CRITICAL SUCCESS FACTORS AFFECTING BUILD OR BUY DECISIONS FOR IN-HOUSE USED EMBEDDED SYSTEMS IN SRI LANKAN COMPANIES

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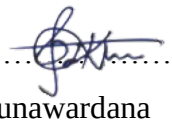

C.L.Gunawardana

(Signature of the candidate) Date: 19/06/2021

The above candidate has carried out research for the Masters thesis under my supervision.

19/06/2021

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ABSTRACT

BUILD or BUY embedded systems, which are used in-house/within the company; which is inherently better for the requirement? The decision between these two types gets a lot of effort and focus in many companies around the globe. While some companies fail to meet their minimum expectations due to their decisions, some succeed and some even go well beyond their expected level. This dilemma has been there since companies started using embedded system inside their companies. While many factors may need to be considered when making this decision, identifying the critical success factors for BUILD or BUY decisions on in-house used embedded systems is of vital importance with the heightened competitiveness in Sri Lankan embedded industry. Managers can align their goals and strategize to avail from these critical success factors to propel the company to success while avoiding potential pitfalls.

Since many business owners are vague on the factors to favour when making such decisions, through this study the author identifies the critical success factors for BUILD or BUY decisions on in-house used embedded systems by interviewing Sri Lankan companies who made such build or buy decisions. When analysing the gathered data, Straussian Grounded Theory was used and a case-by-case account of each decision-making event is used to then identify: Decision Maker's Experience, Strategic Relevance, Decision Making Process, Vendor Selection, IT Workforce, and Cost to be the 6 critical factors to consider for a successful decision. The author then constructed recommendations with the above findings.

Keywords: critical success factors, Build or Buy decision, in-house, embedded systems

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LIST OF ABBREVIATIONS

BB	Build or Buy
COTS	Commercial Off-The-Shelf
DB	Database
IoT	Internet of Things
IS	Information System
PCB	Printed Circuit Boards
PHD	Doctor of Philosophy
R&D	Research and Development
ROI	Return on Investment
SIM	Subscriber Identification Module
USA	United States of America
USD	United States Dollar
WFH	Working From Home

1 INTRODUCTION

1.1 Background

The growth potential for the embedded industry is tremendous and the market is expected to be more than 258 billion USD by 2023 (L. L. Bello, 2019). This is also due to the strong demands for smarter and power-efficient electronic devices and due to emerging areas like the Internet of Things (IoT). Shafique et al. (2010) describes how “28 billion smart devices will be connected across the world by 2021” and states that more than 5 devices per person will become the new normal. IoT is defined as a network that connects uniquely identifiable “Things” to the Internet. The “Things” have sensing/actuation along with possible programmable abilities. The information of a uniquely identified “Thing” can be exchanged, modified regardless of location and time (IEEE, 2015). Legare (2014) defines the “Thing” in the Internet of Things (IoT) as an embedded system that exchange information over a network. How computer systems differ from embedded systems is that the latter are designed to fulfil only a dedicated number of tasks very efficiently with real time responses. Embedded systems can also be defined as technical equipment which is designed specifically for a particular purpose, using microcontrollers (Ebert & Salecker, 2009). For this research the author’s definition of an embedded system is a system with a combination of hardware and software, specifically designed for a particular function using microcontrollers.

According to Berry (2011), an embedded system was oftentimes conceived as a sole piece of machine driven by a single software program. Nowadays as hardware & software are mixed in subtle ways the systems are growing even more complex due to the number of actuators and sensors used, having remote control option with devices like smartphones and being physically distributed.

If a company is faced with a decision to build or buy an embedded system to fulfil the requirements and that company doesn't have IT/embedded skills expertise the obvious resolution for them is to choose the 'buy' option but if they have an IT workforce they have the opportunity to choose between building it in-house or to buying it externally. For such companies with an IT workforce, those managers are then burdened with the decision to build or buy an embedded system mainly because

creating and supporting such complex systems raises many challenges. It may cost them a large overhead to solve those complexities, and managers can't afford to waste resources, time and money on a failing embedded system. So, determining the right approach at earliest is a critical yet complex process. Embedded systems have a high failure rate due to its complexities mainly due to escalating "functional and non-functional" constraints that should be met by embedded systems (Kopetz, 2008) .

Consequently, the objective of the research is to identify the critical success factors for BUILD or BUY decisions on in-house used embedded systems and then to formulate recommendations. The study only focuses on Sri Lankan companies which have an IT workforce excluding employees who attend primarily with administration or end-user applications that are required for daily functions.

1.2 Problem Statement

Sri Lanka has lately delivered some excellent companies which thrive on embedded industries. One of the key divisions in Sri Lanka National Export Strategy from 2018 has been the electronic sector (The Board of Investment of Sri Lanka (BOI) , 2018).

Embedded industry in Sri Lanka has shifted towards rising technologies like Robotics, IoT, Analytics, R&D and has become a competence hub for electronics industry (Sri Lanka Export Development Board (EDB)).

With ever increasing demand for embedded systems, companies must have the correct expertise under them and a motivated team. To be capable of implementing an embedded system successfully, many factors such as team expertise, vendor availability, ability to integrate new functionality with evolving technology, etc. must be considered when making decisions. Else it ends up as a waste of time and money. Therefore, it is very important to identify key factors which will help company managers determine whether to build or buy their next embedded system for in-house requirement to gain the benefits.

Accordingly, this research tries to address the following research question:

What are the critical factors that Sri Lankan companies should consider when deciding to build or buy embedded systems for in-house use?

1.3 Research Objectives

- Identify predetermined factors to consider when deciding to build or buy an embedded system for in-house use by analysing the literature.
- Identify and explore a set of build or buy decision events.
- Identify a set of factors affecting the build or buy decisions by analysing and interpreting the collected data.
- Recommend factors to consider in making a successful build or buy decision.

1.4 Outline

The thesis outline henceforth is as follows: a comprehensive description of the reviewed literature on embedded system, how BB (Build or Buy) decisions are made in different industries, factors affecting BB decisions and Grounded Theory are presented in Chapter 2. Then Chapter 3 offers the methodology used for data collection process and analysis process. Chapter 4 presents the actual analysis of the data collected. Chapter 5 explains the conclusion and future work associated with this study.

2 LITERATURE REVIEW

This chapter presents literature on embedded systems, Sri Lankan embedded industry, BB decision making. Section 2.1 offers an overview of embedded systems; Sections 2.2 and 2.3 provide overviews of BB decision making scenarios related to embedded industry and other industries respectively. Finally, Section 2.4 provides factors identified as affecting the build or buy decision outcome, through the literature review process.

2.1 Embedded Systems

Christof et al. (2009) defines embedded systems as microcontroller-based systems that are assembled into technical equipment. And these systems are implemented with a dedicated purpose. Reddy (2002) states that embedded systems should be extremely stable, responsive, sturdy and low-priced and embedded systems frequently use specific processors such as digital signal processors. Often embedded system programming is done on a general-purpose computer called a host with all the necessary programming tools. How embedded systems differ from general computer systems are primarily due to the involvement of computation which are subjected to physical constraints (Henzinger & Sifakis, 2006).

Exchange of data/interaction with the external environment happens through sensors and actuators. And embedded software is what is executed in those systems. Embedded systems are used in a variety of industries like automobile, consumer electronics, home appliances, telecommunication and security, etc. mainly because of their more elevated reliability, precision, real-time computing capability due to high-performance speed. According to Gartner, Inc. (2018) there will be 25 billion wireless devices connected around the world by 2021.

Sri Lanka has been rapidly expanding its capability in the electrical and electronic industry. The industry adds up to "2.89% of the total exports" of Sri Lanka with a contribution of “US$ 343.4” to the country's total revenue in 2014 (Sri Lanka Export Development Board (EDB), 2015).

Developing embedded systems however has many complexities. Stability of an embedded system is expected to be high by the end-users, an embedded system must

be able to perform well irrespective of the circumstances. Security also plays a huge role in embedded systems with the IoT in the technological frontline with many systems being interconnected with each other over the internet. Another challenge in embedded system development is how to pack conflicting features like longer battery life and high processing power into a small unit. According to Clarinox Technologies Pty Ltd. (2011), to overcome such challenges a diverse set of tools must be used throughout the lifecycle of the embedded system design. Even with all these difficulties companies cannot ignore the embedded industry, in order to keep up with the rest of the world. They have to use embedded systems like KIOSK, Multimedia systems, Robots, Attendance Card Punch Machines, Bill printers, Digital Display within the company.

Then managers are faced with a decision whether to build or buy those embedded system.

2.2 Making Build or Buy Decision in Embedded Industry

According to Fowler (2019) literature regarding BB decision making in embedded industry are limited. The literatures which are present are mostly informal and not scientific publications. Fowler also states when making decisions related to complex systems like embedded systems it greatly depends on human way of making decision that a clear understand on many disciplines like psychology, sociology, decision making and contracts and game theory is needed.

In another study, Fowler et al. (2019) focuses on systems that integrate multiple embedded systems from the designing step till the implementation is done. Maintenance, distribution, marketing, disposal costs are omitted. After analysing 18 case studies of embedded subsystems to simulate the BB decision they came up with 14 parameters as primary concerns when making a BB decision for embedded projects as Cost, Quantity, Discounts for COTS subsystem, Components for custom design component discounts, Blueprints, COTS vendor's consulting service quality and documentation, Technical support from vendor, Customer support from vendor, Team resources, Team expertise, Product lifecycle, Availability of COTS, Tooling, Time to market and opportunity costs. According to them out of these parameters Team expertise and resources or tools to complete the task efficiently played a major

role and had the most impact on the BB decisions. Licensing, life cycle and support was the least significant to BB decisions. For the above-mentioned parameters, a model provided the expected range of crossover since no single value can accurately represent subjective and bias values. When the estimated production cost is lower than the cross over value the model recommends a 'buy' option, when the estimated production quantity is higher than the crossover value it recommends 'build' option. They even state that this model will not give a more refined solution mainly because unknown constrains for the project, liability risks and difficulty to numerically precisely define subjective parameters.

National Instrument's (2017) states several areas to consider, as follows: Cost, opportunity cost, expertise, technical support, specification, and wildcards. Moreover, they state that teams often fail due to wasting time and money on project success dependent tasks rather than differentiators (unique value the system can provide). It says 90% of resources are assigned to R&D non differentiating tasks and following strategies are introduced to reallocate the resources,

- "Standardize" - reduce cost and risk by reducing variability in processes and systems
- "Modularize" - deconstruct a product into modularized subsystems to reuse component
- "Outsource" - hire another company to perform process part of it to cut overhead costs.

Dan Oliver (2002) states there are 5 main criteria which need to be taken into consideration when taking any technical BB decision to avoid utilizing resources on products with no real business value. The 5 criteria are as follows,

- Validate the need without giving into the technology hype
- Precisely identify the core business need
- The infrastructure & the standards of the company
- Research redundant systems within the company
- In-house expertise availability.

The importance of financial factor is confirmed by National Instruments (2014) which state that they gathered customer information regarding cost differences between custom approach and COTS approach and for custom design.

Viewpoint System (2017) have listed 5 reasons as common pitfalls and how to avoid such as,

- Choosing Wrong Tools Which Are Incompatible with Team Expertise.
- Choosing a Wrong Vendor.
- Incorrect Resource Allocation.
- Incorrect Requirements.
- Lack of Communication.

2.3 Making Build or Buy Decision in Other Areas

Buchowicz (1991) has introduced a process model (

Figure 2.1) for BB decision making for Manufacturing Software. In that study, interviewees were selected from areas like manufacturing, R&D, Information Systems and Outlining. Buchowicz identifies 3 stages in decision process as,

- "Strategic Fit Evaluation" - Strategically oriented firms tend to lean toward the 'make' option
- "Initial Categorization" - When the project delivery is urgent, lack resources, the underlying technology is mature and stable and lack of confidence in the internal IS team then those teams tend to lean toward the 'buy' option
- "Selection" - Thorough systematic attempts to pick between make or buy depends on the acknowledgement by the decision maker about the perception or comprehension of the in-house employees' with the application.

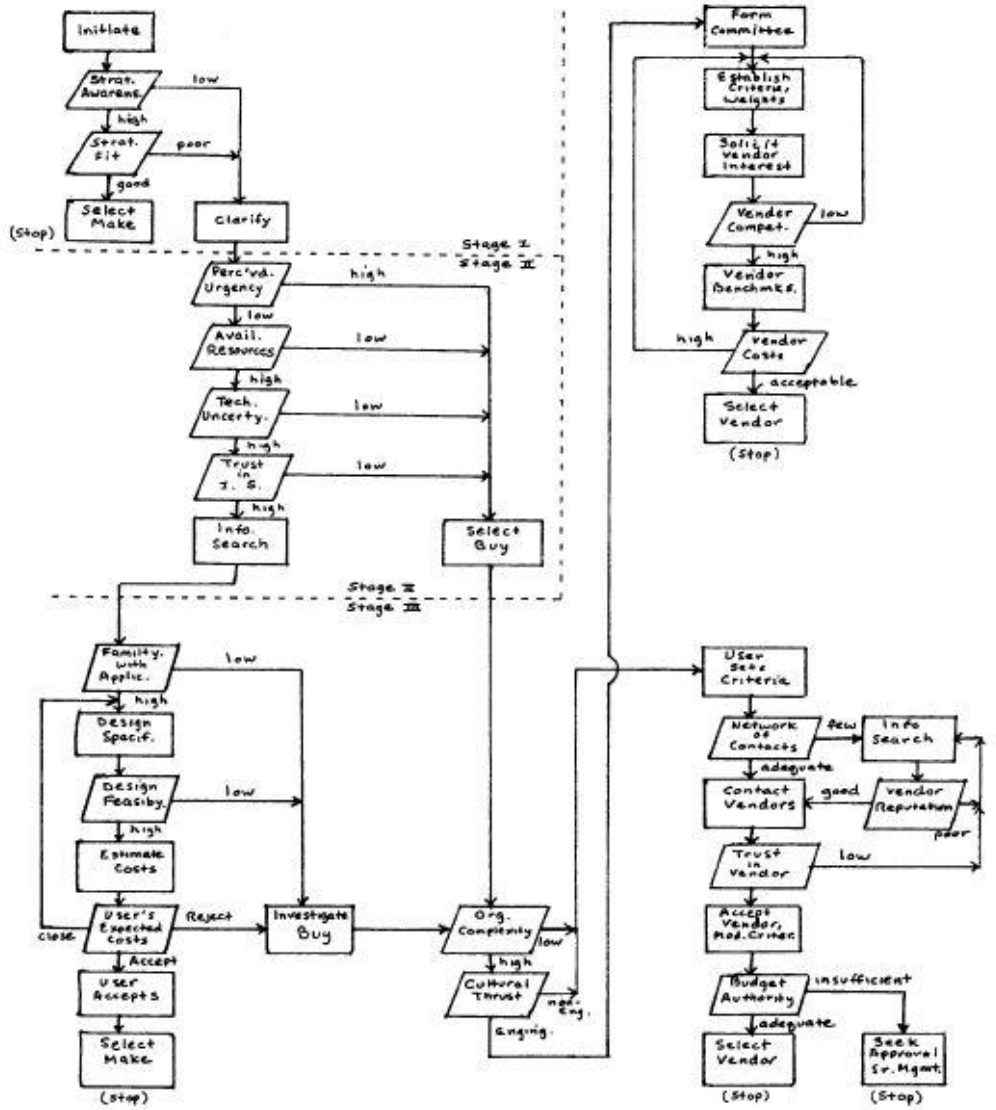

Figure 2.1 Build or buy process model for a Manufacturing Software Source: (Buchowicz, 1991)

Shahzad et al. (2017) in their IEEE journal article, refers to large scale software development cases and few identified factors that influences the BB decision on software such as, development risks, software maintenance support difficulties and strategic value for the software. And few other referencing factors were also identified such as strategic advantage, time, cost, quality of the product, expertise resource availability and availability for customizations in software development.

Platts et al. (2002) examine the factors shaping the making of BB decisions when developing a manufacturing strategy in industrial companies and key areas and respective determinants to be analysed in make or buy decisions. Key areas and factors are as follows,

- “Manufacturing methods” - technology and material, tech support, capability and quality standards, abilities, administration of the process abilities
- “Costing” - production cost, acquisition cost
- “Supply chain management and logistics” – choosing supplier, joint efforts with suppliers, cost cutback processes with supplier, delivery and inventory management
- “Support systems” - quality system, IS, engineering changes system, coaching plans and steady growth.

Daneshgar et al. (2013) identify key factors that influence decisions on small to medium enterprises software acquisitions. The identified factors are: Strategic and competitive advantage, Cost, Complexity and Scale, Requirements fit, commoditization, changes and flexibility, Risk, Time, Support structure, Operational factors, In-house expertise and Intellectual property.

Hung et al. (2008) tries to determine the factors that affect BB decisions in large Australian Companies and they come up with core factors as Strategy, Commoditisation vs. competitive advantage, Package Maturity, Internal Capability, Requirements fit and Cost that directly impacts the BB decisions and identified secondary considerate factors as Risk, Time and timing, Political Factors, On-going support and Type of system that will not impact the decision when they are considered alone.

Sillanpää (2015) has done a research to identify factors that affect BB decisions in manufacturing industry. In it Sillanpää states that there can be few triggers to make BB decisions in a company like lack of capacity, lack of confidence in knowing, company culture issues, economical issues, product life cycle issues, complexities, technology skills and most importantly cost and quality issues.

Even though most of the BB decisions are based on the cost factor Dale & Cunningham (1984) state that there are a number of other tangible and intangible factors that will dictate the outcome of a BB decision. Even requirements like need for solution design secrecy will tip the decision from one to another depending on the importance of it. It also emphasises on the fact that the company should have an open culture where a variety of job roles and people are involved in the decision making

team who are affected by it not only the senior management or the middle management levels. It further states that some make these BB decisions as a result of unfavourable markets and economic atmosphere in which the companies are operating. Dale & Cunningham also explain that the “the physical and financial size of the supplier, past performance, geographical location, source loyalty, personal prejudices and judgement” may also impact the decision outcome hence should be considered when making a BB decision.

2.4 Factors Affecting Build or Buy Decisions

This section provides an overview of which external factors were identified as directly or indirectly affects making a BB decision for in-house used embedded systems. These factors were identified based on the literature described in the previous section.

- strategic-fit
- project characteristics
- resources
- costs

2.4.1 Strategic-Fit

In strategic goals, the term "Strategic fit" is frequently used since it is a crucial part of management. It shows the ability of an organization to utilize its resources and depicts how well the company handles internal and external issues and makes use of opportunities effectively and productively.

The utilization of a company's resources effectively by the organization is linked with Strategic fit. Which indicates that just by selecting the right industry and positioning the company well in the industry doesn't guarantee the profitability of the company but rather through focusing on internal factors that make use of the unique characteristic of the organization’s variety of resources and proficiency (Grant, 2005).

Creating a business structure and identifying and managing the way the business operates and by using and doing necessary adjustments to resources like staff, technology and information to meet the dynamic business structure and new challenges to achieve success are what strategic fit is all about (Johnson, Scholes, &

Whittington, 1984). Strategically fit companies meet requirements and demands with efficiency and responsively. Hence companies who don't have a strategic-fit structure will fail.

Buchowicz (1991) identifies 3 stages in decision process and first stage itself is strategic-fit evaluation, where the initial screening of manufacturing software proposals separated strategically oriented firms from the rest of the firms. Those firms tend to lean toward the ‘make’ option. Others who were not concerned about the strategic consequences tend to skip the first stage completely. A company’s priority order when decision making is important because each company has their own matrices to help them make decisions according to their own preferences and priorities of factors that they think most important to them and their strategic & business values.

2.4.2 Project Characteristics

Under project characteristics the team must consider two areas as business requirements and architectural requirements and analyse these thoroughly to pinpoint each requirement and to consider supported solutions. By understanding project scalability, customizability, urgency of a delivery and existing industry standards etc.

From the identified 3 stages in decision process by Buchowicz the second stage was initial categorization, where decision makers try to go through or filter out software proposals using matters such as urgency, resources availability, stability of the technology and delivery capacity of the IS Team. If any of the above matters bring worry and distress for the decision makers, undoubtedly it will lead to a choice of buy option.

2.4.3 Resources

Team size, team expertise level, delivery potential, team’s design plan feasibility, resource location, technical support, turnaround time for bug fixes, availability of a support team and special scenarios like team members who are enthusiastic or motivated to learn new technologies etc. also plays a major role in when making build or buy decisions.

Fowler (2020) came up with a model for BB Decision for design and development of systems that integrate various embedded subsystems and in it they have added

resources like the team resources, staff expertise, tools and infrastructure needed as direct influencing factors to the outcome.

National Instruments (2014) states that team size and expertise is a major influence on whether to go for a custom solutions.

2.4.4 Costs

Mark Lutchen, former Global CIO of Price Waterhouse Coopers states that cost performs a significant role in BB decision making. Learning the total costs throughout the software lifecycle is essential because more than 50% of software costs occur after the implementation stage. That meticulous analysis of ongoing maintenance cost estimations always has made managers lean towards buy option (Traylor, 2006).

The idea of how to choose the approach according to different costs varies according to the below Figure 2.2.

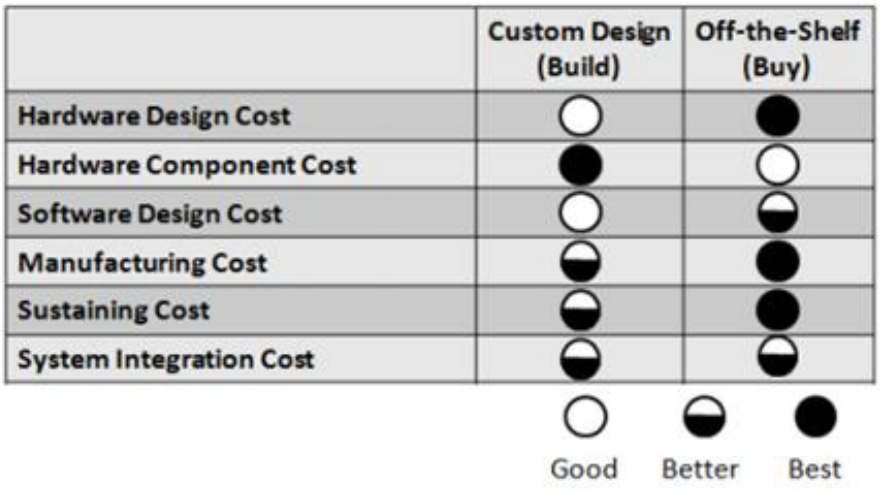

Figure 2.2 Compare the financials of build versus buy Source: (National Instruments, 2014)

National Instrument's (2017) white paper states several Cost areas to consider when making decisions to build or buy an industrial embedded system as follows,

- COST
  - Development
    - Hardware design
    - Software development
    - Mechanical design

- ❖ Vendors selection and management
- ❖ Test
- ❖ System integration
- ❖ Documentation
- ❖ Design tools

- Manufacturing
  - ❖ Tooling
  - ❖ Cost of Assembly
  - ❖ Production Test
- Cost of Component
  - ❖ BOM (bill of materials)
- Sustaining
  - ❖ Inventory management
  - ❖ Software maintenance
  - ❖ Customer support
  - ❖ Upgrade cost
  - ❖ RMAs

In COTS you can only save development costs and sustaining engineering cost. When buying COTS the article says if there any excess features that will be not used in the project or if it does not fit the system or if development needed then it will be too expensive to purchase COTS. Even if those are not to be the case the article emphasizes on re considering sustaining costs because they are easily overlooked.

3 RESEARCH METHODOLOGY

In this chapter, the methodology used to carry out the research is elaborated so the reader can gain clarity on following questions by the end of this chapter. What is the research problem? Why qualitative research and Grounded Theory is selected for this study? What are the factors discovered through literature? What is the population of this study? What is the data collection process and finally how is the data analysed?.

3.1 Research Problem

This study aims to identify the critical success factors to consider for a Sri Lankan company when deciding whether to build or buy embedded systems for in-house use given the fact that the company has an IT workforce. This study ignores IT workforces who are mainly involved with administration tasks or end-user applications that are necessary for daily work responsibilities.

Moreover, this study considers only companies which are directly or indirectly (through subsidiaries, sister companies or business partnerships) involved in the embedded industry.

The present study analyses the factors that influenced such BB decisions, then comes up with recommendations to consider when making BB decisions. A set of BB decision making events in several companies were based for this research.

3.2 Research Method

In 1967 a new revolutionary qualitative research type was introduced by Glaser and Strauss which was named as Grounded Theory. It helps to produce a theory through a methodical approach for analysing the collected data, not conforming to existing theories (Feeler, 2012). This study follows Strauss's approach to Grounded Theory over the Classical approach, mainly because of the freedom to use an initial literature review without restraining the openness throughout the process and this pre-existing knowledge guides the research to a starting point of data collection (Glaser & Strauss, 1967). BB decisions or any managerial decisions can be biased & subjective. Thus, the selection of qualitative grounded theory approach for this study.

In qualitative analysis the researcher start analysing the data from the very early stages like start of the data collection. Researcher start creating and modifying the questions and proceed on new emerging paths further (Pope, Sue, & Nicholas, 2000).

Grounded Theory is considered as unconventional method by Hutchinson (1986) because it mainly generates new theories grounded by data which are not dependent on existing theories.

By using both the author's observations and literature, factor categories and then interview questions were developed. Moreover, Straussian Grounded theory adapts theoretical sampling: The process to decide which data to collect next while the data collection, data coding and data analyzing is happening (Glaser & Strauss, 1967). In theoretical sampling researcher initially identifies a sample for data collection but as the research progresses the researcher has the freedom to select the gaps in the collected data and identify new samples and add to the data collection process. Until reaching a point where no more new theoretical ideas emerge from the data collection and the event under investigation has reached an adequately comprehensive end, also known as reaching theoretical saturation (Given, 2008).

3.3 Potential Factors

By analysing the literature, this study found 4 factors prior to the data analysis which affects BB decisions and its outcome as follows: Strategic – Fit, Project Characteristics, Cost and Resources.

Table 3.1 Dependent and independent factors

Independent	**Dependent**
• Strategic – Fit (Buchowicz, 1991; Viewpoint System, 2017; Fowler, Dyer, & Das, 2019; Grant, 2005; Dale & Cunningham, 1984)	Successful Build Buy Decision Outcome
• Project Characteristics (Buchowicz, 1991; Oliver, 2002; Dale & Cunningham, 1984; National Instrument, 2017)	
• Cost (National Instrument, 2017; National Instruments, 2014; Fowler, Dyer, & Das, 2019; Dale & Cunningham, 1984)	
• Resources (National Instrument, 2017; Fowler, Dyer, & Das, 2019; Buchowicz, 1991; Oliver, 2002)	

3.3.1 Dependent Factors

Successful outcome for BB decision on in-house used embedded systems is the dependent factor throughout this study, which response to the shifts in independent factors.

3.3.2 Independent Factors

Through rigorous evaluation of literature sources following independent factors were derived through deductive coding and listed in Table 3.2. These factors have a direct impact on the dependent factors

Table 3.2 Extraction of independent factors from deductive coding

Selected Independent factor	**from literature sources**	
Strategic – Fit	Company goals	• reflect on the strategy • strategic awareness • short sighted plans • policies
	Vendor selection	• vendor competition • relationship with a vendor
	Priority order	• their own matrixes • attribute's importance
Project Characteristics	Project	• urgency • Internal resources available • technology still evolving • complete redesigns
	Devices needed	• design alterations • complete redesigns
	Project requirements	• reach the market quickly • last minute changes • specifications
Cost	Development cost	• reduce development costs

Selected Independent factor	**from literature sources**	
		• Hardware design • documentation
	Manufacturing cost	• evaluate and validate the design • assembly cost • outsource PCB manufacturing
	Hardware component cost	• device cost • cost more in revision work
	Software cost	• largest development expense • requires software design
	Sustaining cost	• software maintenance • customer support • upgrade cost
	System integration cost	• form a final product • finalizing the mechanical design
	Maintenance Cost	• sustaining costs associated with maintaining the product • cost much more in repair work later
Resources	Team size	• member of staff
	Resource allocation	• resources are most important • expertise and required resources • tools and resources
	Expertise	• technical capabilities • expertise and required resources • requires a high level of expertise
	Technical support	• supportability of your product • reduce development efforts

Selected Independent factor	**from literature sources**	
		• vendor support to development team
	Wildcards	• wildcard considerations • can be hard to quantify • Secrecy of the design

3.4 Population and Sample Selection

The current research's focus is the successful BB decision outcome which is the dependent factor. And other factors that control and add to that focus are independent factors. Therefore, Dependent factor is directly dependent on independent factors within the study. Going forward for this study following standards were established to identify the focused population. The targeted population for this research is BB decision making events in Sri Lankan companies where the companies fall under the selection criteria in Figure 3.1.

Filter	Criterion	Definition
Company based on	Company must be based in Sri Lanka.	
Industry	Company must have an IT workforce.	IT workforce excluding employees such as administrative/executive workers, who are mainly involved with front office or end-user applications that are needed for daily jobs.
	Company must be involved with embedded industry.	Company must be directly or indirectly(subsidiaries, sister companies or business partnerships) involved with embedded industry.
Number of Build or Buy decision making events for in-house used embedded systems	One or more build-buy decision(s) on embedded solutions must be taken prior to the data collection.	Many companies follow Hybrid approach which is considered as a "Build" decision because it contains COTS buy decisions, integration, assembling and embedded system programming. Hence for this study "Build" options must have at least a partial development or implementation related to electronics done for that embedded solution.
	The build or buy decision made solution must be/were used within the company.	
Build or Buy decision status/event outcome	Both failed and successful decision making events are considered.	Each company may have different criteria on how to consider a decision as a success or a failure. So the interviewee's opinion is taken as the final answer on the outcome status.

Figure 3.1 Population selection criterion

Each BB decision event will be considered and investigated using the interview content and the qualitative approach. The initial count of companies involved in embedded industry in Sri Lanka were identified through analysing public resources such as company websites and official sites which listed companies and their competences such as SLASSCOM (Member Directory) , EDB (Sri Lanka Export Development Board (EDB)). Publicly accessible contact details and personal associations were used to arrange appointments for interviews.

An Interview request (see Appendix A) was sent to companies that fit the above population selection criterion in

Figure 3.1. Then the sample size was derived as shown in Table 3.3 using the following criteria,

- Criterion 1 - Replied to the researcher's requests
- Criterion 2 – According to the company, they have made such build or buy decisions
- Criterion 3 – Willing and available to share information with the researcher
- Sample size - Total number of build or buy decision events

Table 3.3 Determining sample size

Initial Count	Criterion 1	Criterion 2	Criterion 3 (Total number of companies)	Sample Size
60	8	6	5	14

3.5 Data Collection

3.5.1 Questions for Interview

Interviewing the targeted population was the method selected for this study to collect the data, since most of the experiences, failures and successes of these decisions are subjective to one company to another. To capture these data, an in-depth interview needs to be carried out to elicit much data as possible from the population. The interview questions (see Appendix B) used for data collection was derived through reviewing literature and the researcher's observations. A semi-structured, interview approach was chosen to supports comprehensive discussion while making the interviewee feels more natural and comfortable to elaborate and expand on

experiences. Following the Straussian grounded theory, the analysis commences as soon as the first interview concludes and the follow up revised interview questions (see Appendix C) evolve according to the outcomes of the previous interview findings.

3.6 Process of Data Analysis

The following section describes the steps taken throughout the Grounded Theory data analysing process.

3.6.1 Constant Comparative Analysis

The constant comparative method is used for classifying and relating qualitative data. It is an inductive data coding process. This method is a constant throughout the analysis since the researcher need to go to the beginning to compare each phase and identify relationships in between codes and memos and the new data with the old data.

3.6.2 Coding and Category

Open coding is the process of coming up with meaningful conceptual labels for each line of analysed data. This process help break down what is actually happening in the data. Through constant comparative method these codes are then categorized and as the open coding progress when these coding become dense they can be further categorized in to subcategories. Through axial coding the relationships between these categories and subcategories are formed. Then the core-categories are formed. Finally all codes are summarized to tell a bigger story through selective coding.

3.6.3 Memo Writing

Writing memos encourages the researcher to bring more depth to analysing the data. When coding is not enough to describe the data or when the interview answers doesn’t capture the emotions of the interviewee that type of missing observations also can be recorded as memos.

3.7 Summary

This chapter explained that due to subjective nature of the data Grounded theory approach was ideal and chosen for this study. Four independent factors were derived from literature which formed the initial interview questions.

4 DATA ANALYSIS

This chapter includes the actual research analysis. It includes the profiles of the participants and explanation on how the final sets of critical success factors are derived. The chapter ends with a summary of the identified critical success factors.

4.1 Participant Profiles

This research used Grounded theory to analyse the collected data through interviews and then came up with a substantive theory on critical success factors affecting build or buy decisions for in-house used embedded systems in Sri Lankan companies. The criteria used to identify the population for data collection and how the sample size was selected is shown in

Figure 3.1 and Table 3.3 respectively. Each BB decision making event was counted as a sample for this research. The study being anonymous and respecting the agreement made when doing interviews, only the BB event will be shared as in the below Figure 4.1.

Table 4.1 Participants and Build or Buy Events

	Build or Buy Events (in-house used solutions)	**Involved in embedded industry directly or indirectly**
Company 001	Attendance Machine	Indirectly (subsidiary)
	Vending KIOSK	
	PBX Phone System	
Company 002	KIOSK Machine	Indirectly (partnership)
	Robot	
	Meeting Room Booking Display	
Company 003	Thermal Camera	Directly
	Sanitization Booths	
	KIOSK	
	Robots	
Company 004	Attendance Machine	Indirectly (subsidiary)
	ID Card Printer	
Company 005	Diesel Management Solution	Directly
	Fuel Gauge	

4.2 Data Analysis

In this study, “QDA Miner Lite”, a popular qualitative analysis software was used to analyze the collected interview data and to code. Using “QDA Miner Lite” the

interview transcripts were coded meticulously, line by line to make sense of what the interviewee was trying to say. When coding, the main 4 factors identified earlier through the literature review as shown in Table 3.1 were used as a base and kept adding new coding to missing areas as the analysis progressed. After finally identifying the emerged core factors from the data as the critical success factors affecting build or buy decisions for in-house used embedded systems the connection in between those factors were derived to ultimately gain a clearer knowledge on the big picture. When doing the data collection the interviews and the questions were always changing according to the merging theories. When doing final few interviews the data did not yield new theories and then the data was considered theoretically saturated.

Data were analysed methodically through the coding process and to illustrate more on it, a basic overview on how the coding takes place in qualitative research is shown in the Figure 4.1.

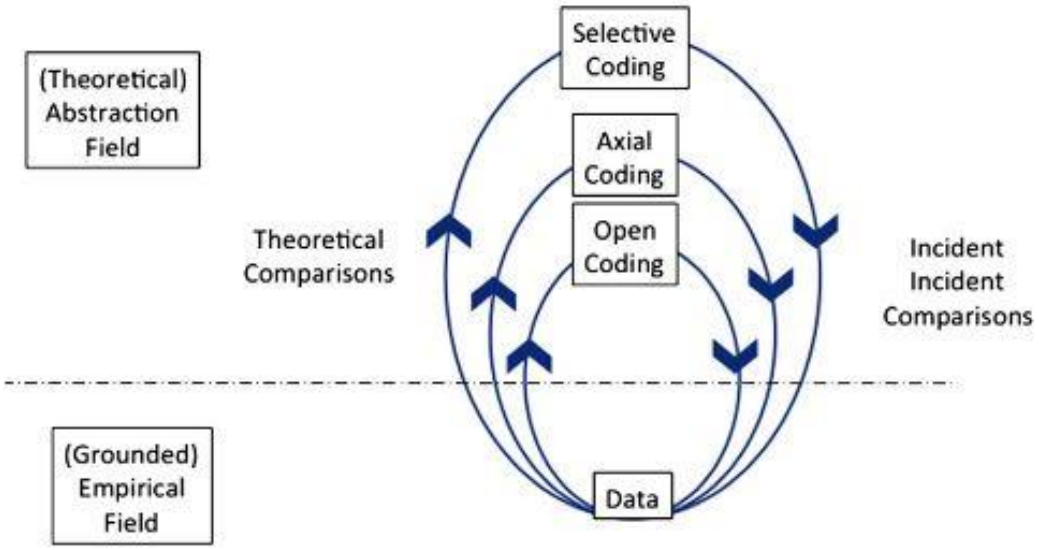

Figure 4.1 Coding process in qualitative analysis Source: (Pozzebon, Petrini, de Mello, & Garreau, 2011)

After the first interview itself the data analysis began and all the data were coded using open coding as well as memo writing. Open codes were then categorized according to similarities (Axial coding). From the next interview onwards constant comparative analysis was carried out, and the questions were modified accordingly to fit the new findings. In this study, all the initial codes and categories uncovered

through the collected data as well as their frequencies and percentages are shown in the below Table 4.2.

Table 4.2 Codes and Cases frequency and percentages taken from 'QDA Miner Lite'

Category	**Sub Category**	**Code**	**Count/ Hits**	**% Codes**	**Cases (out of 5)**	**% Cases**
Experience	educational background	Masters	4	1.20%	4	80.00%
		Degree	6	1.80%	5	100.00%
		PG Dip	2	0.60%	2	40.00%
	current workplace experience		5	1.50%	5	100.00%
	current position		4	1.20%	4	80.00%
	management experience		6	1.80%	5	100.00%
	total work experience		4	1.20%	4	80.00%
	Build or Buy decision making history		6	1.80%	5	100.00%
Company Background	Company Goals	Company Strategic Goals	11	3.30%	5	100.00%
		goal awareness	3	0.90%	3	60.00%
		goal alignment	6	1.80%	4	80.00%
		communication	6	1.80%	4	80.00%
	large company		6	1.80%	4	80.00%
	culture		9	2.70%	4	80.00%
Build or buy decision	Build or buy decision responsibility		2	0.60%	1	20.00%
	well defined process		4	1.20%	3	60.00%
	Buy approach		9	2.70%	4	80.00%
	hybrid approach		2	0.60%	1	20.00%
	Build approach		6	1.80%	2	40.00%
vendor selection	vendor amount		8	2.40%	4	80.00%
	vendors trust		8	2.40%	4	80.00%
	bid		3	0.90%	2	40.00%
	partnership with vendors		4	1.20%	3	60.00%
	benefits		2	0.60%	2	40.00%
	vendor selection process		3	0.90%	3	60.00%
matrices	decision making matrices		9	2.70%	5	100.00%
	priority order		9	2.70%	4	80.00%
IT Workforce	Teams capability	team ability to deliver	8	2.40%	5	100.00%
		team expertise	13	4.00%	5	100.00%

Category	Sub Category	Code	Count/ Hits	% Codes	Cases (out of 5)	% Cases
	workload		7	2.10%	4	80.00%
	Team size		13	4.00%	4	80.00%
technical support	limitations on access		3	0.90%	2	40.00%
	customer support		6	1.80%	3	60.00%
	vendor support		1	0.30%	1	20.00%
wildcards	motivated employees		9	2.70%	5	100.00%
	Response to new technology		5	1.50%	1	20.00%
	covid-19		5	1.50%	3	60.00%
	close connections with vendors		4	1.20%	3	60.00%
	legal barriers		1	0.30%	1	20.00%
	Political factors					
solution	redundant solution	low cost factors	3	0.90%	3	60.00%
		meets requirements	5	1.50%	4	80.00%
		ability to support additional features	4	1.20%	2	40.00%
	solution status	successful	11	3.30%	5	100.00%
		failure	5	1.50%	3	60.00%
		enjoying the benefits	13	4.00%	5	100.00%
	requirements		18	5.50%	5	100.00%
cost	hardware component cost		13	4.00%	5	100.00%
	software cost		6	1.80%	4	80.00%
	maintenance cost		13	4.00%	5	100.00%
	system integrations cost		4	1.20%	3	60.00%
	development/engineering cost		7	2.10%	2	40.00%
	manufacturing cost		1	0.30%	1	20.00%
	hardware design cost		4	1.20%	1	20.00%

On the above coding and categories, axial codes were further derived and finally after analysing, the core categories (selected coding) of the research were derived (Table 4.3). Out of those core categories, to select the key factors that has the most significant impact on the dependent factor: Build or buy decision on in-house used embedded systems, the author used the matrix shown in Appendix D. From a scale of zero to three (0-Not Applicable, 1-Disagree, 2-Nutral, 3-Agree) core categories were

voted by all the data collection participants. Then the factors with more than 50% of the voting as 'Agree' were chosen as the key findings (Table 4.4) or the factors that have the most significant effect on the BB decision or the dependent factor.

Table 4.3 Selected coding/main categories taken from 'QDA Miner Lite'

Core Category	**Sub Category**	**Code**	**Count/ Hits**	**% Codes**	**Cases (out of 5)**	**% Cases**
Decision Maker's Experience	Educational Background	Masters	4	1.50%	4	80.00%
		Degree	6	2.30%	5	100.00%
		PG Dip	2	0.80%	2	40.00%
	Work Experience	Current Workplace Experience	5	1.90%	5	100.00%
		Management Experience	6	2.30%	5	100.00%
		Total Work Experience	4	1.50%	4	80.00%
		Current Position	4	1.50%	4	80.00%
		Decision Making Experiences	6	2.30%	5	100.00%
Strategic Relevance	Strategic Goals	Strategy Roadmap	13	5.00%	5	100.00%
		Goal Awareness	3	1.10%	3	60.00%
		Goal Alignment	6	2.30%	4	80.00%
		Goal Communication	6	2.30%	4	80.00%
	External Environment	Political and Legal Factors	1	0.40%	1	20.00%
		Socioeconomics	6	2.30%	1	20.00%
		Economic				
		Environmental	5	1.90%	3	60.00%
	Corporate Culture	Shared Beliefs and Values	9	3.40%	4	80.00%
		Company Size	6	2.30%	4	80.00%
Decision Making Process	Decision Matrix	Selection Grid	6	2.30%	5	100.00%
		Priority Order	12	4.60%	4	80.00%
	Redundant Solutions	Price	3	1.10%	3	60.00%
		Meets	5	1.90%	3	60.00%

Core Category	Sub Category	Code	Count/ Hits	% Codes	Cases (out of 5)	% Cases
		Requirement				
	Decision Responsibility		2	0.80%	1	20.00%
	Clear-Cut Procedure		4	1.50%	3	60.00%
Vendor Selection	Vendor Availability		8	3.10%	4	80.00%
	Vendor Selection Procedure		6	2.30%	4	80.00%
	Vendor Relationship		19	8.40%	5	100.00%
IT Workforce	Team Capability	Team Competency	8	3.10%	5	100.00%
		Team Proficiency	13	6.10%	5	100.00%
		Team Attitude	10	3.80%	5	100.00%
		Team Workload	7	2.70%	4	80.00%
	Team Size		13	5.00%	4	80.00%
Cost	Software Cost		6	2.30%	4	80.00%
	Maintenance Cost		13	5.00%	5	100.00%
	System Integrations Cost		4	1.50%	3	60.00%
	Engineering Cost		7	2.70%	2	40.00%
	Manufacturing Cost		1	0.40%	1	20.00%
	Hardware Design Cost		4	1.50%	1	20.00%
	Hardware Component Cost		13	5.00%	5	100.00%

4.3 Deriving Final Factors

Following Table 4.4 shows the independent and dependent factors in this study.

Table 4.4 Key factors identified from the study

Independent	Dependent
Decision Maker's Experience	Successful build or buy decision outcome for in-house used embedded systems
Strategic Relevance	
• Strategic Goals • External Environment • Corporate Culture	
Decision Making Process	
• Redundant Solutions	

Independent		Dependent
	• Decision Responsibility • Clear-Cut Procedure	
Vendor Selection		
	• Vendor Availability • Vendor Selection Procedure • Vendor Relationship	
IT Workforce		
Cost		
	• Software Cost • Maintenance Cost • System Integrations Cost • Engineering Cost • Hardware Component Cost	

Following sections explains how each key factor in Table 4.4 was derived from the selected list of core categories in Table 4.3.

4.3.1 Deriving "Decision Maker's Experience" Factor

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated "Decision Maker's Experience" factor (Figure 4.2) as one of the factors to consider when making a BB decision for in-house used embedded systems.

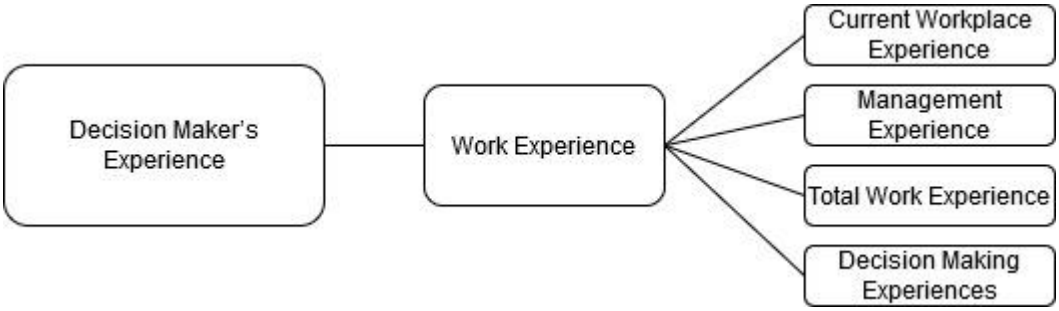

Figure 4.2 Validated "Decision Maker's Experience" factor dimensions

Table 4.5 shows how the open coding and the axial coding derived "Work Experience" subcategory which leads to the selected coding "Decision Maker's Experience".

Table 4.5 "Work Experience" Coding

Work Experience		
Code	**Case**	**Text**
Current Workplace Experience	Company 005	"I have been working at this company for more than 4 years now"
Current Workplace Experience	Company 004	"I have been working at this company for 5 years now"
Current Workplace Experience	Company 001	"6+ years now in this company."
Current Workplace Experience	Company 002	"working at this company for 3.5 years now"
Current Workplace Experience	Company 003	"14 years of service here"
Decision-Making Experiences	Company 004	"I was not directly involved in event such build-buy decisions."
Decision-Making Experiences	Company 003	"But there are many other scenarios where I had to make such decisions yet they are out of the scope of this study"
Decision-Making Experiences	Company 002	"5 time"
Decision-Making Experiences	Company 001	"3 such events, for an Attendance card punching machine, PBX Machine and recently with SIM Vending machine"
Decision-Making Experiences	Company 005	"I have involved in 2 separate build-buy decisions with in my time here directly"
Decision-Making Experiences	Company 003	"I would say 4 times"

Work Experience		
Code	**Case**	**Text**
Management Experience	Company 003	"I'm accountable to come up with solid plans for business marketing. I also have to make sure our customers of our company continue to gain more value-added experience from our products. Involved in planning & organizing the organization's activities to achieve targets. Groom and mentor the lead engineers, project coordinators and project managers"
Management Experience	Company 004	"I'm still managing a very small team in development so I have a long way to go in management field"
Management Experience	Company 002	"I have been involved with build-buy decision making event and I have managed a large number of members under my team"
Management Experience	Company 003	"8 years in my current management position"
Management Experience	Company 001	"but in my line of work and my project I have had the capacity to make decisions, give my opinion on decisions and asked for my opinion on the projects we work"
Management Experience	Company 005	"I have a wide range of management experience. I joined my first workplace as a Software engineer however I then completely diverted to management track. For the past 7 years I've business development manager, assistant manager, and now as a project manager."
Total Work Experience	Company 002	"I have overall 7 years of working experience"
Total Work Experience	Company 005	"8+ years of work experience"
Total Work Experience	Company 001	"IT technical background for almost 6 years"
Total Work Experience	Company 003	"14 years of service here"
Total Work Experience	Company 004	"All together I have 7+ years of work experience"

Following Figure 4.3 shows the "Decision Maker's Experience" factor's coding and cases frequency.

	Count	% Codes	Cases	% Cases
Decision Maker's Experience				
Work Experience				
Current Workplace Experience	5	2.3%	5	100.0%
Management Experience	6	2.8%	5	100.0%
Total Work Experience	5	2.3%	5	100.0%
Decision-Making Experiences	6	2.8%	5	100.0%

Figure 4.3 Coding and cases frequency for "Decision Maker's Experience"

In all the companies the participants believed that the total work experience of a decision maker and the management experience of that person have an impact on final decision's success or failure, and that experience leads to insightful decision making. Past experiences of such decisions can also teach as one can learn from past mistakes to make the right choice in future. Majority of the participants agreed that the current position of the decision maker is irrelevant to the outcome of the decision because majority of those companies had a culture where everyone can speak out their ideas and those ideas were valued.

4.3.2 Deriving "Strategic Relevance" Factor

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated "Strategic Relevance" factor (Figure 4.4) as another factor to consider when making a BB decision for in-house used embedded systems.

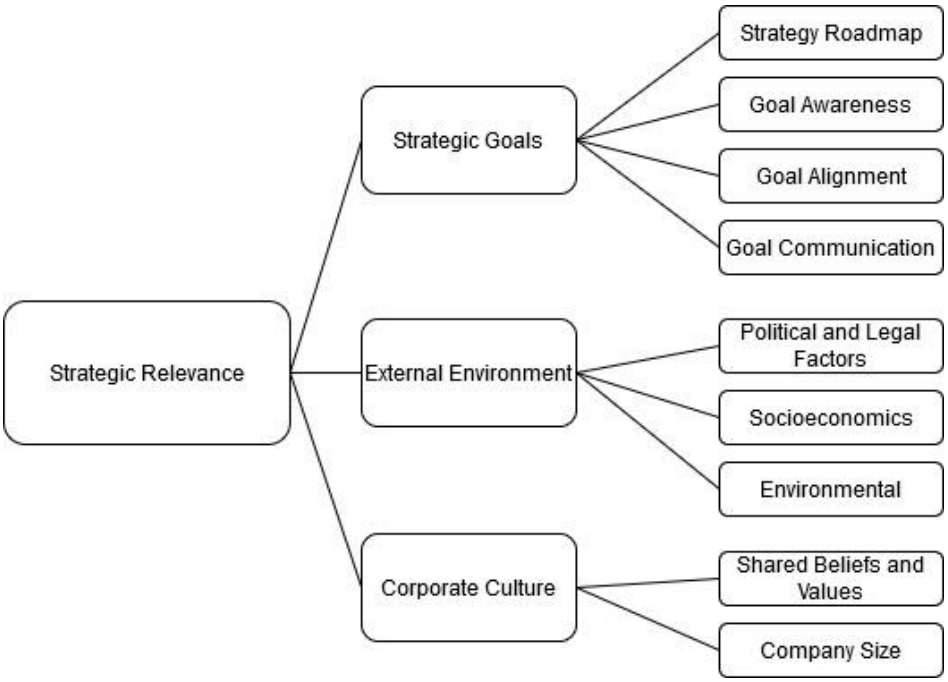

Figure 4.4 Validated “Strategic Relevance” factor dimensions

Table 4.6 shows how the open coding and the axial coding derived “Strategic Goals” subcategory which leads to the selected coding “Strategic Relevance”.

Table 4.6 “Strategic Goals” Coding

Strategic Goals		
Code	**Case**	**Text**
Goal Alignment	Company 003	“build-buy decisions will greatly and mostly dependent on Customer requirements”
Goal Alignment	Company 002	“robot assistance was a first in Sri Lanka”
Goal Alignment	Company 004	“our parent company was doing the embedded system development and we train and educate employees here in Sri Lanka and we send them to japan”
Goal Alignment	Company 001	“we wanted to be the first to introduce such technology to the customers than any other competitors”
Goal Alignment	Company 003	“We always put the business need and the requirements as the priority when developing a solution. So we make sure that we always is on track on business need of the project that the solution provided always meets the requirements.”
Goal Alignment	Company 002	“even if it's 200 million if a project gives us a competitive advantage, and a huge customer gain then we always overlook the price if the business requirement is high”
Goal Awareness	Company 002	“everyone is aware and reminded of how we progress and where we need to be. And the vision and mission is translated as KPIs for each employee targets to achieve for each division portfolio has separate set of KPI that they are encouraged to complete”
Goal Awareness	Company 001	“We have a training session which is compulsory for every new comer and we teach and communicate the company goals and mission”
Goal Awareness	Company 003	“everyone need to be on same page and have a clear idea on what's going on”
Goal Communication	Company 003	“Everyone should be able and know to justify the final decision when made”
Goal Communication	Company 001	“This strategic vision and mission is clearly passed down to each and every new employee when they 1st join the company”
Goal Communication	Company 004	“we send them to japan”
Goal Communication	Company 002	“communication gaps”

Strategic Goals		
Code	**Case**	**Text**
Goal Communication	Company 003	"Yes we make sure that our staff is clearly communicated on the company goals and objectives. Even when recruiting new staff we give an overview of where we started, where we've gotten, and where we're going"
Goal Communication	Company 002	"Quarterly we have 'town hall' meeting where CEO and top management elaborate on quarterly performance and where we stand currently. All staff which is 3000+ employees are addressed at the same time by the CEO and the management. So the goals and vision is cascaded down to the lowest level of a hierarchy"
Strategy Roadmap	Company 002	"whatever we do in the telecom industry we have to do first"
Strategy Roadmap	Company 003	"We are not a product specific company, depending on the customer requirement we adjust our priorities and decide on the solution approach."
Strategy Roadmap	Company 002	"Our vision is to be the number one Telco company in Sri Lanka"
Strategy Roadmap	Company 003	"We are not a product specific company, depending on the customer requirement we adjust our priorities and decide on the solution approach."
Strategy Roadmap	Company 001	"Our co-operate vision is to be Sri Lanka's premier next generation Communication & Information Technology solutions provider. And provide innovative next generation technological solutions in meeting customer needs better than any other industry player."
Strategy Roadmap	Company 003	"Company vision is to Enhance the emotional experience of everyone we touch and company mission is to Weave software and hardware into best-in-class solutions that ensure the enduring growth of our customers."
Strategy Roadmap	Company 004	"provide high quality product oriented software engineers through mutual collaboration with Japan and other IT industries in the world"
Strategy Roadmap	Company 004	"software engineers equipped with latest technological skills and exposure to the most advanced IT industries"
Strategy Roadmap	Company 003	"We are not a product specific company, depending on the customer requirement we adjust our priorities and decide on the solution approach."
Strategy Roadmap	Company 002	"we were focused on introducing both at the earliest we can in Sri Lanka."

Strategic Goals		
Code	**Case**	**Text**
Strategy Roadmap	Company 005	"Our company's mission has always been to use our expertise in design and technical know-how, to work in harmony with the environment. Among the company's primary aim was that it wanted to be regarded as a dynamic organization, with the flexibility to blend innovation into service of the highest standards in meeting the needs of every individual client"
Strategy Roadmap	Company 005	"Our objectivity is to identify the specific needs and expectations of our customers and provide them with the best cost effective solutions, with emphasis on speed, precision and efficiency while adhering strictly to quality and safety standards"
Strategy Roadmap	Company 005	"best cost effective solutions"

All of the participants rated Strategic Goals as an important factor, where the company is headed, what the company's vision and mission are, what are the strategic goals of the company, how they are communicated to the employees, how often are the employees reminded on the company goals and how well is he/she aware of it and how well does the goal align itself with daily tasks in the company & BB decisions? Questions like these lead to a better understanding on what the company's current focus is and requirements are, and how well the decision makers are aware of it makes all the difference on the outcome.

One participant stated,

"Everyone should be able and know to justify the final decision when made."

Another said,

"We have a training session which is compulsory for every new comer and we teach and communicate the company goals and mission."

Table 4.7 shows how the open coding and the axial coding derived "External Environment" subcategory which leads to the selected coding "Strategic Relevance".

Table 4.7 "External Environment" Coding

External Environment		
Code	**Case**	**Text**
Environmental	Company 001	"However the need for another solution was mainly due to the COVID-19 situation and WFH needs. Because with this corona

External Environment		
Code	**Case**	**Text**
		condition when people were told to work from home the management needed a solution to track attendance"
Environmental	Company 002	"soon after we installed it people had to start WFH with COVID-19 situation"
Environmental	Company 003	"Apart from unplanned risks like the current situation with covid-19"
Environmental	Company 003	"This was implemented to battle COVID-19 situation"
Environmental	Company 003	"Lessen the spreading rate of COVID-19."
Political And Legal Factors	Company 003	"legal barriers"
Socioeconomics	Company 002	"people were hesitant to work with new technology at once"
Socioeconomics	Company 002	"some people never get use to new technology"
Socioeconomics	Company 002	"Unfortunately people didn't really welcome it with open hands as expected. Like I said earlier majority are always hesitant to welcome new technology they are always sceptical"
Socioeconomics	Company 002	"But many people to this day avoid using the robot and rather wait in lines to meet the customer service agent"
Socioeconomics	Company 002	"younger generation interested in the solution and are trying to use and gain experience"
Socioeconomics	Company 002	"soon after we installed it people had to start WFH with COVID-19 situation"

Majority of the participants agreed that political factors like government taxation policies, labour laws, trade restrictions and legal factors like employment law, copyright and patent laws may impact the solutions so it has to be considered when making a BB decision.

One participant pointed out:

"Once we had legal barriers for one item to be shipped to Sri Lanka and instead we had to send a team to US to test the items and to complete the process."

There were a considerable amount of participants who put more weight on strategic goal rather than on socioeconomic factors like lifestyles and attitude of the people, cultural barriers and age distributions. So for one of those companies introduced a system as a "1st time in Sri Lanka" approach to match their company's vision and strategic road map. However that solution was not necessarily welcomed well from

the people and it had a very slow ROI comparing the huge amount of investment done for the system.

In one interview one stated:

"Unfortunately people didn't really welcome it with open hands as expected. Like I said earlier majority are always hesitant to welcome new technology they are always sceptical."

Many dismissed the Economic factor mainly because the country's economic status didn't necessarily have a huge impact on stable companies need to buy or build solutions for themselves since these were decisions on in-house-used systems. Since this research was done during COVID-19 pandemic, many systems which were previously successful suddenly became obsolete and discontinued with sudden long term WFH policies adapted by companies. As mentioned by one participant:

"However the need for another solution was mainly due to the Covid-19 situation and work from home needs. Because with this corona condition when people were told to work from home the management needed a solution to track attendance"

And some had to build separate systems to help battle the pandemic as shown below.

"We have implemented thermal camera to detect whether people are using masks and check temperature and is currently in use in the company. This was implemented to battle COVID-19 situation."

Hence, the environmental factor had a huge impact on the BB decisions made.

Table 4.8 shows how the open coding and the axial coding derived "Corporate Culture" subcategory which leads to the selected coding "Strategic Relevance".

Table 4.8 "Corporate Culture" Coding

Corporate Culture		
Code	**Case**	**Text**
Company Size	Company 003	"separate departments and a vendor management"
Company Size	Company 005	"Currently we have more than 3000 employees working for our company."
Company Size	Company 002	"huge company"
Company Size	Company 001	"The team shares the responsibilities of the work and work hard to meet deadlines. We have separate divisions inside the company. In our IT division we have separate units support section, software section, network section etc."
Company Size	Company 002	"7 companies all over the world"
Company Size	Company 003	"large enterprises"

Corporate Culture		
Code	**Case**	**Text**
Shared Beliefs and Values	Company 002	"open culture within the company"
Shared Beliefs and Values	Company 003	"We make sure everyone knows and understands the requirements"
Shared Beliefs and Values	Company 001	"who work tirelessly to achieve common goals"
Shared Beliefs and Values	Company 001	"The decision makers have freedom to raise opinions and challenge a wrong decision."
Shared Beliefs and Values	Company 003	"family like team"
Shared Beliefs and Values	Company 003	"we have a family like culture within the company"
Shared Beliefs and Values	Company 004	"Being a part of the this family one can get a taste of both the Sri Lankan culture where our company is based and Japanese culture where our mother company is based. We see a mixed culture here."
Shared Beliefs and Values	Company 004	"Where a strong sense of belonging"
Shared Beliefs and Values	Company 004	"Enterprise familyism."
Shared Beliefs and Values	Company 001	"Everyone directly related to a product is considered and consulted when making decisions"

Most of the participants consider areas like company culture, shared beliefs and moral values and mindsets have a direct impact on BB decisions. Following are some responses provided by the participants related to "Corporate Culture",

"The decision makers have freedom to raise opinions and challenge a wrong decision."

"*The company culture was so that they weren't aligned with technology*."

"Being a part of the this family one can get a taste of both the Sri Lankan culture where our company is based and Japanese culture"

Along with corporate culture many participants validated that the company size also matters when deciding on a solution.

One participant said:

"Typically large enterprises have their own set of requirements, and needs customizations."

Following Figure 4.5 shows the “Strategic Relevance” factor’s coding and cases frequency.

	Count	% Codes	Cases	% Cases
Strategic Relevance				
Strategic Goals				
Strategy Roadmap	11	5.1%	5	100.0%
Goal Awareness	3	1.4%	3	60.0%
Goal Alignment	6	2.8%	4	80.0%
Goal Communication	6	2.8%	4	80.0%
External Environment				
Political And Legal Factors	1	0.5%	1	20.0%
Socioeconomics	6	2.8%	1	20.0%
Environmental	5	2.3%	3	60.0%
Corporate Culture				
Shared Beliefs and Values	11	5.1%	5	100.0%
Company Size	6	2.8%	4	80.0%

Figure 4.5 Coding and cases frequency for "Strategic Relevance"

4.3.3 Deriving “Decision Making Process” Factors

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated “Decision Making Process” factor (Figure 4.6) as another factor to consider when making a BB decision for in-house used embedded systems.

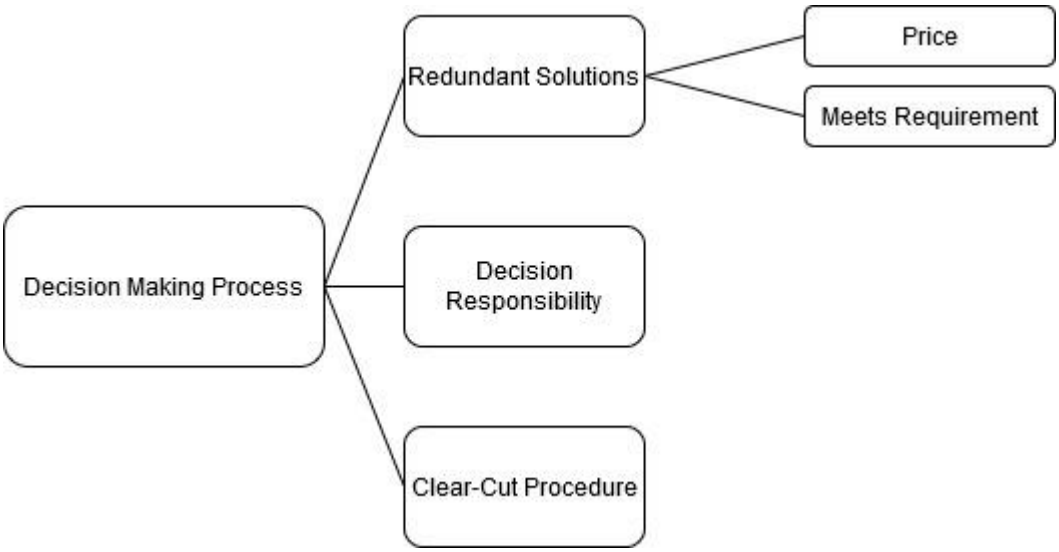

Figure 4.6 Validated "Decision Making Process" factor dimensions

Table 4.9 shows how the open coding and the axial coding derived “Redundant Solutions” subcategory which leads to the selected coding “Decision Making Process”.

Table 4.9 "Redundant Solutions" Coding

Redundant Solutions		
Code	**Case**	**Text**
Meets Requirement	Company 001	"We only had to expand it to within the organization. We currently only have Android app for this and in future the development team will do and IOS app also for this."
Meets Requirement	Company 002	"Now everyone is using online conference resources"
Meets Requirement	Company 003	"There are some off the shelf solutions available but with the limited functionality. Typically large enterprises have their own set of requirements, and needs customizations."
Meets Requirement	Company 003	"So we have to build COTS solutions but add new features as it fits to our organization."
Meets Requirement	Company 005	"Diesel Management solution were commercially available however it had limitations like only if there is a 4L difference and more only it will detect the change and modify he amounts."
Meets Requirement	Company 005	"available solutions had limitations"
Price	Company 001	"We already had a mobile app for tracking purposes and attendance of Sales Representatives within the company with less maintenance cost"
Price	Company 002	"Now everyone is using online conference resources"
Price	Company 004	"There are many other devices in the market with similar capabilities and sometimes even more cheap"

All the participants agreed that having an option of a redundant solution within the company or in the market hugely impact the BB decision. But the existing solution must meet the business requirement, else the IT team has to put extra effort to enhance the existing solution or it will fail to be useful for the correct reasons. Few responses received by the participants related to "Redundant Solutions" are as follows,

"Diesel Management solutions were commercially available however it had limitations like only if there is a 4L difference and more only it will detect the change and display the amount."

"We already had a mobile app for tracking purposes and attendance of Sales Representatives within the company with less maintenance cost"

Table 4.10 shows how the open coding and the axial coding derived “Decision Responsibility” subcategory which leads to the selected coding “Decision Making Process”.

Table 4.10 “Decision Responsibility” Coding

Decision Making Process		
Code	**Case**	**Text**
Decision Responsibility	Company 001	“The team shares the responsibilities of the work”
Decision Responsibility	Company 002	“When it comes to a build-buy decision it's not a responsibility of a single man or woman it's the whole team”
Decision Responsibility	Company 002	“Every decision made it's an equal responsibility among the teams”
Decision Responsibility	Company 003	“All the team members have a shared responsibility”
Decision Responsibility	Company 005	“The director board gave me full responsibility and power to take decisions which was an important turning factor.”

All the participants came to a common ground on the fact that the decision responsibility also is an influencing factor of the outcome of the decisions. When the team is given the power and the responsibility of the work or when they are accountable for the outcome of decisions, the teams tend to take the work serious and even show exceptional results. Following are some responses provided by the participants related to "Decision Responsibility",

“The director board gave me full responsibility and power to take decisions which was an important turning factor.”

“When it comes to a build-buy decision it's not a responsibility of a single man or woman it's the whole team.”

Table 4.11 shows how the open coding and the axial coding derived “Clear-Cut Procedure” subcategory which leads to the selected coding “Decision Making Process”

Table 4.11 “Clear-Cut Procedure” Coding

Decision Making Process		
Code	**Case**	**Text**
Clear-Cut	Company 002	“We have multiple units, let's say you want to buy something

Decision Making Process		
Code	**Case**	**Text**
Procedure		and you are in a supporting division then what you do is you create a Business Requirement Document and pass it down to a project managers team which is a group of 40 to 50 project managers which is a separate unit that project manager will assemble a technical and a strategic unit consists of 10-15 people and they work on the project or the product. One can be working in several projects simultaneously. Then they will float a Request for proposal within some registered vendors. We have a huge database of vendors around 20,000 - 40,000 list of both local and international vendors. Then based on quotations at least 5 we receive then we decide on average how much we'll have to spend on it. Then the investment committee consisting CEO and 5 or 6 other top management people then from a presentation we need to explain why we need it. Then the either approve or reject. If approved they negotiate on the final prices with vendors. Can be multiple rounds of negotiations. It's always a give or take and compromise. Then once finalized we go to legal and they come up with drafted agreements then the finance will issue a purchase order which will be issues to the vendor and after the project is done, they again need to go to the investment committee with CEO and top management then show what happened, pros, cons, budget, progress and all that"
Clear-Cut Procedure	Company 002	"Need to go through the process I mentioned earlier, the presentation, approval and all that. So it reduces the loop holes"
Clear-Cut Procedure	Company 002	"Business requirement is the highest priority"
Clear-Cut Procedure	Company 002	"We didn't focus necessarily on competitive advantage when it comes to the features"
Clear-Cut Procedure	Company 003	"maintenance cost is 12-18% of the overall engineering cost"
Clear-Cut Procedure	Company 005	"huge importance on budget factor when making decisions"

Majority of the participants had a clear cut importance on either business requirement or the cost factor as shown by following responses,

"Huge importance on budget factor when making decisions"

"Create a Business Requirement Document and pass it down to a project managers team which is a group of 40 to 50 project managers who will assemble a technical and a strategic unit consists of 10-15 people to work on the project or the product. Then they will float a Request for proposal within some registered vendors. Then based on quotations we decide on average how much we'll have to spend on it. Then to an investment committee consisting CEO and 5 or 6 other top management people need to be presented with details why we need it…"

Some even had matrices to follow for such decisions. Only one participating company had a "Selection Grid" within the company to support decision making. Due to lower ratings in factor selection matrix "Decision Matrix" is discarded as irrelevant for the decision outcome.

Following Figure 4.7 shows the "Decision Making Process" factor's coding and cases frequency.

	Count	% Codes	Cases	% Cases
Decision Making Process				
Redundant Solutions				
Price	3	1.4%	3	60.0%
Meets Requirement	6	2.8%	4	80.0%
Decision Responsibility	5	2.3%	4	80.0%
Clear-Cut Procedure	6	2.8%	3	60.0%

Figure 4.7 Coding and frequency for "Decision Making Process"

4.3.4 Deriving "Vendor Selection" Factors

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated "Vendor Selection" factor (Figure 4.8) as another factor to consider when making a BB decision for in-house used embedded systems.

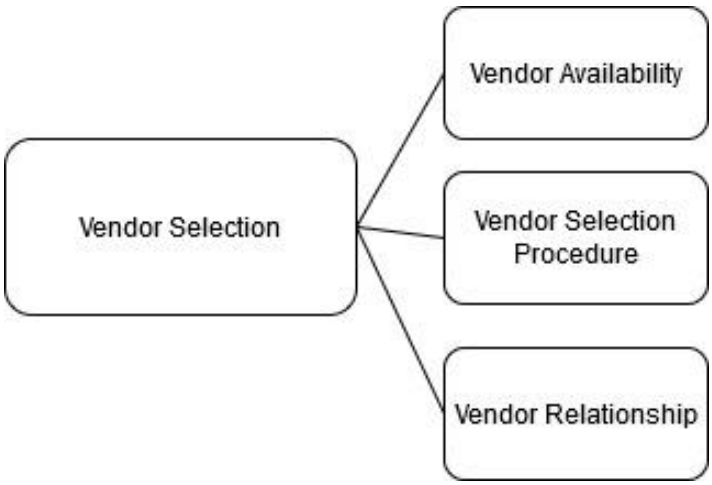

Figure 4.8 Validated “Vendor Selection" factor dimensions

Table 4.12 shows how the open coding and the axial coding derived “Vendor Availability” subcategory which leads to the selected coding “Vendor Selection”.

Table 4.12 “Vendor Availability” Coding

Vendor Selection		
Code	**Case**	**Text**
Vendor Availability	Company 001	“We do not have a vendors in abundance”
Vendor Availability	Company 002	“We have a huge database of vendors around 20,000 - 40,000 list of both local and international vendors”
Vendor Availability	Company 002	“The Vendor DB is created with we have 7 companies all over the world and those companies and their vendors also are added to the database so we have a full comprehensive database”
Vendor Availability	Company 002	“we have a huge number of vendors”
Vendor Availability	Company 003	“no we don't have vendors abundantly only very few”
Vendor Availability	Company 003	“in this industry is sometimes only a handful of vendors meet our requirements and deadlines”
Vendor Availability	Company 003	“a handful of vendors were available”
Vendor Availability	Company 005	“we did have vendors in abundance”

Vendor availability is the high road when making BB decisions. How many vendors are available for the company holds a lot of power on making the outcome successful. Some participants even said that there are not many vendors available for some items here in Sri Lanka so they had no other choice but to invest on foreign vendors for that. In such cases the total cost will become much higher if the availability of vendors is not considered at the beginning stage of the decisions making. Few responses on "Vendor Availability" are as follows,

“*In this industry it’s sometimes only a handful of vendors meet our requirements and deadlines*”

“*We have a comprehensive database of vendors around 20,000-40,000 list of both local and international vendors*”

Table 4.13 shows how the open coding and the axial coding derived "Vendor Selection Procedure" subcategory which leads to the selected coding "Vendor Selection".

Table 4.13 "Vendor Selection Procedure" Coding

Vendor Selection		
Code	**Case**	**Text**
Vendor Selection Procedure	Company 001	"In our company we have a bidding process"
Vendor Selection Procedure	Company 003	"We do not bid"
Vendor Selection Procedure	Company 003	"No bids. Only through contacts."
Vendor Selection Procedure	Company 003	"vendor management team who are more focused on vendor communication and selection processes"
Vendor Selection Procedure	Company 004	"Since most of the vendors are based in japan and the clientele is in japan we cater to them through the vendor base in japan"
Vendor Selection Procedure	Company 005	"selection was done based on the budget parameter mainly"

One participant company didn't directly do embedded solution building however their parent company in Japan did do embedded system building. The Sri Lankan subsidiary was the place to hire and train undergraduate to be later sent to their parent company as skilled professionals. Even though their mother company had a set of vendors to work with Sri Lankan company didn't bother about vendor availability since their domain was not the same as their Japanese parent company. Other than them every other participant agreed that availability of vendors is crucial for decision making.

Table 4.14 shows how the open coding and the axial coding derived "Vendor Relationship" subcategory which leads to the selected coding "Vendor Selection".

Table 4.14 "Vendor Relationship" Coding

Vendor Selection		
Code	**Case**	**Text**
Vendor Relationship	Company 005	"we didn't have access to the implementation of the available solution and couldn't customize it as we need."
Vendor Relationship	Company 005	"We do believe the vendors capability to deliver on time"

Vendor Selection		
Code	**Case**	**Text**
Vendor Relationship	Company 004	"technical support from the vendor"
Vendor Relationship	Company 004	"vendor was a close friend of the company and whom the company trust"
Vendor Relationship	Company 004	"vendor was a close friend of the company"
Vendor Relationship	Company 004	"it's Japanese culture of course it's all about trust"
Vendor Relationship	Company 004	"close relationship with the vendors"
Vendor Relationship	Company 003	"Manufacturing partner who would do the complete manufacturing of the product after the design is finalized. For that we used a vendor in China and Taiwan"
Vendor Relationship	Company 003	"close relationship with our vendors"
Vendor Relationship	Company 003	"we have a family like culture within the company an even with vendors, we have contacts and work closely with such vendors that support our way of thinking and working."
Vendor Relationship	Company 003	"we use the same familiar know set of vendors"
Vendor Relationship	Company 003	"recommendations by our known vendors"
Vendor Relationship	Company 003	"we have close relationship with our vendors and we always work with them with the relationship built and the trust we have and experience we have shared"
Vendor Relationship	Company 002	"vendors also have tried to mislead us trying to sell the same solution to separate companies inside the same group"
Vendor Relationship	Company 002	"if it's a complete failure, then we go for vendors support"
Vendor Relationship	Company 002	"we don't have access to do development on the platform"
Vendor Relationship	Company 002	"It's all on agreements. We do not know the vendors personally"
Vendor Relationship	Company 001	"Zero software cost, since it was an agreement to sell the software for free"
Vendor Relationship	Company 001	"close connections top management"

Vendor Selection		
Code	**Case**	**Text**
Vendor Relationship	Company 001	"If we are to expand the capabilities new integrations are to be done by the vendor itself and the software integration is done by our internal team."
Vendor Relationship	Company 001	"needed devises and solutions are available for us with some benefits"
Vendor Relationship	Company 001	"we have partnered up with some vendors"

Majority of the participants had close partnership with their vendors, both had mutual understanding and contract to help each other, some even provided free maintenance and some sold the systems free of software cost and only charged for the hardware component costs. Likewise many benefits come with vendor connections and the partnership they maintain. People who maintain a close partnership tend to have complete trust on the vendors and their ability to provide. Some participant only had a very limited number of vendors available and they had a very close partnership with them. They were fully satisfied with the services and abilities of the vendors and they never had a reason to look for other vendors. And as observed the higher the amount of vendors available the lesser the trust factor they have on the vendors. And one participant even mentioned that for them with a huge number of vendors available some even tried to deceive the company by selling the same product for different companies under same group of companies for different amount. Few responses are as follows,

"*It's all on agreements. We do not know the vendors personally*"

"*Vendors also have tried to mislead us trying to sell the same solution to separate companies inside the same group for different amounts*"

Following Figure 4.9 shows the "Vendor Selection" factor's coding and cases frequency.

	Count	% Codes	Cases	% Cases
Vendor Selection				
Vendor Availability	8	3.7%	4	80.0%
Vendor Selection Procedure	6	2.8%	4	80.0%
Vendor Relationship	22	10.1%	5	100.0%

Figure 4.9 Coding and frequency for "Vendor Selection"

4.3.5 Deriving "IT Workforce" Factors

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated "IT Workforce" factor (Figure 4.10) as another factor to consider when making a BB decision for in-house used embedded systems.

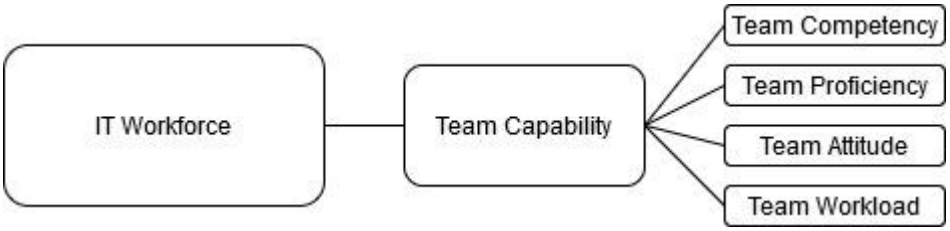

Figure 4.10 Validated "IT Workforce" factor dimensions

Table 4.15 shows how the open coding and the axial coding derived "Team Capability" subcategory which leads to the selected coding "IT Workforce".

Table 4.15 "Team Capability" Coding

Team Capability		
Code	**Case**	**Text**
Team Attitude	Company 005	"Genuinely needed to change the way of working in a traditional workplace to a more technology evolved work place. Who had a vision to help the company cut unnecessary wastages of material and cost"
Team Attitude	Company 005	"Yes we do. All the new joiners are fresh in the industry and they are willing to learn and gain experience."
Team Attitude	Company 002	"Yes there are many employees in our company who is eager to learn new technologies new areas"
Team Attitude	Company 001	"They have the capacity to learn new thing and even with steep learning curves they are able to meet deadlines"
Team Attitude	Company 003	"Yes the team is always eager to learn new technologies they are resilient and motivated"
Team Attitude	Company 004	"We always hire people with the correct attitude people who are willing to learn new technologies whose mind-set is to always do their level best."
Team Attitude	Company 004	"we hire people for the attitude then we train them"
Team Attitude	Company 002	"It's always encouraged for the employees to need and want more for their career learn and grow"
Team Attitude	Company 002	"Yes there are many employees in our company who is eager to learn new technologies new areas"

Team Capability		
Code	**Case**	**Text**
Team Attitude	Company 003	"We have complete trust in the team because they are eager to learn and fast learners"
Team Competency	Company 003	"I have complete faith in them"
Team Competency	Company 001	"We have a capable teams who work tirelessly to achieve common goals"
Team Competency	Company 005	"3rd year undergraduates"
Team Competency	Company 002	"Depends, if we don't have the capacity then we outsource"
Team Competency	Company 003	"we have the trust on the team that they will deliver the product on time that's what managers' support"
Team Competency	Company 002	"we have full faith on the teams they always try to deliver on time"
Team Competency	Company 004	"The team has the Ability to meet tight deadlines and maintain fast turnaround times"
Team Competency	Company 003	"We have a very capable and family like team."
Team Proficiency	Company 002	"In their domain levels we have expertise"
Team Proficiency	Company 003	"I have complete faith in them"
Team Proficiency	Company 001	"we do not have the expertise with in the company"
Team Proficiency	Company 004	"Human resources who are working in this company and their technical abilities are the foundation that supports our development in the future"
Team Proficiency	Company 003	"We have one expert who had double PHDs in USA and he transfers the knowledge to the SL team continuously"
Team Proficiency	Company 004	"We hire people undergraduates from Sri Lanka and we train them through a native Japanese Teachers within the local company premises and thereafter we send the skilled employee to work for Parent company in Japan."
Team Proficiency	Company 002	"which was not too much trouble"
Team Proficiency	Company 002	"And integration and set up was also done by the internal team."

Team Capability		
Code	**Case**	**Text**
Team Proficiency	Company 002	"If the expertise is not within the company we hand it over to one of the seven mainly Malaysian company then they do the development and we only take over the maintenance and we keep few people hand in hand with the Malaysian team to help transfer the knowledge."
Team Proficiency	Company 005	"We hired couple of undergraduates from Sabaragamuwa university they are all enthusiastic and motivated. They have the knowledge and I have only provided them a platform to make use of it."
Team Proficiency	Company 003	"We maintain a database of all the resource pool, their availability and their skill level"
Team Proficiency	Company 001	"They are well versed software developers"
Team Proficiency	Company 001	"There are people who have expertise level of knowledge with having to work on those projects for years and years"
Team Proficiency	Company 001	"Software improvements are anyway under our team's expertise and the PBX units are managed by our partnering company, So we have benefits on device maintenance & services."
Team Workload	Company 002	"you might have multiple projects at hand"
Team Workload	Company 003	"database of all the resource pool, their availability"
Team Workload	Company 004	"gives a range of responsibilities and control"
Team Workload	Company 002	"available project managers juggle multiple projects as a single time"
Team Workload	Company 003	"At a given time, we know the number of resource who are available"
Team Workload	Company 005	"internships in our company"
Team Workload	Company 002	"If people are neck deep in projects we outsource"

The IT workforce of the company plays a major role in BB decisions in both build scenarios and buy scenarios. If the bought system had additional implementation needed, enhancements needed to meet business requirements the IT workforce comes into play and their expertise comes in handy in scenarios like these. Also even with no implementations many of the participants did the integration of the systems to their existing systems through the IT team without having to pay for extra installations cots or integration costs to the vendor. Some teams even managed maintenance of the devices unless it was a complete device failure. The participant

companies valued the attitude of the IT workforce in high regards, some had a "Hire for attitude, teach skills" mind-set when hiring people to the IT workforce. They believe the motivation of the team comes with the attitude the team have to learn new technologies, accept the unknown domains etc. The ability to persevere and deliver on time is also dependent on the team's attitude. In IT industry the most important attitude the teams have is the eagerness to learn new technologies and adapt to constantly evolving technologies. This is why the having a capable team was considered highly by all the participants. Few responses on it are as follows,

"*We always hire people with the correct attitude people who are willing to learn new technologies whose mind-set is to always do their level best.*"

"*If the expertise is not within the company we hand it over to one of the seven mainly Malaysian companies then they do the development and we only take over the maintenance and we keep few people hand in hand with the Malaysian team to help transfer the knowledge.*"

The companies however believe that the size of the team doesn't have an impact on the decision making and discarded the "Team Size" aspect. If they can form even a small 3-4 people team with the right attitude and vision it is enough to provide the management team the needed confidence in making BB decisions.

Once participant said:

"*We hired couple of undergraduates from Sabaragamuwa university they are all enthusiastic and motivated*"

Following Figure 4.11 shows the "IT Workforce" factor's coding and cases frequency.

	Count	% Codes	Cases	% Cases
IT Workforce				
Team Capability				
Team Competency	8	3.7%	5	100.0%
Team Proficiency	14	6.5%	5	100.0%
Team Attitude	10	4.6%	5	100.0%
Team Workload	7	3.2%	4	80.0%

Figure 4.11 Coding and frequency for "IT Workforce"

4.3.6 Deriving "Cost" Factors

After dismissing factors with lower than 50% rating in the factor selection matrix (see Appendix D) the author was able to derive the following validated "Cost" factor (Figure 4.12) as another factor to consider when making a BB decision for in-house used embedded systems.

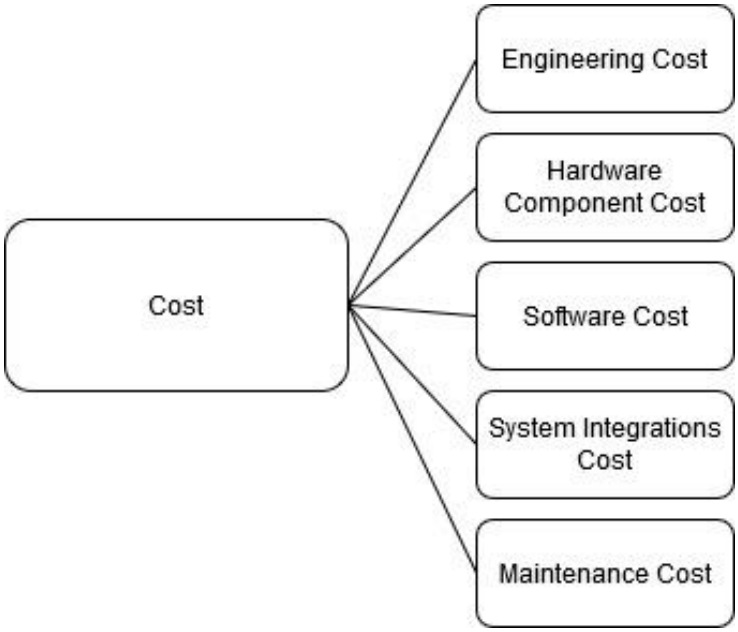

Figure 4.12 Validated "Cost" factor dimensions

Table 4.16 shows how the open coding and the axial coding derived the selected coding "Cost".

Table 4.16 "Cost" Coding

Cost		
Code	**Case**	**Text**
Engineering Cost	Company 003	"Once some items were not allowed in Sri Lanka and we had to send a team to US to test the items and to complete the process"
Engineering Cost	Company 003	"Average one-month cost of an engineering team with architects and engineers would come around 2,000,000LKR to 3,000,000LKR per month"
Engineering Cost	Company 003	"Hardware design cost again falls under the engineering cost"
Engineering Cost	Company 003	"The software cost includes the development and maintenance of the solution. Sometime we need to develop software to integrate our solution with existing infrastructure/processes of the customer as well. So all those development costs will get added to the final solution."

Cost		
Code	**Case**	**Text**
Engineering Cost	Company 005	"total design and development, salaries etc. roughly (500,000LKR-800,000LKR)"
Engineering Cost	Company 003	"maintenance cost is 12-18% of the overall engineering cost"
Engineering Cost	Company 003	"System integration also done by the internal team. So this is also added to the development cost."
Hardware Component Cost	Company 001	"So we only had to pay for the device cost."
Hardware Component Cost	Company 001	"This was around 55,000LKR for 5 items."
Hardware Component Cost	Company 001	"Device purchase price was in between 100,000LKR 200,000LKR."
Hardware Component Cost	Company 001	"We had to buy the PBX units and land line phones to set up the solution for every branch. 5,000,000LKR - 10,000,000LKR"
Hardware Component Cost	Company 003	"KIOSK: 1,200,000LKR - 1,500,000LKR"
Hardware Component Cost	Company 004	"150,000LKR for both systems."
Hardware Component Cost	Company 005	"To actually implement the solution I would say it cost us roughly 300,000LKR for hardware components."
Hardware Component Cost	Company 002	"device cost per item came around 1,200,000LKR. And we bought 120 items one for each of main customer outlets. So total around 144,000,000LKR"
Hardware Component Cost	Company 003	"Robot: 1,000,000LKR - 1,500,000LKR"
Hardware Component Cost	Company 002	"So total roughly around 500,000LKR - 700,000LKR"
Hardware Component Cost	Company 003	"Sanitization Booths: 125,000LKR 250,000LKR"
Hardware Component Cost	Company 003	"Thermal camera: 150,000LKR - 400,000LKR"
Hardware Component Cost	Company 002	"one robot for around 1,500,000LKR"
Maintenance Cost	Company 001	"Minimal since we had internal resources to do that"
Maintenance Cost	Company 001	"TRCSL licence need to be renewed annually and which might take more than 150,000LKR. Those costs like license renewal also should be considered."
Maintenance Cost	Company 001	"Minimal since we had internal resources to do that"

Cost		
Code	**Case**	**Text**
Maintenance Cost	Company 003	"maintenance cost is 12-18% of the overall engineering cost"
Maintenance Cost	Company 002	"Robot: annually around 100,000LKR."
Maintenance Cost	Company 002	"KIOSK: Maintenance cost annually per KIOSK item is around 100,000LKR. So for all the customer outlets in total its roughly around 1,200,000LKR"
Maintenance Cost	Company 004	"Like I said it was on a mutual agreement and the maintenance fee was free for the company."
Maintenance Cost	Company 004	"technical support from the vendor was provided for free out of charge"
Maintenance Cost	Company 003	"so for a 2,000,000LKR - 3,000,000LKR development cost we had a roughly 360,000LKR - 540,000LKR maintenance cost annually."
Maintenance Cost	Company 002	"For the meeting room booking display we still didn't incur any maintenance cost since it was installed very recently."
Maintenance Cost	Company 002	"But we have an annual price payment for the vendor to make sure the devices are working as expected and in good condition. About 50,000LKR-100,000LKR"
Maintenance Cost	Company 005	"Maintenance also done by the team in-house."
Maintenance Cost	Company 001	"Minimal since we had internal resources to do that."
Software Cost	Company 005	"Software is implemented in-house."
Software Cost	Company 003	"The software cost includes the development and maintenance of the solution. Sometime we need to develop software to integrate our solution with existing infrastructure/processes of the customer as well. So all those development costs will get added to the final solution."
Software Cost	Company 001	"close connections top management had with the company we were able to omit the software cost totally"
Software Cost	Company 001	"Software was built within the company for billing."
Software Cost	Company 001	"Zero software cost, since it was an agreement to sell the software for free"
Software Cost	Company 002	"The software use for the KIOSK was roughly around 50,000LKR and which was a onetime payment"
System Integrations Cost	Company 005	"Implementation is also done by the team in-house."
System Integrations Cost	Company 002	"KIOSK: System integrations are done the company internally."
System	Company 004	"We bought both the attendance machine and the ID printer to

Cost		
Code	**Case**	**Text**
Integrations Cost		integrate the systems."
System Integrations Cost	Company 002	"Meeting room booking display: System integrations are done the company internally."

Many participants rejected the "Manufacturing Cost" factor mainly because they didn't focus on production aspect of the system rather they built or bought the system to be used with in the company not to sell outside of the company. Moreover majority of the participants added the material cost which is normally under manufacturing costs to be under "Hardware Component Cost" or "Engineering Cost". Engineering cost covers all the non-recurring engineering costs in other words any cost that is related to development design process such as the planning costs, labour costs, material costs etc. Some participants bought systems and paid only for the "Hardware Component Cost" without paying for the "Software Cost" due to benefits from the close partnership they maintain with vendors. But some had to pay the software component along with the cost of the device. "System Integration Cost" refers the cost that is spent on integrating the new built or bought system to an existing solution. Many participants did this internally to save up on integration costs. Hardware Design Cost which normally comes up when a special kind of testing or design alteration is need to the system which was only relevant to one participant of the list. When they needed to test out new wheels for the robot and test out different cameras for the thermal cameras likewise when the original design is altered the extra cost is categorized as hardware design costs. Due to lower rating Hardware Design Cost and Manufacturing Cost is dismissed from this research. Few responses on "Cost" are as follows,

"*Close connections top management had with the company we were able to omit the software cost totally.*"

"*It was on a mutual agreement and the maintenance fee was free for the company.*"

"*Hardware design cost again falls under the engineering cost. Only additional cost component that would get added is, if the team wants to evaluate different hardware types before finalizing a design decision.*"

Following Figure 4.13 shows the "IT Workforce" factor's coding and cases frequency.

	Count	% Codes	Cases	% Cases
Cost				
Software Cost	6	2.8%	4	80.0%
Maintenance Cost	13	6.0%	5	100.0%
System Integrations Cost	4	1.8%	3	60.0%
Engineering Cost	7	3.2%	2	40.0%
Hardware Component Cost	13	6.0%	5	100.0%

Figure 4.13 Coding and frequency for "Cost"

4.4 Summary

In summary for this research the author interviewed 5 separate companies and within them 14 different BB decision events. Then the gathered data was analysed using "QDA Miner Lite" software, using open, axial and selective coding in Grounded Theory. Then the identified factors were presented to the interviewees again to rate form 0-3 scale. Depending on the total percentage amount being more than 50% the factors were validated and selected as independent factors that affect the dependent factor of this research.

The author identified 6 main factors that affect a successful BB decision for in-house used embedded systems in Sri Lankan companies as follows: Decision Maker's Experience, Strategic Relevance, Decision Making Process, Vendor Selection, IT Workforce and Cost. These factors influence the outcome of a BB decisions in the given context.

5 RECOMMENDATIONS AND CONCLUSION

This chapter provides the research conclusions and recommendations on factors a BB decision maker should consider. Along with that in section 5.2 Research limitations are explained and possible future works to overcome the limitations are suggested in section 5.3.

5.1 Conclusion

According to Fior Markets (2020), the global embedded system market is expected to grow by USD 53.08 billion in 6 years. With such huge attention focusing over embedded industry the demand for usage of embedded systems at personal and professional levels has also increased. With that note when considering about the need for embedded systems usage in office premises leaves the managers with a decision to make, whether to build or buy the needed solution and what factors must be considered when making such a decision?

For number of reasons these build or buy decisions may give a negative outcome. Managers must always be vigilant to avoid such pitfalls since these BB decision are tricky and complex subjects which requires effort and time which will impact a large number of employees and departments within the organization. Hence, to help them make such decisions the author came up with this research idea to identify critical factors to consider which will lead to a positive/successful outcome from the decision.

This research aimed to find critical factors that Sri Lankan companies with an IT workforce should consider when making a build or buy decision on an embedded system for in-house use. The research is based on a qualitative data analysis on data collected from 5 companies and 14 separate BB decision events, Determining a sufficient sample size for qualitative research is directly associated with the notion of saturation (Marshall, Cardon, Poddar, & Fontenot, 2013). In this research, from a sample size of 14 different build-buy events the author was able to come to a theoretical saturation in data collection since in the last few interviews the author didn't find new emerging theories or new properties for the existing attributes. Hence, it was concluded that the data set was complete or theoretically saturated. According to Philipp (2007), theoretical sampling is a form of systematic reasoning

in generalization in the process of data collection. So the below findin/gs can be generalized to companies which are under same research population context.

The research concludes that Decision Maker's Experience, Strategic Relevance, Decision Making Process, Vendor Selection, IT Workforce and Cost are 6 important core factors to consider when making such decisions.

Through this study it was discovered that having past experience on BB decisions can help understand the context of the scenario much more clearly and how it aligns to the current company's strategic goals. Past experiences in management areas and past BB decisions experiences will give the decision maker the needed insight and knowledge. Also the decisions maker's awareness on company goals and interests also plays a major role in selecting the correct path for the company. Matters like having a clear and wide understanding on company interests and goals, the decision maker's total work experience within the company, their understanding on co-operate culture and shared beliefs and ideas do have an impact on the final outcome.

For any business decision to be a success the decisions must align with the company's vision, mission and goals. It makes sure the decision will support the long term goals of the company. Along with that having a clear set of steps and a process on making company decisions will also help make the correct decision for the company. To make sure all the decisions taken inside the company are aligned with the company's way of working and moving direction, factors like how well the company's goals and vision-mission is communicated to the employees (decision makers) and how well are the employees updated on it are critical and need consideration.

The study was carried out during the pandemic outbreak of COVID-19. It was evident that many companies or participants had to make decisions based on such environmental factor as well. The normal way of working was interrupted in all the companies and they had to make quick decisions based on such circumstances. Many other external factors as Socioeconomics: how well the users adapt technology, their way of living and beliefs and cultural limitations plays a huge role in the outcome being success or a failure. Political & legal factors also should be given proper

consideration since that will dictate how well the company carry out the planned process and to identify if there are any barriers in doing so.

The decision making process should be involved with a clear-cut set of steps within a company to follow at any given situation. It shouldn't be ambiguous and vague. How the responsibility flows in a decision, whom to contact and the procedures and guidelines. A process to check alternative solutions and it's prices and features comes under the same decision making process since in such BB decisions the first thing to check is if there are already existing solutions for the same business requirements and if so, how well does it fit to the company's business requirement? Depending on the answer for that the decision makers have facts to make a solid decision.

When selecting a vendor to buy the system or to buy parts vendor availability, trustworthiness, ability to deliver, the support they provide such factors plays a huge role in the decision outcome. How the vendor selection is done has a huge impact since many areas like vendor's attitude, the relationship with the company, past experiences, trustworthiness of the vendor comes in to play when making a vendor selection. Hence managers must be really thorough when processing the vendor selection.

The resources inside the company mainly the IT workforce is the factor that no company can overlook since a capable IT workforce is the confidence the managers have to walk into uncharted territories. As long as the IT workforce is capable in learning, persevering, adapting and influencing others, companies can survive or even thrive in evolving domains like embedded industry.

The cost factor as usual is also a priority when making business decisions. However separate companies have different weight on each cost factors. Those preferences may also vary with the strategic goals and plans of the company.

Figure 5.1 shows the key findings of this research or the recommended factor to take into consideration when making a BB decision for in-house used embedded systems in Sri Lankan companies. Following are the critical factors that influence a positive outcome from the BB decision.

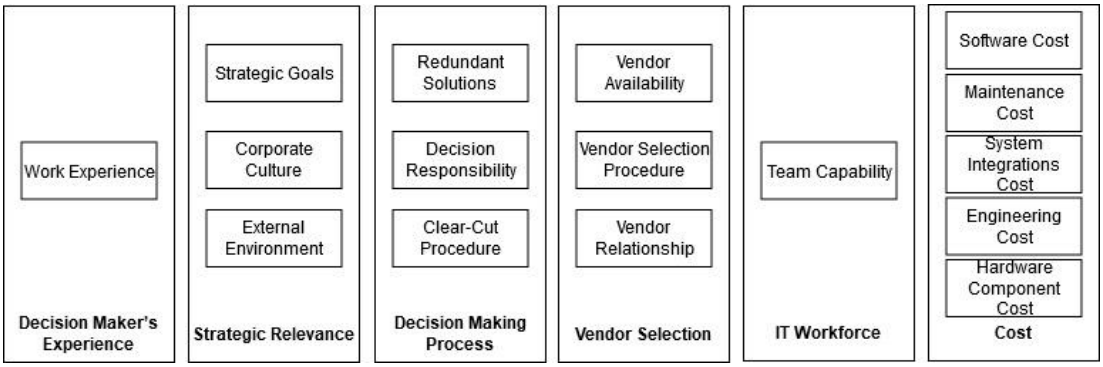

Figure 5.1 Critical success factors affecting BB decisions for in-house used embedded systems in Sri Lankan companies

5.2 Research Limitations

This research has a sample size of 14 build or buy decision events made by companies, however all those events came from a collection of 5 companies which may lead to a biased result. However the factors were identified using 14 separate build or buy events and the researcher made sure that each company contributes unique events to the data collection to confirm that a wide range of situations are covered in the data.

This research is trying to identify how factors effect build or buy decisions. Such decisions are mostly a group decision; however in this research not all the people who were involved in those events were interviewed. The researcher considers that the common ground on the considered factors when making the decision has to be same for every decision maker involved and that the whole group agreed on the decision.

The outcome of the build or buy decision is biased on the interviewee and in same company the people who made the decision may try to glorify their decision outcome while the users may not agree with it. In such identified cases, user's perspective and the decision maker's perspective both were recorded under the same build or buy decision making event to make sure all the factors which lead to each one of those opinions are considered.

Lack of previous research papers on in-house used embedded systems is another limitation faced by the author. Only a limited amount of research papers were available for build or buy decision on embedded systems and very rare and almost none on in-house used embedded systems. To cater to this the researcher referred

research papers on build or buy decisions made in other industries non IT-related industries as well.

This research focus is on companies based in Sri Lanka, so these findings may not be directly applicable for other companies outside of the context more or less.

5.3 Future Work

To incorporate the system user's perspective within the research, it can be extended to cover the user's opinion on whether the decision outcome was a success or a failure for all the events instead of only the identified conflicting events.

This research considers Sri Lankan companies which have a direct or indirect involvement with the embedded industry. It would be interesting to consider only the companies which are directly involved in the embedded industry to find out which factors might lead to a buy option rather than a build option for them.

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APPENDIX A: INTERVIEW REQUEST LETTER

Dear <Full Name>,

I am conducting interviews as part of a research study to examine the "build or buy decision-making strategies for embedded systems". This study intends to identify the critical factors that contribute to the success of a build or buy decisions for in-house used embedded systems.

An online interview may take around 30 minutes and is casual. Discussion topics to include the following:

- Management Experience
- Company Goals
- Project Characteristics
- Resources Details
- Costs

I am simply striving to capture your views and perspectives on factors that contributed and shaped during your build or buy decision/s. Your responses will be kept confidential and I wish to share my findings with you after the completion of this study.

I am sending the interview questions along with this for your reference.

Your participation in the research would be highly appreciated.
In case there is no dedicated person for this matter I highly appreciate if you could nominate a colleague who is accountable for such build or buy decision making at your company.

Thank you very much for your time and assist in making this study possible.

Sincerely,

Chathuri Gunawardana
MBA Student
<contact information>
Department of Computer Science and Engineering,
University of Moratuwa.

APPENDIX B: INTERVIEW QUESTIONNAIRE

	1. Could you please tell a little bit about yourself and how you joined the company, management level experience and roughly how many events/times in the past have you made 'Build or Buy' decisions?
Strategic Fit	2. Can you please explain to me about the company's strategic goals, and how it's communicated to the rest and how it aligns to you decisions? 3. Can you describe to me about the vendor service selection process of the company, are there any matrixes for selection process? 4. Can you describe to me about the vendor service selection process of the company, number of vendors available and if any priorities/matrixes are used for selection?
Project Characteristics	5. Can you tell me about each build or buy event requirement and whether and why the company consider each project to be a success or otherwise?
Resources	6. What can you tell me about the team and their capacity levels? 7. What other resources were required for the project? 8. What about the technical support level of the company?
Cost	9. How about cost factors? (Focus) ❖ Development Cost? ❖ Manufacturing? ❖ Hardware Design? ❖ Hardware Component Cost? ❖ Software Cost?

	❖ Sustaining Cost? ❖ System Integration Cost? ❖ Purchase Price? ❖ Maintenance Cost?
Other	10. Any other comments?

APPENDIX C: REVISED INTERVIEW QUESTIONNAIRE

General Questions	
Opening Questions	Management Experience 1. Could you please tell a little bit about yourself and your educational background and how you joined the company? 2. Can you explain to me about you total work experience? 3. How long have you been working in the top management position? 4. For how long have you been in this current workplace? Build or Buy' decision making history 1. Roughly how many events/times in the past have you made 'Build or Buy' decisions? 2. Can you briefly explain to me about each product/solution/event?
Strategic Fit	Company Goals 1. Can you please explain to me about the company's strategic goals and how you communicate it to the team, how it's applied in the company?
	Vendor Selection 1. Can you describe to me about the vendor service selection process of the company, the amount of vendors available any given time and trust level?
	Priority 1. Do you have a specific matrixes for such selection processes, if so which attribute has the highest priority?
Resources	IT workforce 1. What can you tell me about the internal IT workforce?

	2. What about the IT workforce expertise level?
	Technical support 1. What about the technical support level of the company how is it handled?
	Wildcards 1. Do you have enthusiastic, motivated employees who are eager to learn new technologies or any such unique opportunities or mishaps?
Other	Any other comments?
Product Specific Questions	
	1. Can you briefly explain to me about each build or buy event?
Project Characteristics	Solution Can you tell me about the product description/requirement and whether and why the company consider each project to be a success or otherwise?
	Project requirements 1. Are the solutions redundant with an existing capability from other custom or COTS solutions in the market/ inside the company? If so, is there a logical migration path to this new capability?
Resources	Resource Allocation 1. What other resources were required for the project if any?
Cost	1. Can you tell me how the following cost factors were for the solution? • Development/Engineering Cost • Manufacturing Cost • Hardware Design Cost

	• Hardware Component Cost • Software Cost • Sustaining Cost • System Integration Cost • Maintenance Cost

APPENDIX D: FACTORS SELECTION MATRIX

0 = Not relevant when making a build or buy decision
1 = Disagree It doesn't matter for a build or buy decision
2 = Neutral It's not irrelevant but neither important
3 = Agree It matters for a successful build or buy decision
Company 001,002,003,004,005 participants
Total % = No of agreed or neutral participants / Total no of participants × 100

Factors that received more than 50% total percentage is only considered as validated and are selected for this study analysis.

Factor			Company					Total %
			001	002	003	004	005	
Decision Maker's Experience								
	Educational Background							
		Masters	2	0	0	0	2	40
		Degree	3	0	0	0	2	40
		PG Dip	1	0	0	0	1	0
	Work Experience							
		Current Workplace Experience	3	2	3	2	2	100
		Management Experience	2	3	2	3	3	100
		Total Work Experience	3	3	2	3	3	100
		Current Position	3	1	2	1	1	40
		Decision Making Experiences	2	2	3	2	2	100
Strategic Relevance								
	Strategic Goals							
		Strategy Roadmap	2	3	3	3	3	100
		Goal Awareness	3	3	3	3	3	100
		Goal Alignment	2	3	3	3	3	100
		Goal Communication	3	3	3	3	3	100
	External Environment							
		Political and Legal Factors	1	2	2	2	2	80

Factor			Company					Total
			001	002	003	004	005	%
		Socioeconomics	2	3	0	1	2	60
		Economic	0	2	2	0	0	40
		Environmental	3	2	3	0	0	60
	Corporate Culture							
		Shared Beliefs and Values	2	3	3	3	0	80
		Company Size	3	2	2	2	1	80
Decision Making Process								
	Decision Matrix							
		Selection Grid	0	2	1	1	1	20
		Priority Order	0	2	0	0	0	20
	Redundant Solutions							
		Price	3	3	3	3	3	100
		Meets Requirement	3	3	3	3	3	100
	Decision Responsibility		3	3	3	2	2	100
	Clear-Cut Procedure		1	3	2	2	3	80
Vendor Selection								
	Vendor Availability		3	3	3	3	3	100
	Vendor Selection Procedure		2	2	3	3	3	100
	Vendor Relationship		3	3	3	3	3	100
IT Workforce								
	Team Capability							
		Team Competency	3	3	3	3	3	100
		Team Proficiency	3	3	3	3	3	100
		Team Attitude	3	3	3	3	3	100
		Team Workload	3	3	3	3	3	100
	Team Size		1	2	2	1	1	40
Cost								
	Software Cost		3	3	3	3	3	100

Factor	Company					Total
	001	002	003	004	005	%
Maintenance Cost	2	3	3	3	3	100
System Integrations Cost	1	2	3	1	3	60
Engineering Cost	3	3	3	1	3	80
Manufacturing Cost	1	1	3	1	1	20
Hardware Design Cost	1	1	1	1	1	0
Hardware Component Cost	3	3	3	3	3	100