0	1	1	0	0
Sub-total	**61**	**48**	**13**	**0**	**2**	**2**	**3**	**3**	**1**	**2**	**0**	**0**
Kaizen												
Benchmark	15	13	2	0	1	1	0	0	0	0	0	0
Assessment	10	3	7	0	0	0	4	0	0	3	0	0
Measurement	12	12	0	0	0	0	0	0	0	0	0	0
Analyse	12	10	2	0	0	0	2	0	0	0	0	0
Action	12	11	1	0	0	0	1	0	0	0	0	0
Sub-total	**61**	**49**	**12**	**0**	**1**	**1**	**7**	**0**	**0**	**3**	**0**	**0**
Total	**183**	**140**	**43**	**1**	**9**	**5**	**18**	**4**	**1**	**5**	**0**	**0**

The second most problematic area is the *Waste Elimination* module; with 7 BP (below PC-4), followed by *Kaizen* module; with 9 BP (below PC-4). Although *Kaizen* has more BP compared to *Waste Elimination*, the latter is more problematic (2 PC-2, 2 PC-3, and 3 PC-4). The KB System shows that both *Waste Elimination* and *Kaizen* modules must concentrate on the improvement processes especially for *Benchmark* and *Assessment* sub-modules for a successful LVAM development.

The KBLVAM System uses the above GAP analysis results to produce the AHP analysis to determine which aspect should be prioritised for improvement. The embedded AHP in the KBLVAM System will determine the weight of Priority Vector (PV) values for sub-modules in *Employee Involvement*, sub-modules in *Waste Elimination*, and sub-modules in *Kaizen*. Tables 8.31, 8.32, and 8.33 illustrate the PV values for each of the elements in each of the sub-modules.

Table 8.31: AHP analysis for Proton's *Employee Involvement* module

Aspect (Employee Involvement)	**Benchmark**	**Assessment**	**Measurement**	**Analyse**	**Action**	**PV**
Benchmark	1	1	1/2	1	2	0.1930
Assessment	1	1	2	1/2	2	0.2130
Measurement	2	1/2	1	1/2	2	0.1962
Analyse	1	2	2	1	3	**0.3030**
Action	1/2	1/2	1/2	1/3	1	0.0948

Table 8.31 indicates the PVs for *Employee Involvement* module. The PV values for *Benchmark*, *Assessment*, *Measurement*, *Analyse*, and *Action* are 0.1930, 0.2130, 0.1962, **0.3030**, and 0.0948 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Analyse* (KB System highlighted the result of analysis sharing was the major issue that needs to be improved), before attempting the sub-modules *Assessment*, *Measurement*, *Benchmark* and *Action*.

Table 8.32: AHP analysis for Proton's *Waste Elimination* module

Aspect (Waste Elimination)	Benchmark	Assessment	Measurement	Analyse	Action	PV
Benchmark	1	1	2	1	2	0.2431
Assessment	1	1	3	3	3	**0.3396**
Measurement	1/2	1/3	1	2	1/2	0.1295
Analyse	1	1/3	1/2	1	1/2	0.1205
Action	1/2	1/3	2	2	1	0.1673

Table 8.32 indicates the PVs for *Waste Elimination* module. The PV values for *Benchmark*, *Assessment*, *Measurement*, *Analyse*, and *Action* are 0.2431, **0.3396**, 0.1295, 0.1205, and 0.1673 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Assessment* (KB System highlighted the 5S practice in the car body assembly was the major issue that needs to be improved), before attempting the sub-modules *Benchmark*, *Action*, *Measurement*, and *Analyse*.

Table 8.33: AHP analysis for Proton's *Kaizen* module

Aspect (*Kaizen*)	Benchmark	Assessment	Measurement	Analyse	Action	PV
Benchmark	1	1	2	1	2	0.2433
Assessment	1	1	3	2	2	**0.3033**
Measurement	1/2	1/3	1	1/2	1/2	0.0983
Analyse	1	1/2	2	1	2	0.2133
Action	1/2	1/2	2	1/2	1	0.1417

Table 8.33 indicates the PVs for *Kaizen* module. The PV values for *Benchmark*, *Assessment*, *Measurement*, *Analyse*, and *Action* are 0.2433, **0.3033**, 0.0983, 0.2133, and 0.1417 respectively. Therefore, the priority for Proton to focus in this module is by improving the sub-module *Assessment* (KB System highlighted the set-up time reduction in Tooling Department was the major issue that needs to be improved), before attempting the sub-modules *Benchmark*, *Analyse*, *Action*, and *Measurement*.

The next analysis is to find the PV at the modules' stage of *Employee Involvement*, *Waste Elimination* and *Kaizen* by using the same AHP process. The summary of the PV values for these modules is presented in Table 8.34. The PV values for *Employee Involvement*, *Waste Elimination* and *Kaizen* are 0.2015, **0.6806**, and 0.1179 respectively. Therefore, the priority for Proton to focus on this *Lean Process Optimisation* Perspective is by improving the module *Waste Elimination*, followed by the module *Employee Involvement*, and finally the module *Kaizen*.

Table 8.34: AHP analysis for Proton's Level 5: *Lean Process Optimisation* perspective

Aspect	Employee Involvement	Waste Elimination	*Kaizen*	PV
Employee Involvement	1	1/4	2	0.2015
Waste Elimination	4	1	5	**0.6806**
Kaizen	1/2	1/5	1	0.1179

Table 8.35 provides the summary of the AHP PVs for each of the sub-modules and modules for Level 5 (*Lean Process Optimisation* Perspective). The analysis by the KBLVAM System proposes that Proton should concentrate firstly to improve the *Waste Elimination* elements due to the highest PV of 0.6806 together with its *Assessment* sub-module which has PV of 0.3396.

The KB System also proposes that Proton should then focus to improve the *Employee Involvement* module (PV 0.2015) before continuing the improvement processes in the *Kaizen* (PV 0.1179). In the *Employee Involvement* module, Proton needs to focus more on the *Analyse* aspect (PV 0.3030), since the PV value is the highest. Referring to Table 8.31, the next priority effort of Proton is to improve the performance and competitive position in LVAM environment is by improving the *Assessment* (0.2130), *Measurement* (0.1962), *Benchmark* (0.1930), and *Action* (0.0948). The company can address these issues in a sequential manner following

the priority order. This will help them to manage better resources to solve the most relevant problems.

In the *Kaizen* activities, Proton needs to concentrate more on the *Assessment* aspect (PV 0.3033). Next, by referring to Table 8.33, Proton needs to prioritise the effort by improving the aspects of *Benchmark* (0.2433), Analyse (0.2133), *Action* (0.1417), and *Measurement* (0.0983) sequentially in order to be competitive in LVAM environment.

Table 8.35: Summary of AHP results for Level 5: *Lean Process Optimisation* perspective for Proton

Level 5: *LVAM Manufacturer Capability Lean Process Optimisation* Perspective			
Module	**Priority Vector**	**Sub-module**	**PV**
Employee Involvement	0.2015	Benchmarking	0.1930
		Assessment	0.2130
		Measurement	0.1962
		Analyse	**0.3030**
		Action	0.0948
Waste Elimination	**0.6806**	Benchmarking	0.2431
		Assessment	**0.3396**
		Measurement	0.1295
		Analyse	0.1205
		Action	0.1673
Kaizen	0.1179	Benchmarking	0.2433
		Assessment	**0.3033**
		Measurement	0.0983
		Analyse	0.2133
		Action	0.1417

In summary, for the Level 5, the KBLVAM System has recorded the GAP Analysis of 43 BPs from 183 questions asked, which suggested that Proton's performance is 23 % lower than the benchmark standard. In order to achieve LVAM environment, the KBLVAM concluded that Proton needs to take actions to improve the *Assessment* element in the *Waste Elimination* module.

8.4 Verification Summary of KBLVAM Model Based on the Industry Data

As discussed in detail for each perspective in Section 8.3, this section will only summarise the results analysis based on the verification process at Proton and Miyazu.

8.4.1 Summarised Perspectives Analysis for Proton

Based on the KBLVAM model analysis, the total results for Proton are summarised as shown in Table 8.36.

Table 8.36: Summarised GAP analysis results for Proton

Perspective / Module		**No of Questions**	**GAP Analysis**										
			GP	BP	Problem Category (PC)								
					1	2	3	4	5	6	7	8	9
Level 2	***LVAM Manufacturer Resources***												
	Human	56	45	11	3	6	1	1	0	0	0	0	0
	Technology	37	34	3	0	0	0	0	0	0	3	0	0
	Financial	30	12	18	0	0	0	0	4	3	11	0	0
	Sub-Total	**123**	**91**	**32**	**3**	**6**	**1**	**1**	**4**	**3**	**14**	**0**	**0**
	Percentage (%)		**74**	**26**	**9**				**17**				
Level 3	***LVAM Manufacturer Capability Car Body Parts Manufacturing***												
	Car Body Design Dev	96	49	47	3	1	2	0	19	0	11	9	2
	Car Body Parts Mfg Pro	49	45	4	4	0	0	0	0	0	0	0	0
	Car Body Assy Process	44	41	3	0	1	2	0	0	0	0	0	0
	Sub-Total	**189**	**135**	**54**	**7**	**2**	**4**	**0**	**19**	**0**	**11**	**9**	**2**
	Percentage (%)		**71**	**29**	**7**				**22**				
Level 4	***LVAM Manufacturer Capability Competitive Priorities***												
	Quality	57	52	5	5	0	0	0	0	0	0	0	0
	Cost	44	38	6	1	3	0	2	0	0	0	0	0
	Delivery	33	3	30	12	0	2	7	9	0	0	0	0
	Flexibility	36	28	8	4	4	0	0	0	0	0	0	0
	Supply Chain	32	25	7	3	0	0	0	3	0	0	0	1
	Sub-Total	**202**	**146**	**56**	**25**	**7**	**2**	**9**	**12**	**0**	**0**	**0**	**1**
	Percentage (%)		**72**	**28**	**21**				**7**				
Level 5	***LVAM Manufacturer Capability Lean Process Optimisation***												
	Employee Involvement	61	43	18	1	6	2	8	1	0	0	0	0
	Waste Elimination	61	48	13	0	2	2	3	3	1	2	0	0
	Kaizen	61	49	12	0	1	1	7	0	0	3	0	0
	Sub-Total	**183**	**140**	**43**	**1**	**9**	**5**	**18**	**4**	**1**	**5**	**0**	**0**
	Percentage (%)		**77**	**23**	**18**				**5**				
Grand Total		**697**	**512**	**185**	**36**	**24**	**12**	**28**	**39**	**4**	**30**	**9**	**3**
Percentage (%)			**73**	**27**	**14**				**13**				

The total number of questions asked in these perspectives was 697. The responses from Proton users revealed that 185 were BPs which suggested that Proton's overall performance is 27 % lower relative to the benchmark standard. However, as mentioned earlier, KBLVAM System considers category PC-4 and below as the most problematic area, whereas the category PC-5 and above is a minor problem.

In Proton case; 14 % of the BPs are in the most problematic areas, whilst 13 % of the BPs in the minor problematic areas. Table 8.38 also provides the breakdown percentage for each perspective (Level 2 to Level 5) together with its major : minor ratio as 26 % (9:17), 29 % (7:22), 28 % (21:7), and 23 % (18:5) respectively.

The developed hybrid KB/GAP/AHP System also supports the manufacturer (Proton) on how to prioritise the decisions by providing the AHP Analysis embedded in the System in terms of PV values. Table 8.37 summarised the PV (in bold figures) for each perspective (Level 2 to Level 5), hence, provides the results that can be reassigned to the developed KBLVAM framework as shown in Figure 8.8.

Table 8.37: Summary of AHP PV values for Proton

Perspective	Module	Priority Vector	Sub-Module (with Priority Vector)				
Level 2: Resources	**Human**	**0.5889**	Development 0.1199	**Culture 0.6080**		Benefits 0.2721	
	Technology	0.1592	Technology Management 0.2500	Manufacturing Technology **0.5000**		Information & Communication Technology 0.2500	
	Financial	0.2519	Human 0.3119	Technology 0.4905		Development 0.1976	
Level 3: Car Body Parts Manufacturing	Car Body Design Dev	0.3119	Car Body Design Concept **0.5390**	Conceptual Design Analysis 0.1638		Car Body Design Development Assessment 0.2972	
	Car Body Parts Mfg Process	**0.4905**	**Design of Dies & Checking Fixtures 0.6667**		Design of Manufacturing Process 0.3333		
	Car Body Assembly Process	0.1976	Design of Assembly Tools 0.3333		Design of Assembly Process **0.6667**		
Level 4: Competitive Priorities	Quality	0.0617	Supply Quality Audit 0.2000	Main Production Quality Audit **0.6000**		Customer Quality Audit 0.2000	
	Cost	0.0641	Supply Cost 0.1199	Main Production Cost 0.2721		Resource Cost **0.6080**	
	Delivery	**0.6259**	**Supply Timing 0.5390**	Main Production Timing 0.2972		Delivery Timing 0.1638	
	Flexibility	0.1389	Supply Flexibility 0.2000	Main Production Flexibility **0.6000**		Delivery Flexibility 0.2000	
	Supply Chain	0.1094	Location **0.7500**		Logistics 0.2500		
Level 5: Lean Process Optimisation	Employee Involvement	0.2015	Benchmark 0.1930	Assess 0.2130	Measure 0.1962	Analyse **0.3030**	Action 0.0948
	Waste Elimination	**0.6806**	Benchmark 0.2431	**Assess 0.3396**	Measure 0.1295	Analyse 0.1205	Action 0.1673
	Kaizen	0.1179	Benchmark 0.2433	Assess **0.3033**	Measure 0.0983	Analyse 0.2133	Action 0.1417

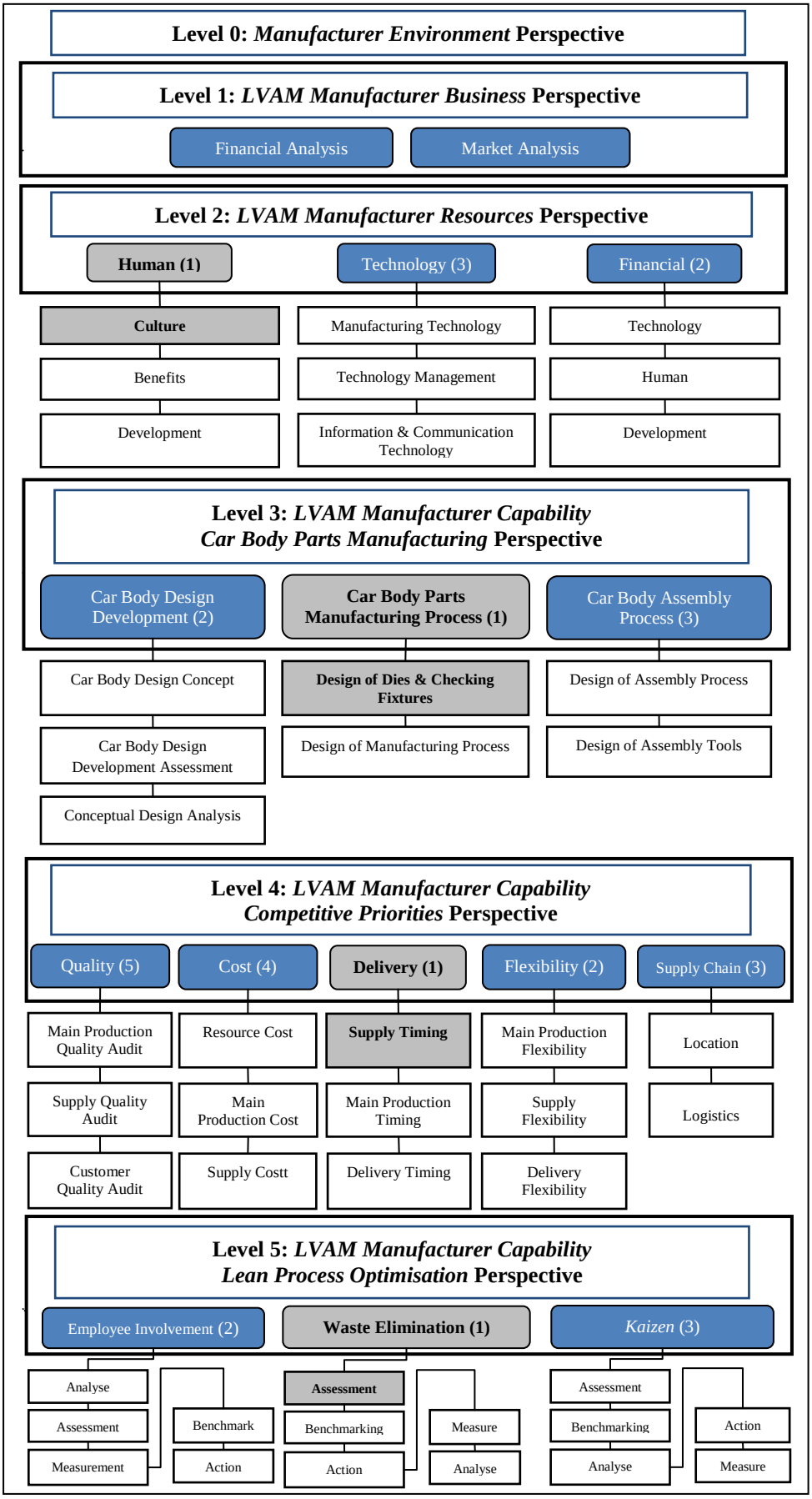

Figure 8.8: The immediate improvement areas for Proton based on GAP/AHP analysis

Referring to Figure 8.8, the KB System has identified the areas that need priority improvement for the manufacturer (Proton) in all the levels (Level 2 to Level 5), in a step-by-step, prioritised manner to improve the LVAM. The immediate task for Proton is to concentrate on improving the 14 % of its major problems in order to reduce the GAP with the best practice standard.

8.4.2 Summarised Perspectives Analysis for Miyazu

Based on the KBLVAM model analysis as shown in Appendix C, the total results for Miyazu are summarised as shown in Table 8.38.

Table 8.38: Summarised GAP analysis results for Miyazu

Perspective Module		**No of Questions**	**GAP Analysis**										
			GP	BP	Problem Category (PC)								
					1	2	3	4	5	6	7	8	9
Level 2	***LVAM Manufacturer Resources***												
	Human	56	45	11	3	7	0	1	0	0	0	0	0
	Technology	37	20	17	0	4	0	1	3	0	9	0	0
	Financial	30	9	21	0	0	9	3	6	3	0	0	0
	Total	**123**	**74**	**49**	**3**	**11**	**9**	**5**	**9**	**3**	**9**	**0**	**0**
	Percentage (%)		**60**	**40**	**23**				**17**				
Level 3	***LVAM Manufacturer Capability Car Body Parts Manufacturing***												
	Car Body Design Dev	96	39	57	14	0	0	1	14	0	12	14	2
	Car Body Parts Mfg Pro	49	45	4	4	0	0	0	0	0	0	0	0
	Car Body Assy Process	44	41	3	0	1	1	1	0	0	0	0	0
	Total	**189**	**125**	**64**	**18**	**1**	**1**	**2**	**14**	**0**	**12**	**14**	**2**
	Percentage (%)		**66**	**34**	**12**				**22**				
Level 4	***LVAM Manufacturer Capability Competitive Priorities***												
	Quality	57	40	17	14	2	0	1	0	0	0	0	0
	Cost	44	35	9	2	4	1	2	0	0	0	0	0
	Delivery	33	3	30	15	1	2	5	7	0	0	0	0
	Flexibility	36	24	12	8	4	0	0	0	0	0	0	0
	Supply Chain	32	19	13	6	1	1	0	4	0	0	0	1
	Total	**202**	**121**	**81**	**45**	**12**	**4**	**8**	**11**	**0**	**0**	**0**	**1**
	Percentage (%)		**60**	**40**	**34**				**6**				
Level 5	***LVAM Manufacturer Capability Lean Process Optimisation***												
	Employee Involvement	61	36	25	1	9	5	9	1	0	0	0	0
	Waste Elimination	61	43	18	1	2	3	4	4	2	1	0	1
	Kaizen	61	41	20	0	6	2	7	0	0	4	0	1
	Total	**183**	**120**	**63**	**2**	**17**	**10**	**20**	**5**	**2**	**5**	**0**	**2**
	Percentage (%)		**66**	**34**	**27**				**7**				
Grand Total		**697**	**440**	**257**	**68**	**41**	**24**	**35**	**39**	**5**	**26**	**14**	**5**
Percentage (%)			**63**	**37**	**24**				**13**				

The total number of questions asked in these perspectives was 697. The responses from Miyazu users revealed that 257 were BPs, which suggested that Miyazu's overall performance is 37 % lower relative to the benchmark standard. In Miyazu's case; 24 % of the BPs were in the most problematic areas, whilst 13 % of the BPs were in the minor problematic areas. Table 8.38 also provides the breakdown percentage for each perspective (Level 2 to Level 5) together with its major : minor ratio as 40 % (23:17), 34 % (12:22), 40 % (34:6), and 34 % (27:7) respectively.

Table 8.39: Summary of AHP PV values for Miyazu

Perspective	Module	Priority Vector	Sub-Module (with Priority Vector)				
Level 2: Resources	Human	0.3119	Development 0.0964	Culture 0.6194	Benefits 0.2842		
	Technology	0.1976	Technology Management 0.5889	Manufacturing Technology 0.1592	Information & Communication Technology 0.2519		
	Financial	**0.4905**	Human 0.2395	**Technology 0.6232**	Development 0.1373		
Level 3: Car Body Parts Manufacturing	**Car Body Design Dev**	**0.6232**	Car Body Design Concept 0.1395	**Conceptual Design Analysis 0.7938**	Car Body Design Development Assessment 0.0667		
	Car Body Parts Mfg Process	0.2395	Design of Dies & Checking Fixtures 0.6667	Design of Manufacturing Process 0.3333			
	Car Body Assembly Process	0.1373	Design of Assembly Tools 0.3333	Design of Assembly Process 0.6667			
Level 4: Competitive Priorities	Quality	0.0596	Supply Quality Audit 0.6366	Main Production Quality Audit 0.0609	Customer Quality Audit 0.3025		
	Cost	0.0641	Supply Cost 0.1038	Main Production Cost 0.2231	Resource Cost 0.6651		
	Delivery	**0.5960**	Supply Timing 0.2395	Main Production Timing 0.1373	**Delivery Timing 0.6232**		
	Flexibility	0.1442	Supply Flexibility 0.7668	Main Production Flexibility 0.1741	Delivery Flexibility 0.0591		
	Supply Chain	0.0913	Location 0.3333	Logistics 0.6667			
Level 5: Lean Process Optimisation	**Employee Involvement**	**0.5390**	Benchmark 0.1866	Assess 0.1566	Measure 0.2650	**Analyse 0.3048**	Action 0.0871
	Waste Elimination	0.1638	Benchmark 0.1864	Assess 0.2264	Measure 0.3394	Analyse 0.1070	Action 0.1408
	Kaizen	0.2973	Benchmark 0.1866	Assess 0.3048	Measure 0.2650	Analyse 0.1566	Action 0.0870

Similar to Proton's assessment, the developed hybrid KB/GAP/AHP System also supports Miyazu on how to prioritise the decisions by providing the AHP Analysis embedded in the System in terms of PV values. Table 8.39 summarised the PV (in bold figures) for each perspective (Level 2 to Level 5), which has been discussed in Section 8.3.

Finally, based on the summarised PV, as in Table 8.39, the KB System provides the suggestion for improvement areas that can be transferred to the developed KBLVAM framework, as shown Figure 8.9. The KB System has identified the areas that need priority improvement for Miyazu in all the levels (Level 2 to Level 5), in a step-by-step, prioritised manner especially for the 24 % of the major problem areas in order to achieve the LVAM.

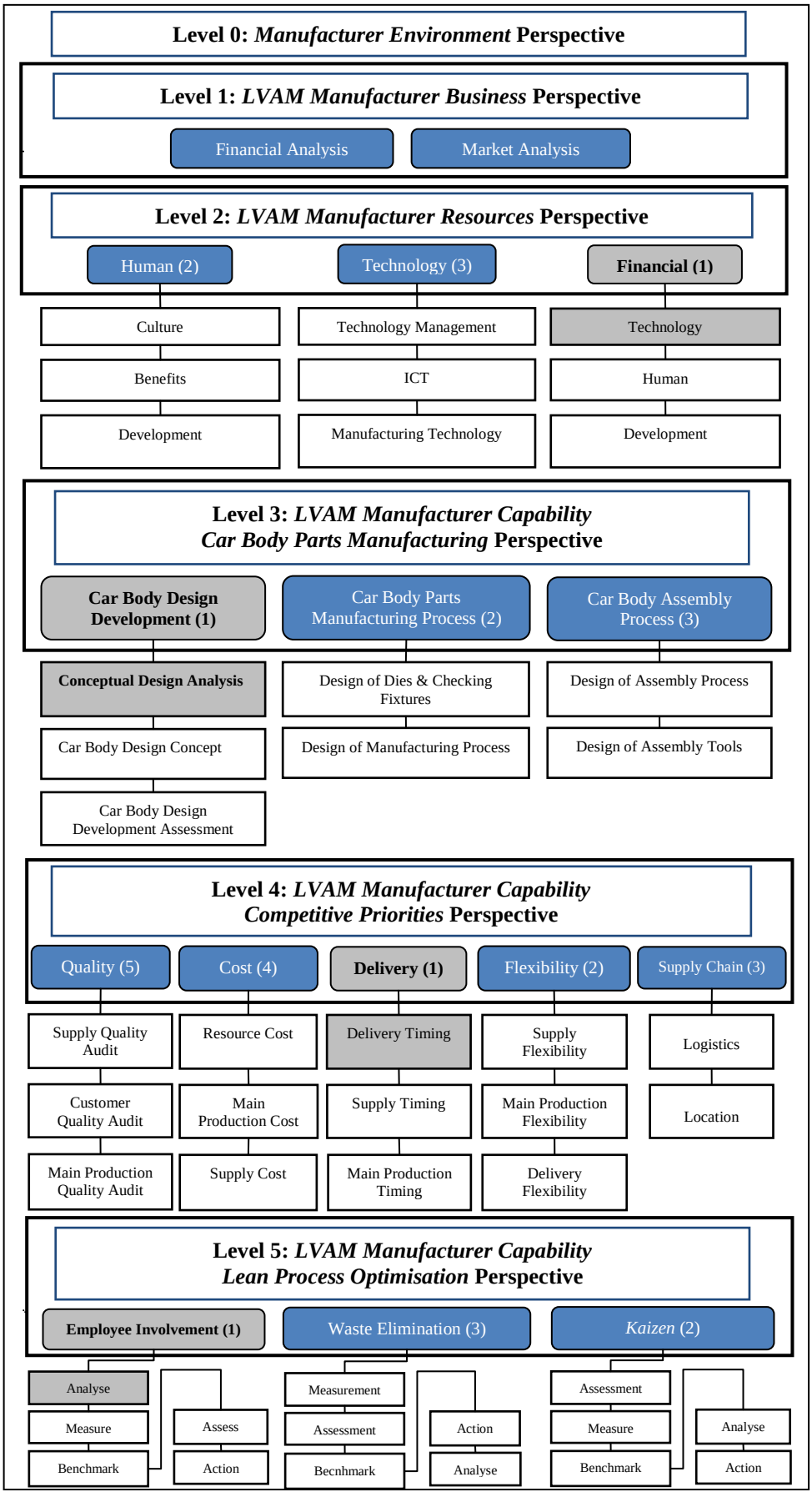

Figure 8.9: The immediate improvement areas for Miyazu based on AHP/GAP analysis

8.4.3 Manufacturers' GAP Relationship in LVAM Identified by KBLVAM

The developed KBLVAM System results can also be used to identify the GAP relationship among the manufacturers. For this study, the GAP relationship of Proton and Miyazu can be analysed based on Table 8.40. The analysis will give the opportunity for both sides of the manufacturers, the OEM (Proton) and the 1st tier supplier (Miyazu) in identifying their problems or strengths. By filling the GAP as suggested by the KBLVAM System, will improve the performance of the manufacturers and will reduce the performance GAP with the benchmark standard.

The analysis will use the immediate improvement areas for improvement data based on Figure 8.8. Level 2 of Table 8.40 for example, shows that Proton's main problem is *Human* module specifically the *Culture* activities within the company which recorded 3 BPs (3 PC-1). The worse problem found with Miyazu in this module, which has 4 BPs (3 PC-1, and 1 PC-2). This shows that both the OEM and 1st tier companies need to concentrate on the *Culture* activities within the company and work together in order to improve their performance.

Another example is for Level 3 of Table 8.40 shows that both Proton and Miyazu have the same problem with their *Car Body Parts Manufacturing Process* module. The area that they need to work closely is the *Design of Dies & CF* sub-module. Both companies have recorded 3 BPs with all of them in PC-1 category. The KB system reveals that both companies need to strategise immediate actions in order to overcome the low ratings in this area.

It also can be seen in Table 8.40 that in the *Delivery* activities at Level 4, the KBLVAM System reveals that both Proton and MIYAZU experienced the similar pattern of problems from *the Supply Timing sub - module*. However, Miyazu

problem is more critical with 9 BPs of PC-4 and below category compared to Proton with 7 BPs in the same category. In this case, Proton could help Miyazu in the improvement process as well as both of the companies could benefit from the improvement programme.

As for Level 5 example, the KBLVAM System found that in the *Waste Elimination* module, again the problems recorded for Proton and Miyazu are the same for the category of PC-4 and below with 3 BPs (2 PC-3, and 1 PC-1). However, for category PC-5 and above, Miyazu is more problematic with 3 PC-5, whereas for Proton, 2 PC-5 and 1 PC-7. The analysis by the KBLVAM System suggests that Proton and Miyazu have to work collaboratively to improve their *Assessment* methods in order to reduce the performance GAP.

The next important analysis of the KBLVAM System is the AHP analysis. Table 8.41 summarised the results for both Proton and Miyazu in terms of PV values. In the Level 2: *Resources* Perspective, the KBLVAM System suggests that Proton needs to concentrate on *Human* for improvement, and within this module, it needs to give more focus on the *Cultures* elements. On the other hand, Miyazu needs to stress more on *Financial*, with special attention on *Technology* sub-module. In the Level 3: *Car Body Parts Manufacturing* Perspective, the highest PV values for Proton is in the *Car Body Parts Mfg Process*, together with the *Supply Timing* sub - module. For Miyazu, the *Car Body Design Dev* module and the *Conceptual Design Analysis* sub-module, scored the highest PV values respectively. The analysis suggests that Proton and Miyazu to focus more on the highlighted areas in order to improve their LVAM programme.

Table 8.40: Summary of KBLVAM GAP analysis relationship

Perspective Module	Sub- Module		No.Q	GAP Analysis (Proton)										GAP Analysis (MIYAZU)										
				GP	BP	Problem Category (PC)									GP	BP	Problem Category (PC)								
						1	2	3	4	5	6	7	8	9			1	2	3	4	5	6	7	8	9
Level 2	***LVAM Manufacturer Resources***																								
	Human	Development	31	26	5	0	3	1	1	0	0	0	0	0	28	3	0	2	0	1	0	0	0	0	0
		Culture	14	11	3	3	0	0	0	0	0	0	0	0	10	4	3	1	0	0	0	0	0	0	0
		Benefits	11	8	3	0	3	0	0	0	0	0	0	0	7	4	0	4	0	0	0	0	0	0	0
		Sub-Total	**56**	**45**	**11**	**3**	**6**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**45**	**11**	**3**	**7**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
	Technology	Technology Mgmt	11	11	0	0	0	0	0	0	0	0	0	0	8	3	0	3	0	0	0	0	0	0	0
		Mfg Technology	15	12	3	0	0	0	0	0	0	3	0	0	3	12	0	0	0	0	3	9	9	0	0
		ICT	11	11	0	0	0	0	0	0	0	0	0	0	9	2	0	1	0	1	0	0	0	0	0
		Sub-Total	**37**	**34**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**20**	**17**	**0**	**4**	**0**	**1**	**3**	**0**	**9**	**0**	**0**
	Financial	Financial for Human	9	3	6	0	0	0	0	0	0	6	0	0	3	6	0	0	2	0	4	0	0	0	0
		Financial for Tech	9	0	9	0	0	0	0	4	0	5	0	0	0	9	0	0	7	0	2	0	0	0	0
		Financial for Devmt	12	9	3	0	0	0	0	0	3	0	0	0	6	6	0	0	0	3	0	3	0	0	0
		Sub-Total	**30**	**12**	**18**	**0**	**0**	**0**	**0**	**4**	**3**	**11**	**0**	**0**	**9**	**21**	**0**	**0**	**9**	**3**	**6**	**3**	**0**	**0**	**0**
	Level 2 Total		**123**	**91**	**32**	**3**	**6**	**1**	**1**	**4**	**3**	**14**	**0**	**0**	**74**	**49**	**3**	**11**	**9**	**5**	**9**	**3**	**9**	**0**	**0**
Level 3	***LVAM Manufacturer Capability Car Body Parts Manufacturing***																								
	Car Body Design Dev	Design Concept	13	44	3	0	0	0	19	0	11	9	2	13	10	47	4	0	0	1	14	0	12	14	2
		Design Analysis	19	0	0	0	0	0	0	0	0	0	0	19	9	10	10	0	0	0	0	0	0	0	0
		Design Assessment	17	3	0	1	2	0	0	0	0	0	0	17	20	0	0	0	0	0	0	0	0	0	0
		Sub-Total	**96**	**49**	**47**	**3**	**1**	**2**	**0**	**19**	**0**	**11**	**9**	**2**	**39**	**57**	**14**	**0**	**0**	**1**	**14**	**0**	**12**	**14**	**2**
	Car Body Parts Mfg Proc	Design of Dies & CF	31	28	3	3	0	0	0	0	0	0	0	0	28	3	3	0	0	0	0	0	0	0	0
		Design of Mfg Proc	18	17	1	1	0	0	0	0	0	0	0	0	17	1	1	0	0	0	0	0	0	0	0
		Sub-Total	**49**	**45**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**45**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Car Body Assy Process	Design of Assy Tools	26	25	1	0	0	1	0	0	0	0	0	0	25	1	0	0	1	0	0	0	0	0	0
		Design of Mfg Proc	18	16	2	0	1	1	0	0	0	0	0	0	16	2	0	1	0	1	0	0	0	0	0
		Sub-Total	**44**	**41**	**3**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**41**	**3**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
	Level 3 Total		**189**	**135**	**54**	**7**	**2**	**4**	**0**	**19**	**0**	**11**	**9**	**2**	**125**	**64**	**18**	**1**	**1**	**2**	**14**	**0**	**12**	**14**	**2**
Level 4	***LVAM Manufacturer Capability Competitive Priorities***																								
	Quality	Supply QA	18	18	0	0	0	0	0	0	0	0	0	0	10	8	8	0	0	0	0	0	0	0	0
		Main Prodn QA	20	20	0	0	0	0	0	0	0	0	0	0	19	1	0	1	0	0	0	0	0	0	0
		Customer QA	19	14	5	5	0	0	0	0	0	0	0	0	11	8	6	1	0	1	0	0	0	0	0
		Sub-Total	**57**	**52**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**40**	**17**	**14**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
	Cost	Supply Cost	17	17	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0
		Main Prodn Cost	15	14	1	1	0	0	0	0	0	0	0	0	13	2	1	1	0	0	0	0	0	0	0
		Resource Cost	12	7	5	0	3	0	2	0	0	1	0	0	5	7	1	3	1	2	0	0	1	0	0
		Sub-Total	**44**	**38**	**6**	**1**	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**35**	**9**	**2**	**4**	**1**	**2**	**0**	**0**	**0**	**0**	**0**
	Delivery	Supply Timing	11	1	10	4	0	2	1	3	0	0	0	0	1	10	4	1	2	2	1	0	0	0	0
		Main Prodn Timing	11	1	10	4	0	0	3	3	0	0	0	0	1	10	4	0	0	3	3	0	0	0	0
		Delivery Timing	11	1	10	4	0	0	3	3	0	0	0	0	1	10	7	0	0	0	3	0	0	0	0
		Sub-Total	**33**	**3**	**30**	**12**	**0**	**2**	**7**	**9**	**0**	**0**	**0**	**0**	**3**	**30**	**15**	**1**	**2**	**5**	**7**	**0**	**0**	**0**	**0**
	Flexibility	Supply Flexibility	10	5	5	3	2	0	0	0	0	0	0	0	2	8	6	2	0	0	0	0	0	0	0
		Main Prod Flexibility	15	12	3	1	2	0	0	0	0	0	0	0	11	4	2	2	0	0	0	0	0	0	0
		Delivery Flexibility	11	11	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0
		Sub-Total	**36**	**28**	**8**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**24**	**12**	**8**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Supply Chain	Location	15	11	4	2	0	0	0	2	0	0	0	0	9	6	3	0	1	0	2	0	0	0	0
		Logistics	17	14	3	1	0	0	0	1	0	0	0	1	10	7	3	1	0	0	2	0	0	0	1
		Sub-Total	**32**	**25**	**7**	**3**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**1**	**19**	**13**	**6**	**1**	**1**	**0**	**4**	**0**	**0**	**0**	**1**
	Level 4 Total		**202**	**146**	**56**	**25**	**7**	**2**	**9**	**12**	**0**	**0**	**0**	**1**	**121**	**81**	**45**	**12**	**4**	**8**	**11**	**0**	**0**	**0**	**1**
Level 5	***LVAM Manufacturer Capability Lean Process Optimisation***																								
	Employee Involvement	Benchmark	15	12	3	0	2	1	0	0	0	0	0	0	9	6	0	3	1	2	0	0	0	0	0
		Assessment	10	4	6	0	0	0	6	0	0	0	0	0	4	6	0	0	2	4	0	0	0	0	0
		Measurement	12	9	3	0	2	0	1	0	0	0	0	0	7	5	0	4	0	1	0	0	0	0	0
		Analyse	12	9	3	1	1	1	0	0	0	0	0	0	8	4	1	1	2	0	0	0	0	0	0
		Action	12	9	3	0	1	0	1	1	0	0	0	0	8	4	0	1	0	2	1	0	0	0	0
		Sub-Total	**61**	**43**	**18**	**1**	**6**	**2**	**8**	**1**	**0**	**0**	**0**	**0**	**36**	**25**	**1**	**9**	**5**	**9**	**1**	**0**	**0**	**0**	**0**
	Waste Elimination	Benchmark	15	12	3	0	2	0	1	0	0	0	0	0	10	5	0	2	0	1	0	1	0	0	1
		Assessment	10	4	6	0	0	2	1	2	0	1	0	0	4	6	0	0	2	1	3	0	0	0	0
		Measurement	12	11	1	0	0	0	0	1	0	0	0	0	9	3	1	0	0	1	1	0	0	0	0
		Analyse	12	12	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
		Action	12	9	3	0	0	0	1	0	1	1	0	0	8	4	0	0	1	1	0	1	1	0	0
		Sub-Total	**61**	**48**	**13**	**0**	**2**	**2**	**3**	**3**	**1**	**2**	**0**	**0**	**43**	**18**	**1**	**2**	**3**	**4**	**4**	**2**	**1**	**0**	**1**
	Kaizen	Benchmark	15	13	2	0	1	1	0	0	0	0	0	0	11	4	0	2	0	0	0	0	1	0	1
		Assessment	10	3	7	0	0	0	4	0	0	3	0	0	1	9	0	0	2	4	0	0	3	0	0
		Measurement	12	12	0	0	0	0	0	0	0	0	0	0	9	3	0	3	0	0	0	0	0	0	0
		Analyse	12	10	2	0	0	0	2	0	0	0	0	0	9	3	0	1	0	2	0	0	0	0	0
		Action	12	11	1	0	0	0	1	0	0	0	0	0	11	1	0	0	0	1	0	0	0	0	0
		Sub-Total	**61**	**49**	**12**	**0**	**1**	**1**	**7**	**0**	**0**	**3**	**0**	**0**	**41**	**20**	**0**	**6**	**2**	**7**	**0**	**0**	**4**	**0**	**1**
	Level 5 Total		**183**	**140**	**43**	**1**	**9**	**5**	**18**	**4**	**1**	**5**	**0**	**0**	**120**	**63**	**2**	**17**	**10**	**20**	**5**	**2**	**5**	**0**	**2**
Grand Total			**697**	**512**	**185**	**36**	**24**	**12**	**28**	**39**	**4**	**30**	**9**	**3**	**440**	**257**	**68**	**41**	**24**	**35**	**39**	**5**	**26**	**14**	**5**

Table 8.41: Summary of KBLVAM AHP analysis for Proton and Miyazu

Perspective	Proton		MIYAZU	
	Module (PV)	**Sub-module (PV)**	**Module (PV)**	**Sub-module (PV)**
Level 2: Resources	Human 0.5889	Culture 0.6080	Financial 0.4905	Technology 0.6232
Level 3: Car Body Parts Manufacturing	Car Body Parts Mfg Process 0.4905	Design of Dies & Checking Fixtures 0.6667	Car Body Design Dev 0.6232	Conceptual Design Analysis 0.7938
Level 4: Competitive Priorities	Delivery 0.6259	Supply Timing 0.5390	Delivery 0.5960	Delivery Timing 0.6232
Level 5: Lean Process Optimisation	Waste Elimination 0.6806	Assess 0.3396	Employee Involvement 0.5390	Analyse 0.3048

Table 8.41 also shows, in Level 4: *Competitive Priorities* Perspective, the KBLVAM System found that both Proton and Miyazu shared the same highest PV values for the Delivery module. However, the System suggests that within this module, Proton and Miyazu need to focus on the Supply Timing and Delivery Timing sub-module correspondingly.

Lastly, in the Level 5: *Lean Process Optimisation* Perspective, the KBLVAM System suggests that Proton to focus first on refining the *Waste Elimination* module, and within this module they need to focus on *Assess* activities. For Miyazu, PV scored the highest value for *Employee Involvement* module and *Analyse* sub-module activities. In essence, the KBLVAM provides the suggestions for Proton and Miyazu to choose the area which need to be prioritised in the performance improvement activities.

8.5 Published Case Study Validation of KBLVAM Model

The validation process for KBLVAM System also uses published case studies. In this study, the published data were used to check the effectiveness of

the KBLVAM System especially that is involved with the quantitative information. Below is the brief explanation of the case study activities.

8.5.1 Financial Analysis Module

As the market leader in the automotive industry, this study uses the Toyota Motor Corporation (Toyota), 2011 Annual Report (Toyota, 2011) for the validation process of the *Financial Analysis* module. The inputs concerning the financial analysis based on the reports are listed in Table 8.42 (*Income Statement),* Table 8.43 (*Balance Sheet),* and Table 8.44 (*Cash Flow Statement*).

Table 8.42: Income Statement of Toyota (An exchange rate of £1.00 = ¥121)

INCOME STATEMENT			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Net Sales	169,368.95	156,345.53	156,697.93
Cost of goods sold	144,114.43	131,764.84	131,882.71
Other expenses	20,911.94	17,487.20	15,758.18
Depreciation	12,335.15	11,670.19	9,698.48
Net Interest	755.58	369.72	506.99
Tax	-465.65	764.48	2,580.77

Table 8.43: Balance Sheet of Toyota (Based on exchange rate of £1.00 = ¥121)

BALANCE SHEET			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Current Assets			
Cash & short term securities	19,095.25	29,825.52	22,240.92
Receivables	14,235.14	18,534.88	14,481.65
Inventories	12,040.00	11,734.58	10,760.00
Other current assets	-	50.61	21.61
Long term assets			
Land, plant & equipment	141,841.75	141,023.42	137,043.63
Other long term assets	2,613.95	2,851.21	2,336.24
Current liabilities			
Payables	16,253.23	16,141.17	12,400.34
Short term debt	2,035.20	1,326.06	1,586.55
Other current liabilities	9,284.84	10,503.23	11,245.64
Long term liabilities			
Long term debt & capital leases	5,847.83	9,461.68	7,538.33
Other long term liabilities	2,422.47	276.48	377.93
Common shareholders' equity	83,004.96	85,467.71	85,242.06

Table 8.44: Cash Flow Statement of Toyota (Based on exchange rate of £1.00 = ¥121)

CASH FLOW STATEMENT			
Currency in Millions of Pound Sterling as of:	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Cash From Operations	12,184.47	21,107.87	16,698.07
Cash From Investing	-10,149.32	-23,514.02	-17,459.84
Cash From Financing	5,765.44	-2,293.35	3,583.20
Foreign Exchange Rate Adjustments	-1,070.79	-73.41	-1,047.99
Net Income in Cash	6,729.80	-4,772.91	1,773.44

KBLVAM Model uses its internal rules to produce the output as shown in Table 8.45 based on the above data of *Income Statement*, *Balance Sheet*, and *Cash Flow Statement*.

Table 8.45: Output of *Financial Analysis* for Toyota

FINANCIAL PERFORMANCE RESULTS							
As of:	**Mar 31, 2009**		**Mar 31, 2010**		**Mar 31, 2011**		**Trend**
	Ratio	Category	Ratio	Category	Ratio	Category	
Leverage Ratio							
Debt Ratio	0.56	Fair	0.10	Good	0.07	Good	Improved and in Good category
Liquidity Ratio							
Current Ratio	1.88	Good	2.15	Good	1.65	Good	Fluctuating and in Good category
Quick Ratio	1.46	Good	1.73	Good	1.21	Good	Fluctuating and in Good category
Profitability Ratio							
Net Profit Margin (%)	-4.89	Bad	-3.72	Bad	-2.38	Bad	Decreases continuously in Bad category **(PC-1)**
Sales to Total Assets	1.15	Good	0.91	Good	1.11	Good	Fluctuating and in Good category
Inventory Turnover	1.13	Good	5.86	Fair	5.55	Fair	Decreases continuously
Return on Total Assets (%)	-5.62	Bad	-3.40	Bad	-2.64	Bad	Increases continuously in Bad category **(PC-1)**
Return on Equity (%)	-9.72	Bad	-6.80	Bad	-4.49	Bad	Increases continuously in Bad category **(PC-1)**
Profit Values							
Gross Profit	£17,108.60 million		£18,704.20 million		£19,621.49 million		Increased continuously

Table 8.45 shows that Toyota has an improved in *Debt Ratio* from the *Fair* category in 2009 to the *Good category* in the last two consecutive years. In terms of *Current Ratio* and *Quick Ratio*, the performance has fluctuated for both categories for the past three years, but still maintained the *Good* category. In the *Profitability Ratio* category, the performance of Toyota has decreased continuously in the past three years in all areas. However, the *Net Profit Margin* for Toyota has shown continuous improvements from -4.89% (loss) in 2009 to -3.72% (loss) in 2010 to -2.38% (loss) in 2011. Furthermore, the *Sales to Total Assets Ratio* has decreased from 1.15 in 2009 to 1.11 in 2011.

The KBLVAM System has also indicated that the cash flow of Toyota was fluctuating in good category for the last three consecutive years. This indicates that Toyota is having a good financial control. This is proved by the KBLVAM System which concluded that Toyota has recorded the gross profit of £17,108.60 million in 2009 to a gross profit of £19,621.49 million in 2011. Based on the provided data, the KBLVAM system suggests the trend in the last three years for Toyota. In essence, the KBLVAM System concluded that Toyota's financial performance has improved continuously over the last three consecutive years.

8.5.2 Market Analysis Module

As the market leader in the automotive industry, this study uses the reports concerning the Toyota Motor Corporation (Toyota) market analysis from different sources were used in this validation process (Toyota, 2011), (OICA, 2011). Table 8.46 shows the inputs of performance for market competition and

market share of Toyota. The figures suggest that Toyota has a steady market competition for the last three years for all market regions. According to Toyota's 2011 Annual Report (Toyota, 2011), Toyota managed to sell 5.4 million passenger cars worldwide (6.3% increased from 2010); of which 1.9 million sold in Japan, 1.3 million in Asia, 2 million in North America, and 0.8 million in Europe. In terms of market share in 2011, Toyota secured 12.2 % globally, 43.7 % of Japan market, 28.1% of Asia market, 15.2 % of North America market, and 4.4 % of the European market. However, there are no exact percentage figures for regional market share. The output for this information as processed by the KBLVAM System is shown in Table 8.47.

Table 8.46: Inputs of *Market Analysis* for Toyota

Main Product: **Passenger Cars**			
Market Competition	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Local	10 -20 companies	10 -20 companies	10 -20 companies
Regional	> 20 companies	> 20 companies	> 20 companies
Global	> 30 companies	> 30 companies	> 30 companies
Market Share	**Mar 31, 2009**	**Mar 31, 2010**	**Mar 31, 2011**
Local	40-50%	40-50%	40-50%
Regional	30-40%	30-40%	30-40%
Global	10-20%	10-20%	10-20%

Table 8.47: Output of *Market Analysis* for Toyota

Aspect	Area	Trend	Remarks
Market Competition	Local	Steady for 3 years	Good Point
	Regional	Steady for 3 years	Good Point
	Global	Steady for 3 years	Good Point
Market Share	Local	Steady for 3 years	Good Point
	Regional	Steady for 3 years	Good Point
	Global	Steady for 3 years	Good Point

It is concluded by the KBLVAM System that the TOTOTA's market competition and market share for the last three years, are in stable trend for local (40-50%), regional (30-40%) and global (10-20%). In principle, the results from the KBLVAM prove that Toyota is one of the key leaders in the automotive car manufacturer in the world.

8.5.3 Summary of Published Case Studies

The *Financial Analysis* and *Market Analysis* modules of the KBLVAM System are the modules that can be validated completely due to the availability of the data. The information about the *Market Share, Income Statement, Balance Sheet*, and *Cash Flow Statement* are standardised and freely available from the manufacturer's annual reports.

The validation results based on published case study data (based on Proton and Toyota financial reports) also proved that the KBLVAM System run as intended and the KB embedded in the System is valid since the performance given by the KBLVAM System gave the same outcomes as the published data for *Financial Analysis* module. Hence, the developed KBLVAM System is capable of in helping the manufacturer in the decision making process.

8.6 Summary

The developed KBLVAM System is verified and validated through two industrial case studies and two published case studies. Two Malaysian manufacturers involved in the industrial case study were Proton and Miyazu. For published case studies, Toyota data were used as a benchmark for the key automotive leader in the world. The verification process for Proton was discussed in detail for all levels (Level 0 to Level 5) of the KBLVAM System, whereas the detail results for Miyazu are given in the Appendix C and the summarised results were elaborated in this chapter.

The whole process was to show the capability of the KBLVAM System in helping the manufacturer in the decision making process. The results of the GAP and AHP analysis were discussed in detail, indicating how each could be used to prioritise the internal environment (between sub-modules) and external (between modules) for performance improvement. Finally, the purpose of the verification and validation is to confirm that the developed KBLVAM System has the capability to provide a decision for the manufacturers who are involved in LVAM environment.

Based on the verification and validation analysis results, it was found that in Level 2: *LVAM Manufacturer Resources* Perspective, the KBLVAM System suggested that Proton needs to focus on *Culture* aspects in *Human Resource* Module while Miyazu to focus on the *Technology* aspects in the *Financial Resource* Module. In Level 3: *LVAM Manufacturer Capability-Car Body Parts Manufacturing* Perspective, the System recommended that Proton needs to focus more on *Design of Dies and Checking* activities, whereas Miyazu on the *Conceptual Design Analysis* activities. In Level 4: *LVAM Manufacturer Capability-Competitive Priorities* Perspective, the KBLVAM System suggested both Proton and Miyazu to focus on the *Delivery* Module, specifically the *Supply Timing* and *Delivery Timing* respectively. Finally, in Level 5: *LVAM Manufacturer Capability-Lean Process Optimisation* Perspective, the KBLVAM System suggested that Proton to focus on improving the *Waste Elimination* activities, whereas for Miyazu, the concerned area was in the *Employee Involvement* Module.