PATENTING ACTIVITY AND FINANCIAL PERFORMANCE AT THE MALAYSIAN FIRM LEVEL: AN EMPIRICAL STUDY (1994 – 2008)

This thesis is submitted in fulfillment of the requirement for the degree of Doctor of Philosophy

by

FARHA ABDOL GHAPAR
Master of Business Administration (UiTM – Shah Alam)
BSc. in Human Environmental Sciences (Missouri – Columbia)

Faculty of Business & Economics
Monash University

June 2012

COPYRIGHT

TABLE OF CONTENTS

TABLE OF CONTENTS .... **III**

LIST OF TABLES .... **VI**

LIST OF FIGURES .... **VIII**

ABSTRACT .... **IX**

DECLARATION .... **X**

ACKNOWLEDGEMENTS .... **XI**

CHAPTER 1 RESEARCH BACKGROUND **1**

1.0 Introduction 1
1.1 Research Problem 1
1.2 Research Motivation 3
1.3 Research Question 4
1.3.1 Main Research Question 4
1.3.2 Subsidiary Research Questions 5
1.4 Research Contribution 6
1.4.1 To the Malaysian Firm Level Empirical Study 6
1.4.2 To the Malaysian Technology and Innovation Stakeholders 7
1.4.3 To the Malaysian Firms 7
1.5 Thesis Organization 7

CHAPTER 2 THE PATENT SYSTEM **8**

2.0 Introduction 8
2.1 The Evolution of the Patent System 8
2.1.1 The Application of Patent Statistics in Academic Research 9
2.2 The Background of the Malaysian and U.S. Patent System 12
2.2.1 The Malaysian Patent System 13
2.2.2 The U.S. Patent System 14
2.3 The Similarities and Differences between the Malaysian and U.S. Patent Systems 15
2.3.1 The Similarities 15
2.3.2 The Differences 16
2.4 The Current Situation of Patenting Activity in Malaysia 19
2.4.1 Patenting Activity by Malaysian Residents and Non-Residents 20
2.4.2 Patenting Activity by Malaysian Firms 23
2.4.3 Patenting Activity by Malaysian Firms in the U.S. 26
2.5 Chapter Summary 28

CHAPTER 3 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT **29**

3.0 Introduction 29
3.1 Measures of Firm Performance 30
3.2 Measures of Patent 34
3.2.1 Patent Renewal and Application Measures 35
3.2.2 Patent Quality Measures 36
3.3 Relationship between Patenting Activity and Firm Performance 37
3.3.1 Relationship between Patent Renewal/ Application and Firm Performance 39
3.3.2 Relationship between Patent Quality and Firm Performance 41
3.3.3 Relationship between Patent Technology Field and Firm Performance 46
3.4 Summary of Hypotheses Development 49
3.5 Patenting Activity and Firm Characteristics 50
3.5.1 Firm Size and Age 50
3.5.2 Firm Sector 51
3.6 Patenting Activity and the Issue of Timing 52
3.7 Patenting Activity in the Emerging Economies 53
3.8 Chapter Summary 55

CHAPTER 4 DATA AND METHODS 56

4.0 INTRODUCTION 56
4.1 THE DATA 56
4.1.1 Sample Selection 59
4.1.2 Variable Selection 62
4.1.3 Descriptive Statistics 64
4.1.4 Analysis of Competitive Condition 68
4.2 PANEL DATA MODEL 70
4.3 DYNAMIC PANEL DATA MODEL 71
4.4 MODEL ESTIMATION 72
4.4.1 Panel Least Square 72
4.4.2 Fixed Effects Model / Random Effects Model 72
4.4.3 Generalized Method of Moments 74
4.5 CHAPTER SUMMARY 75

CHAPTER 5 PATENT RENEWAL/ APPLICATION STOCKS AND FINANCIAL PERFORMANCE 76

5.0 INTRODUCTION 76
5.1 MODEL SPECIFICATION 76
5.1.1 Measurement of Variables 77
5.2 RELAXING THE ASSUMPTIONS 79
5.2.1 Multicollinearity 79
5.2.2 Autocorrelation 80
5.2.3 Heteroskedasticity 83
5.2.4 Misspecification 83
5.3 PANEL MODEL RESULTS 87
5.3.1 Panel Least Square 87
5.3.2 Fixed Effects Model / Random Effects Model 89
5.3.3 Hausman Test 99
5.4 DYNAMIC PANEL MODEL RESULTS 99
5.4.1 Generalized Method of Moments 100
5.5 SUMMARY OF FINDINGS 108
5.5.1 Summary of Findings Based on Estimation 108
5.5.2 Summary of Findings Based on Hypotheses Development 113
5.6 CHAPTER SUMMARY 119

CHAPTER 6 PATENT QUALITY AND FINANCIAL PERFORMANCE 120

6.0 INTRODUCTION 120
6.1 MODEL SPECIFICATION 120
6.1.1 Measurement of Variables 121
6.2 RELAXING THE ASSUMPTIONS 122
6.2.1 Multicollinearity 122
6.2.2 Autocorrelation 126
6.2.3 Heteroskedasticity 126
6.2.4 Misspecification 126
6.3 PANEL MODEL RESULTS 129
6.3.1 Panel Least Square 129
6.3.2 Fixed Effects Model / Random Effects Model 131
6.3.3 Hausman Test 140
6.4 DYNAMIC PANEL MODEL RESULTS 140
6.4.1 Generalized Method of Moments 141
6.5 SUMMARY OF FINDINGS 148
6.5.1 Summary of Findings Based on Estimation 148
6.5.2 Summary of Findings Based on Hypotheses Development 152
6.6 CHAPTER SUMMARY 157

CHAPTER 7 PATENT TECHNOLOGY FIELD AND FINANCIAL PERFORMANCE 158

7.0 INTRODUCTION 158

7.1 MODEL SPECIFICATION AND MEASUREMENT OF VARIABLES 158
7.2 RELAXING THE ASSUMPTIONS 159
7.3 RESULTS BASED ON PATENT RENEWAL/ APPLICATION MEASURES 168
7.3.1 Panel Model Results....168
7.3.2 Dynamic Panel Model Results....178
7.3.3 Summary of Findings Based on Estimation....186
7.3.4 Summary of Findings Based on Hypotheses Development....191
7.4 RESULTS BASED ON PATENT QUALITY MEASURES....196
7.4.1 Panel Model Results....196
7.4.2 Dynamic Panel Model Results....205
7.4.3 Summary of Findings Based on Estimation....212
7.4.4 Summary of Findings Based on Hypotheses Development....216
7.5 CHAPTER SUMMARY....221

CHAPTER 8 CONCLUSION.... 222

8.0 INTRODUCTION....222
8.1 KEY FINDING....223
8.1.1 Based on Model Estimation....224
8.1.2 Based on Measurement and Sample Study....224
8.2 RESEARCH FINDINGS IMPLICATIONS....226
8.3 RESEARCH LIMITATIONS AND EXTENSIONS....227

REFERENCES.... 230

LIST OF TABLES

TABLE 2.1: THE MALAYSIAN AND U.S. PATENT SYSTEMS 17
TABLE 2.2: THE DIFFERENCES BETWEEN THE MALAYSIAN AND U.S. PATENT SYSTEMS 18
TABLE 2.3: SCIENCE AND TECHNOLOGY (S&T) INDICATORS IN MALAYSIA 20
TABLE 2.4: PATENTS GRANTED BASED ON FIELD OF TECHNOLOGY IN MYIPO 22
TABLE 2.5: NUMBER OF PATENTS APPLIED FOR AND GRANTED TO MALAYSIAN FIRMS IN MALAYSIA 25
TABLE 2.6: MALAYSIA'S GROSS EXPORTS 26
TABLE 2.7: NUMBER OF PATENTS GRANTED TO MALAYSIAN FIRMS IN THE U.S. 27
TABLE 3.1: HYPOTHESES DEVELOPMENT MOTIVATED BY PATENT RENEWAL AND APPLICATION MEASURES 49
TABLE 3.2: HYPOTHESES DEVELOPMENT MOTIVATED BY PATENT QUALITY MEASURES 49
TABLE 4.1: TOTAL NUMBER OF FIRMS GATHERED AFTER THE FINAL DATA GATHERING 58
TABLE 4.2: TOTAL NUMBER OF FIRMS TO BE ANALYZED 59
TABLE 4.3: DESCRIPTIVE STATISTICS – FINANCIAL PERFORMANCE AND CONTROL VARIABLES 66
TABLE 4.4: DESCRIPTIVE STATISTICS – PATENTING ACTIVITY VARIABLES BASED ON PATENT RENEWAL/ APPLICATION MEASURES 66
TABLE 4.5: DESCRIPTIVE STATISTICS – PATENTING ACTIVITY VARIABLES BASED ON PATENT QUALITY MEASURES 67
TABLE 4.6: DESCRIPTIVE STATISTICS BASED ON HUMAN NECESSITIES AND PERFORMING OPERATIONS TECHNOLOGY FIELD 68
TABLE 4.7: DESCRIPTIVE STATISTICS BASED ON MECHANICALS AND ELECTRONICS TECHNOLOGY FIELD 68
TABLE 4.8: ANALYSIS OF COMPETITIVE CONDITION 69
TABLE 5.1: CORRELATION MATRIX – ALL FIRMS 81
TABLE 5.2: CORRELATION MATRIX – MANUFACTURING FIRMS 82
TABLE 5.3: RESET TEST 86
TABLE 5.4: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 93
TABLE 5.5: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 94
TABLE 5.6: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 95
TABLE 5.7: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 96
TABLE 5.8: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 97
TABLE 5.9: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 98
TABLE 5.10: HAUSMAN TEST 99
TABLE 5.11: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION – ALL FIRMS 103
TABLE 5.12: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION – ALL FIRMS 104
TABLE 5.13: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION – ALL FIRMS 105
TABLE 5.14: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION – MANUFACTURING FIRMS 106
TABLE 5.15: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION – MANUFACTURING FIRMS 107
TABLE 5.16: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION – MANUFACTURING FIRMS 108
TABLE 5.17: SUMMARY OF FINDINGS BASED ON ESTIMATIONS 112
TABLE 5.18: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – ALL FIRMS 117
TABLE 5.19: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – MANUFACTURING FIRMS 118
TABLE 6.1: CORRELATION MATRIX – ALL FIRMS 124
TABLE 6.2: CORRELATION MATRIX – MANUFACTURING FIRMS 125
TABLE 6.3: VARIANCE INFLATION FACTOR (VIF) – ALL FIRMS 126
TABLE 6.4: VARIANCE INFLATION FACTOR (VIF) – MANUFACTURING FIRMS 126
TABLE 6.5: RESET TEST 128
TABLE 6.6: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 134
TABLE 6.7: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 135
TABLE 6.8: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS – ALL FIRMS 136
TABLE 6.9: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 137
TABLE 6.10: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 138
TABLE 6.11: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS – MANUFACTURING FIRMS 139
TABLE 6.12: HAUSMAN TEST 140
TABLE 6.13: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION – ALL FIRMS 143
TABLE 6.14: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION – ALL FIRMS 144
TABLE 6.15: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION – ALL FIRMS 145
TABLE 6.16: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION – MANUFACTURING FIRMS 146
TABLE 6.17: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION – MANUFACTURING FIRMS 147
TABLE 6.18: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION – MANUFACTURING FIRMS 148

TABLE 6.19: SUMMARY OF FINDINGS BASED ON ESTIMATIONS 151
TABLE 6.20: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – ALL FIRMS 155
TABLE 6.21: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – MANUFACTURING FIRMS 156
TABLE 7.1: CORRELATION MATRIX BASED ON PATENT RENEWAL/ APPLICATION MEASURES – HUMAN NECESSITIES AND PERFORMING OPERATIONS 160
TABLE 7.2: CORRELATION MATRIX BASED ON PATENT RENEWAL/ APPLICATION MEASURES – MECHANICALS AND ELECTRONICS 161
TABLE 7.3: CORRELATION MATRIX BASED ON PATENT QUALITY MEASURES – HUMAN NECESSITIES AND PERFORMING OPERATIONS 162
TABLE 7.4: CORRELATION MATRIX BASED ON PATENT QUALITY MEASURES – MECHANICALS AND ELECTRONICS 163
TABLE 7.5: VARIANCE INFLATION FACTOR (VIF) BASED ON PATENT QUALITY MEASURES – HUMAN NECESSITIES AND PERFORMING OPERATIONS 164
TABLE 7.6: VARIANCE INFLATION FACTOR (VIF) BASED ON PATENT QUALITY MEASURES – MECHANICALS AND ELECTRONICS 164
TABLE 7.7: RESET TEST – BASED ON PATENT APPLICATION AND RENEWAL MEASURES 166
TABLE 7.8: RESET TEST – BASED ON PATENT QUALITY MEASURES 167
TABLE 7.9: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 171
TABLE 7.10: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 172
TABLE 7.11: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 173
TABLE 7.12: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 174
TABLE 7.13: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 175
TABLE 7.14: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM ESTIMATIONS (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 176
TABLE 7.15: HAUSMAN TEST – BASED ON PATENT RENEWAL AND APPLICATION MEASURES 178
TABLE 7.16: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 181
TABLE 7.17: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 182
TABLE 7.18: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 183
TABLE 7.19: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 184
TABLE 7.20: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 185
TABLE 7.21: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 186
TABLE 7.22: SUMMARY OF FINDINGS BASED ON ESTIMATIONS – PATENT RENEWAL/ APPLICATION MEASURES 190
TABLE 7.23: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – HUMAN NECESSITIES AND PERFORMING OPERATIONS 194
TABLE 7.24: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – MECHANICALS AND ELECTRONICS 195
TABLE 7.25: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 198
TABLE 7.26: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 199
TABLE 7.27: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 200
TABLE 7.28: PANEL MODEL RESULT FOR MODEL 1 WITH PLS, FEM & REM (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 201
TABLE 7.29: PANEL MODEL RESULT FOR MODEL 2 WITH PLS, FEM & REM (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 202
TABLE 7.30: PANEL MODEL RESULT FOR MODEL 3 WITH PLS, FEM & REM (BASED ON PATENT RENEWAL/ APPLICATION MEASURES) – MECHANICALS & ELECTRONICS 203
TABLE 7.31: HAUSMAN TEST – BASED ON PATENT QUALITY MEASURES 204

TABLE 7.32: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 207
TABLE 7.33: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 208
TABLE 7.34: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – HUMAN NECESSITIES & PERFORMING OPERATIONS 209
TABLE 7.35: DYNAMIC PANEL MODEL RESULT FOR MODEL 1 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – MECHANICALS & ELECTRONICS 210
TABLE 7.36: DYNAMIC PANEL MODEL RESULT FOR MODEL 2 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – MECHANICALS & ELECTRONICS 211
TABLE 7.37: DYNAMIC PANEL MODEL RESULT FOR MODEL 3 WITH GMM ESTIMATION (BASED ON PATENT QUALITY MEASURES) – MECHANICALS & ELECTRONICS 212
TABLE 7.38: SUMMARY OF FINDINGS BASED ON ESTIMATIONS – PATENT QUALITY MEASURES 215
TABLE 7.39: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – HUMAN NECESSITIES AND PERFORMING OPERATIONS 219
TABLE 7.40: SUMMARY OF FINDINGS BASED ON HYPOTHESES DEVELOPMENT – MECHANICALS AND ELECTRONICS 220

LIST OF FIGURES

FIGURE 2.1: PATENT APPLICATIONS IN MALAYSIA BY MALAYSIAN AND SELECTED ADVANCED ECONOMIES 21
FIGURE 2.2: DATA GATHERING 24
FIGURE 2.3: PATENT APPLICATIONS IN THE U.S. BY FILING ROUTES/ RESIDENTS/ NON-RESIDENTS 27
FIGURE 4.1: PATENT TECHNOLOGY FIELD BASED ON INTERNATIONAL PATENT CLASSIFICATION (IPC) 61

ABSTRACT

While patenting activity is common in advanced economies, this is not the case in emerging economies. However, there is reason to be optimistic that patenting activity benefits an emerging economy such as Malaysia. This study analyzes the relationship between the patenting activity and financial performance at the Malaysian firm level for firms that have been granted patents in Malaysia and the United States of America. While previous empirical studies adopted the market valuation model, we use the profit maximization model as our theoretical underpinning for this study. Hence, the financial performance variables are measured based on the accounting information – the sales, profits and profit margin. While previous empirical studies measured the patenting activity from an invention based on a simple patent count, we measure from within the patent system. Hence the patenting activity variables are measured based on the patent renewal/ application and quality measures. The sample study has also been divided into manufacturing firms and technology fields – human necessities/ performing operations and mechanicals/ electronics. We applied a panel dataset from 1994 to 2008 and the model is estimated using panel least square, fixed effects model, random effects model and generalized method of moments with various types of effects specifications and transformations. The key finding from the hypotheses testing is that there is a significant relationship between patenting activity and financial performance at the Malaysian firm level, but that the impact is rather small and the signs are mixed. This situation may due to the competitive condition that the firms faced, even though patenting is well known for its monopoly power.

DECLARATION

This thesis contains no material that has been accepted for the award of any other degree or diploma in any university or equivalent institution, and to the best of my knowledge, contains no material previously published or written by another person, except where due reference is made in the text of this thesis.

[redacted]

Farha Abdol Ghapar

Dated: June 2012

ACKNOWLEDGEMENTS

With the grace of Sovereign Lord the Most Beneficent and Most Compassionate, this thesis finally has become a reality, instead of a dream. Although my journey is a long one, I am determined to hold on to You, O-Ya- *Álĭm* the All Knowing and I will never make it without Your Love.

My highest appreciation goes to my main and associate supervisors, Professor Russell Smyth and Professor Robert Brooks for your guidance, support, motivation, patience and trust. To me you are a God-Send and I will never make it without your supervision. Your established experience in supervision has brought light into my journey. I have learned so much and looking forward to apply all the knowledge I gathered in becoming a better scholar. I am also grateful to my ex-supervisor, Dr Gary Deng, who taught me how to fish instead of giving me the fish, so that I can survive my whole life instead of a single day.

I would like to thank MARA University of Technology and the Malaysian Government for the approval of study leave and scholarship. Also a bunch of thanks to the Intellectual Property Corporation of Malaysia (MyIPO) and Companies Commission of Malaysia (CCM) for the kind assistance and cooperation during my data collection. I am also indebted to the School of Business & Economics at Monash University – Gippsland Campus that first accepted me in February 2008, and the Faculty of Business & Economics at Monash University – Clayton Campus that finally accepted me in September 2010.

A warm thanks to friends who have been there through good and bad times. Last but not least, a special thanks to my family who has been there virtually every second even though we are thousand of miles apart. Your support and tolerance is superbly astounding and I have no words to express my gratitude. We have made it and this thesis is especially dedicated to you – Mak & Ayah (my mom and dad), and Bina & Ja'a (my daughter and husband).

CHAPTER 1 RESEARCH BACKGROUND

1.0 Introduction

According to the World Intellectual Property Organization (WIPO) in its World Patent Report (2008), patent applications by non-residents in emerging economies have been increasing steadily. This shows that non-residents are taking advantage of the patent system in emerging economies. The same situation has happened in Malaysia, in that from 1986 to 2008, out of 95,124 patent applications in the Malaysian patent office (MyIPO, 2010b), known as the Intellectual Property Corporation of Malaysia (MyIPO), only 2,191 patents were applied for by Malaysian firms. Out of that, only 450 patents were granted to Malaysian firms. Other applications not granted are either patent pending or have been rejected due to non-compliance with the patenting rules. Furthermore, there is an ongoing debate over whether the patenting system benefits only advanced economies when compared to emerging economies (Sarkissian, 2008; Matthews, 2002) and, further, whether the patent system benefits only the rich (Kranakis, 2007). However, even though Malaysia is a developing country, there is reason to be optimistic that patenting activity benefits this country as one of the emerging economies.

This chapter begins with a concise discussion of the research problem followed by the research motivation in sections 1.1 and 1.2, respectively. From the research problem and research motivation, Section 1.3 presents the research questions of this study, which are divided into the main and subsidiary research questions. This is followed by a discussion of the research contribution of this study in Section 1.4. This chapter ends with Section 1.5 outlining the organization of the thesis.

1.1 Research Problem

Patenting involves extra costs (Schmookler, 1966) besides those of innovation. Patent applications attract fees and, if a patent is granted, more costs then accrue to maintain the patent (Griliches, 1990). To complicate matters, a patent is also territorial in nature (WIPO, 2006a, 2007b; MyIPO, 2008), which means that there are extra costs involved to secure protection in different regions. Therefore, firms that have estimated benefits beyond the costs involved in the patenting activity (Schumpeter, 1942) are the ones with an incentive to patent their innovation, not only in one region but in more than one region (Stoddard & Danielsen, 2008). Some firms even patent in a region where the market share is larger and the intellectual property rights are tighter (Teece, 2005) than in other regions. A patent also involves many fields of technology. Some technology fields represent fast moving technology, while some do not, with the former having a higher obsolescence rate compared to the latter (Schankerman, 1998). In spite of this situation, there are firms that undertake patenting activity in both fast and slow moving technology fields.

Theoretically, a firm's goal is to maximize profits (Mansfield, 1997). Therefore, a firm that has undertaken patenting activity must have estimated benefits beyond the costs of patenting the product (Schumpeter, 1942). Indeed, the monopoly power resulting from the patenting activity may have a significant positive impact on the firm's financial performance. A patent can also be a process rather than a product (WIPO, 2006a). Consequently, some firms patent products and processes either to be sold in the market or to be used in their own firms. The former may directly maximize the firm's sales revenue in order to maximize profits, while the latter is used to reduce the business costs in order to maximize profits (Van Triest & Vis, 2007). Indirectly, the latter may also maximize the firm's sales revenue once the firm's business costs have been reduced. Hence, patenting an invention represents a profit-maximizing strategy both in the short and long run. Empirically, however, when dealing with Malaysian firms that are still at the infancy stage with respect to patenting activity (Ghapar, 2009), the monetary returns to these firms have not yet been proved.

In Malaysia, out of 95,124 patent applications, only 37,161 patents were granted from 1986 to 2008 (MyIPO, 2010b), and of these 37,161 granted patents, only 3% were granted to Malaysian residents (MyIPO, 2010b). Refining this further, only 450 patents have been granted to 296 Malaysian firms. In contrast, there were 77 Malaysian firms that had been granted 156 patents in the United States Patent Trademark Office (USPTO, 2010e). The details of these statistics are discussed further in Chapter 4 of this study. However, in spite of these patent statistics (MyIPO, 2010b; USPTO, 2010e), little is known on whether the technology patented by the Malaysian firms has impacted on their financial performance.

1.2 Research Motivation

The central motivation of this study is geographical in nature, in that for the first time Malaysian firms which have been granted patents in Malaysia and the United States of America (U.S.) are used as the sample study. To reach the stage where a patent that is applied for by Malaysian residents can be considered to be a major breakthrough because the patenting activity in Malaysia has been dominated by foreigners, especially from the advanced economies (Ghapar, 2009; Malaysia, 2006, 2001). Hence, a Malaysian firm that successfully patented its inventions must have been outstanding, in the sense that it had the ability both to patent and to further exploit the patent given limited resources. Furthermore, patenting activity in emerging economies by its own residents is new compared to the activity in advanced economies (Idris, 2002). However, the question, of whether an indigenous innovation patented by a Malaysian firm would bring monetary returns remains to be investigated.

Even if a patent offered the patent owner monopoly power, a competitive market environment could render this patent obsolete as time passes (Schumpeter, 1942). New and rigorous technology advancement in the competitive market may well result in patents by Malaysian firms that are still in the learning stage of patenting activity (Ghapar, 2009) and are vulnerable both in the short and long run. Nevertheless, Malaysian firms must have learned implicitly or explicitly from the patented technological advancement from advanced economies that have poured into the Malaysian patent office. In turn, the knowledge flows from the patenting activity may lead to the Malaysian firms receiving monetary returns. This is because studies have shown that the patent citation in the patent system that represent the firm's intangible stock of knowledge (Hu & Jaffe, 2003) may be able to provide a positive impact on the firm's performance (Hall, Jaffe, & Trajtenberg, 2005).

To innovate has never been easy (Tidd, Bessant, & Pavitt, 2005), with patenting the product or process adding to the costs involved (Schmookler, 1966). Another challenge for those Malaysian firms pursuing patenting activity is to understand that patenting has its own system which involves patent laws (Hunt, 2004). However, since in this study we address patents that have already been granted to Malaysian firms, we are at this stage optimistic that these firms have overcome these challenges.

Nevertheless, the question of whether these firms have been able to receive monetary benefits from the patenting activity remains to be empirically analyzed.

1.3 Research Question

1.3.1 Main Research Question

The focus of this study is to analyze the impact of patenting activity on financial performance. The unit of analysis of this study concentrates on Malaysian firms which have been granted patents. As patenting is territorial in nature (WIPO, 2006a, 2007b; MyIPO, 2008), this study focuses attention on patenting activity in Malaysia and the U.S. Malaysia's economic history shows had a large quantity of manufactured products are assembled in that country from foreign components parts, and that these products are then exported to other parts of the world (Jomo & Felker, 1999). Statistics show that Malaysia's manufacturing industries constitute its largest exporting industries compared to other industries (Malaysia, 2006, 2001, 1996), with the U.S. being Malaysia's largest trading partner since the 1990s (Malaysia, 2006, 2001, 1996). Furthermore, more research has been carried out into the patenting activities of manufacturing firms within the advanced economies (Rogers, 2002; Hall & Ziedonis, 2001; Griliches, 1990) than into other types of industries and intellectual property (IP). In fact, 73% of Malaysian firms in our sample data that have been granted patents in Malaysia and the U.S. are manufacturing firms (see Chapter 4); thus, we would expect that Malaysian firms that have manufactured new products or processes and exported to the U.S. would also want to secure patent protection in the U.S. territory.

A firm's goal is to maximize its profits (Mansfield, 1997), and this goal can be targeted in the short or long run. In terms of patents, some patents are not solely for sale directly to the market, but are secured as a maximizing strategy in the long run. Therefore, a firm may secure a patent as part of a strategy to develop a strong market position, enter new markets, access other technology through cross-licensing, or even for defensive purposes (Matthews, Pickering, & Kirkland, 2003). Nevertheless, the basic reason for a firm to secure a patent is still to maximize its profits, unless that firm is a non-profit organization (Mansfield, 1997). Whether or not the patenting activity has a positively statistically significant impact on the firm's financial performance will be empirically tested in this study. Thus, this study aims to answer the fundamental research question:

What is the relationship between patenting activity and financial performance at the Malaysian firm level for firms which have been granted patents in Malaysia and the United States of America (U.S.)?

1.3.2 Subsidiary Research Questions

Since a patent has its own system, the subsidiary research questions are based on the variables generated from within this system. In addition, as this study is empirical in nature, the variables are measured following this patent system. First, the measurement is related to the patent application and granted lag, since a patent application is bound by certain time lags (Griffith, Jensen, & Webster, 2005) as it goes through a thorough application process before it is, or is not, granted by the patent office. If the patent is granted, a patent renewal maintenance fee is required to keep it in force (Schankerman & Pakes, 1986). Second, the measurement is based on patent citation, claim and family, collectively known as *patent quality* (Lanjouw & Schankerman, 2004). In the patent specification, patent citation and claim are required in which the former refers to others in developing the invention (Trajtenberg, 1990; Sapsalis & Potterie, 2007), while the latter points out the inventor's right to exclude others from the invention (Lanjouw & Schankerman, 2004). On the other hand, the *priority-data* in the patent specification represents the *patent family* (Hall, Thoma, & Torrisi, 2007), which states that the same patent has also been granted in other territories.

These two measurements are then formulated within a panel data framework using a separate model specification to address each question. Thus, maintaining the unit of analysis as Malaysian firms which have been granted patents in two territories (Malaysia and the U.S.), the first two subsidiary research questions are as follows:

1) *What is the relationship between the patent application/ granted stocks and financial performance?*
2) *What is the relationship between the patent quality and financial performance?*

In the patent system, other than the patent citation, claim and family information that is required to be revealed in the patent specification, the patent technology field must also be presented. Thus, we have arranged the sample study based on patent technology fields to examine the impact of patenting on the firms' financial performance. Using the same measures as above (patent renewal/ application and patent quality measure), we formulate the third subsidiary research question as follows:

3) *To what extent do differences in the patent technology field impact on the financial performance of the firm?*

1.4 Research Contribution

1.4.1 To the Malaysian Firm Level Empirical Study

Little is known about the impact of patenting activity on firms' financial performances in emerging economies. Most of the academic research that has been done empirically in this area has focused on advanced economies (Hall, et al., 2007; Greenhalgh & Rogers, 2006), while studies from emerging economies have mostly used descriptive statistics (Rezapour, Bagheri, Rashtchi, & Bakhtiari, 2007; Fai, 2005). This may due to the advancement of patented technology and the availability of patent data in the advanced economies compared to emerging economies. This study, however, uses micro level data on Malaysian firms that have patenting activity in Malaysia and the U.S.

Gathering the secondary data and modeling such data with a panel data framework will be a major contribution to the body of knowledge specifically in the intellectual property (IP) area of emerging economies. In our sample data, which is discussed further in Chapter 4, we find that 97% of our sample firms come from privately limited firms. Thus, instead of using market-based financial performance (Hall, et al., 2005; Bosworth & Rogers, 2001; Cockburn & Griliches, 1988; Griliches, 1981), we use accounting-based financial performance (Coombs & Bierly, 2006; Griffith, et al., 2005; Geroski, Machin, & Walters, 1997) in this study. We therefore use the profit maximization model instead of the market valuation model as the theoretical underpinning of our research. In addition, the measurement of the patent value is generated from within the patent system (Schankerman & Pakes, 1986; Lanjouw & Schankerman, 2004), which differs from other studies that generally concentrate on the value of a patent generated from the invention.

1.4.2 To the Malaysian Technology and Innovation Stakeholders

Other than contributing to academic research, this study will be of value to those policymakers in Malaysia that deal with patenting activity, such as the Ministry of Science Technology and Innovation (MOSTI) and MyIPO. MOSTI has awarded grants to public and private organizations to conduct research in the science and technological area. Before this, many grants were given to public organizations instead of to private parties (Kondo, 1999) and the commercialization rate was very disappointing (Malaysia, 2001, 2006). From this research, MOSTI may be able to re-evaluate its decision on grants given to private parties, so that the money granted may provide valuable returns to the firms specifically, and to the country generally. MyIPO on the other hand may use this study to make the public more aware of the importance of patenting activity, since they have traditionally focused more on trademark activity (MyIPO, 2008), which is another form of IP.

1.4.3 To the Malaysian Firms

Since this study specifically examines the Malaysian firms that have been granted patents in Malaysia and the U.S., it would particularly benefit firms in many ways. The firms may be able to decide on the patenting territories (Teece, 2005), technology fields (Schankerman, 1998), and industries (Hall, 2005) that may resulted to a higher profits from the patenting activity. The firm may also gather some knowledge on the market competitive condition in the patenting activity area, even though patent is well known for its monopoly power.

1.5 Thesis Organization

This thesis is divided into eight chapters. Chapters 1 and 2 introduce the background of the study and the patent system, particularly in Malaysia and the U.S. Chapter 3 presents the literature review, and the hypotheses are then developed. Chapter 4 describes the data and methods for this study. Chapters 5 through 7 are the results chapters of this study which present an empirical analysis to answer all the research questions established in this chapter. Chapters 5, 6 and 7 therefore analyze the first, second and third subsidiary research questions, respectively. Finally Chapter 8 concludes this study.

CHAPTER 2 THE PATENT SYSTEM

2.0 Introduction

This study measures the value of a patent generated from within the patent system. This differs from other studies that generally concentrate on the value of a patent generated from the invention. The patent specification within the patent system consists of valuable information regarding the characteristics of an invention. This includes the patent's technological fields and citations. The patent laws within the patent system involve the patent being territorial in nature, having its own family and requiring a renewal maintenance fee to keep it in force. If the patent system is effectively implemented, it should create value to the patent holder. Therefore this study measures patenting activity based not on a simple patent count generated from an invention but on more complex variables generated from within the patent system.

This chapter provides an overview of the patent system. Section 2.1 introduces the history of the patent system, then relating it to the application of the patent statistics in empirical studies. Since a patent is territorial in nature, this study concentrates on the patent systems in two countries, Malaysia and the United States of America (U.S.). These are discussed in Section 2.2, with the introduction providing a setting for the empirical analysis. In Section 2.3, the similarities and differences between the two systems are presented. The differences are highlighted in order to set the empirical setting for the study. In Section 2.4, a discussion of the current situation of patenting activity in Malaysia is presented. This firstly concentrates on the broader patenting activities in Malaysia by residents and non-residents, then on those undertaken by Malaysian firms domestically and in the U.S. This reflects this study's focus on the patenting activity of Malaysian firms in the two countries under review.

2.1 The Evolution of the Patent System

A patent is a form of intellectual property (IP). The origin of the first systematic patent law was the Venetian Law of 1474 (Idris, 2002). This gave inventors exclusive rights to their inventions. On the other hand, the origin of patent law in England was in the Tudor period in the form of the Statute of Monopolies of 1624 (Idris, 2002). It was the first written law that had the purpose of granting monopoly power to the inventor for a limited time period. The 18th Century saw a dramatic increase in patents due to the Industrial Revolution (Brue & Grant, 2007). Patent law was also enacted in France and the U.S. in 1771 and 1788 respectively (Idris, 2002). The laws were enacted with a similar purpose as today; that is to provide exclusive rights to the inventor.

International trade became increasingly important in the 19th Century, making the demand for global patent protection more prominent. In 1873, potential foreign exhibitors at the International Exhibition of Inventions in Vienna refused to attend due to their concern that their ideas might be stolen and commercialized in other countries (WIPO, 2004a). Due to this, the first major treaty that protected inventors who secured patents in other countries was enacted. This was the Paris Convention for the Protection of Industrial Property of 1883 (WIPO, 2004a; Idris, 2002). Since then more treaties have been ratified such as the Patent Cooperation Treaty (PCT) in 1978. There are several principal provisions of these treaties (WIPO, 2004a), but their main focus is to provide the same protection in each contracting state as it grants to its own nationals (Idris, 2002).

The World Intellectual Property Organization (WIPO), a specialized agency under the United Nations (UN) has the responsibility for administering the worldwide IP system (WIPO, 2004b). To date, it has administered more than 24 treaties, and the most popular relating to patents being the old Paris Convention of 1883 and the new Patent Cooperation Treaty (PCT) of 1978. These treaties however, do not grant patents. The power of granting patents is under the jurisdiction of the regional or national patent office. Hence, a patent is territorial in nature (WIPO, 2006a, 2007b; MyIPO, 2008). The treaties only assist with international filing. International filing is called the *international phase*, while entering any territory in the contracting states is called the *national phase*. Nevertheless, an applicant can elect to go through the national phase without going through any treaties (Zuallcobley, 2007).

2.1.1 The Application of Patent Statistics in Academic Research

As discussed previously, the patent system emerged as early as the 1400s and patenting activity started to boom during the Industrial Revolution (Brue & Grant, 2007). Hence, historical patent statistics from as early as the 1700s have been used in academic research (Macleod, 1986). Even though McLeod (1986) neither specifically produced any descriptive statistics nor conducted an empirical study, her discussion on the history of patents was based on patent statistics from the 18th Century. She used patent statistics and related them to inventions, the patent system and financial markets. Sullivan (1989) also used historical data on patent statistics in the period between the mid 1700s and mid 1800s. In contrast to McLeod (1986), Sullivan (1989) employed patent data in an empirical study. He tested a simple model on the propensity to patent. His main finding suggested that England at that particular time had entered the *Age of Invention* due to the growth rate of patenting preceding the growth rate of total factor productivity, which had implied a causal relationship. Lerner (2002), who also used historical patent statistics, examined the strength of patent protection by conducting an empirical study. He regressed four models with three different types of estimations using the patent data from 60 countries over a 150-year period from 1850 to 1999. The main finding was that wealthier countries with patent systems were likely to offer stronger and longer patent protection to the patent holder.

Schmookler (1951) was a pioneer in the study of invention and economic development, who applied patent statistics extensively in his PhD dissertation. According to Kortum (1997), Schmookler reported that U.S. patent applications rose from 1860 to 1930 but found that the relationship between the number of patent applications and productivity did not increase, as he had hypothesized. Fifteen years later, Schmookler (1966) published a book on invention and economic growth which included some discussions on patent statistics in the firm and industry setting. He interpreted descriptive statistics that were related to this area, taken from relevant organizations and databases. He also referred to the work of others, such as Sanders (1963, 1962), and Federico (1958). Some patent statistics analyzed in the firms and industries were relatively adverse to inventive output and economic growth. However, Schmookler interpreted them optimistically as he said (Schmookler, 1966, p. 50):

"…relatively few patented inventions are used commercially, [this] suggests that patent statistics might not be a bad index of inventive output conceived simply in terms of use or nonuse."

The application of patent statistics in academic research continued to study the firm in particular. The term *firm* is defined as an institution that attempts to make profits (Mansfield, 1997). While a patent provides protection to the firm (WIPO, 2006a), *if secured, may have to be used in order to justify investment* (Schumpeter, 1942, p. 88). Hence, the decision to patent an invention may rely on the relative costs and benefits (Schankerman, 1998; Schumpeter, 1942). The internal (Terziovski & Lai, 2007; Coombs & Bierly, 2006) and external factors (Greenhalgh & Rogers, 2006; Rogers, 2002; Schankerman, 1998) also played a great significant role in determining the firm's success in gaining profits. Merely securing the patent is not enough as the patent system requires the patent to be maintained. Given that patented inventions have their own lifespan and decay indertiministically thereafter (Schankerman & Pakes, 1986), firms may only maintain certain patent lifespans in order to maximize profits. Therefore, another step in applying patent statistics in a firm and industry setting is by relating it to the firm's performance. These kinds of studies have been of interest to researchers (Hall, et al., 2005; Bosworth & Rogers, 2001; Griliches, 1981; Pakes & Schankerman, 1979). They will be discussed further in the literature review.

In this study, patent statistics are used to assess the relationship between patenting activity and financial performance in firms. Its geographical context is more challenging as it assesses the patenting activity undertaken by Malaysian firms. This relates to the availability of data in Malaysia compared to advanced economies. In advanced economies patent statistics have been compiled and made available through organizations and databases; the United States Patent and Trademark Office (USPTO), National Science Foundation (NSF) and National Bureau of Economic Research (NBER) in the U.S.; the Oxford Intellectual Property Research Centre (OIPRC) and Science and Technology Policy Research (SPRU) in the U.K.; the European Patent Office (EPO) and Department of Industry R&D Scoreboard in the European countries. On the other hand, in Malaysia patent statistics are available, but are not as detailed as in the advanced economies. These limitations will be discussed further in the methodology chapter.

Further challenges include measuring the value of patents generated from within the patent system. Thus, the measurement of the patenting activity is not based on a simple patent count generated from the invention (Cockburn & Griliches, 1988; Griliches, 1981), but on more complex patent variables generated from within the patent system. They are based on the patent's application-granted lag (Griffith, et al., 2005), renewal fee (Schankerman & Pakes, 1986), technological field (Lanjouw & Schankerman, 2004), citation (Trajtenberg, 1990), territory (Sapsalis & Potterie, 2007) and family (Hall, et al., 2007). In the patent system, the invention has to wait for an average of two years before it is granted. During this time the *patent pending* can always enter the market for sale. While this may be useful strategy for a firm to test the patent in the market, it may also lead to the idea being stolen and perfected. This could lead to the invention becoming obsolete even before the patent is granted (Pakes & Schankerman, 1979). Once it is granted, a renewal fee which rises with the patent's age must be paid in order to keep it in force (Griliches, 1990).

The system also requires that the patent's technological fields and citations are included in the patent specification. This involves classifying the patent's technological field and citing other patents upon which the patent is built. The value of patent varies across technological fields (Lanjouw & Schankerman, 2004; Schankerman, 1998). Additionally, the patent citation, which is the firm's intangible stock of knowledge (Hu & Jaffe, 2003), can also impact the firm's performance (Hall, et al., 2005). Since a patent is territorial in nature, if an invention requires protection beyond its country of origin then patents must be obtained in the relevant countries. The applications of an individual patent in several countries are known as the *patent family* (WIPO, 2009; Jensen, Palangkaraya, & Webster, 2008). Thus, the patent data generated from within the system might significantly impact the firm's financial performance. Simple patent count measurement often leads to misleading results as patents have different mean values (Lanjouw, Pakes, & Putnam, 1998), and are highly skewed (Schankerman & Pakes, 1986).

2.2 The Background of the Malaysian and U.S. Patent System

Since a patent is territorial in nature (WIPO, 2006a, 2007b; MyIPO, 2008) Malaysian firms that have invented a new product or process that they wish to exploit must apply for a patent in the relevant countries, which in this study are Malaysia and the U.S. Recognizing that patents are territorial in nature, the two countries will also be called territories. Thus, the background of the patent system in these two territories is described below.

2.2.1 The Malaysian Patent System

Since Malaysia was once a British colony, its legal system and jurisprudence were fundamentally adopted from the United Kingdom (U.K.) (Goon, 2003). The Patents Act 1983 was formerly introduced on 1 October 1986 and is still in operation today, with some minor amendments. The Intellectual Property Corporation of Malaysia, known as MyIPO, is Malaysia's formal patent office. It handles issues relating to IP and also has been raising awareness among Malaysians of the importance of IP. Specifically relating to the treaties which have been discussed earlier in this chapter, Malaysia has become a member of the Paris Convention on 1 January, 1989 (WIPO, 2010c) and the PCT on 16 August, 2006 (WIPO, 2010a). As discussed in the evolution of the patent system, these treaties have given an option to the applicants of entering the national phase directly or going through the treaties. One of the many benefits of going through the treaties is that there is more opportunity for the applicants to buy time until they enter the national phase. This normally relates to patenting strategies, as both inventors and investors need time in order to make sure that the patent has a place in the market (Hornickel, 2002), or has the potential to be commercialized (Hall, et al., 2005). In addition to the treaties, Malaysia established an IP court on 6 June 2007 (Hamsawi, 2007), in the hope of further enhancing Malaysia's IP system.

In Malaysia there are two types of patent; the *patent*, which will be narrowly-defined in this study, and the *utility innovation*. The narrow definition of patent given by MyIPO (2004) is:

"An exclusive right granted for an invention, which is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem."

While a utility innovation is defined by WIPO (2006b) as:

"An exclusive right granted for a minor invention which does not need to satisfy the test for inventiveness that is required for a patent."

As mentioned earlier, once granted the patent needs to be maintained by paying a renewal fee. In the Malaysian patent system this is annually, from the second until the twentieth year. The patent can be protected for a maximum period of 20 years given payment of the renewal fees. On the other hand, the utility innovation can be protected for a period of 10 years and may be extended for another two 5-year terms from the date of filing, upon proof of working, to give a maximum of 20 years. If the renewal fee is not paid, the patent will cease to be protected under the law. Normally, when the patent has given less value to the owner compared to previous years, they would stop paying the fees (Lanjouw, et al., 1998; Schankerman & Pakes, 1986; Pakes, 1985).

2.2.2 The U.S. Patent System

The U.S. patent law, which also originated from the British, was first enacted in 1788. It was reformed in 1836 (Lamoreaux & Sokoloff, 2001) and there were two further revisions that are still in operation. First, the Patent Act of 1870 (J. M. Mueller, 2006) that required that a patent specification contains *claim*, which points out the scope of the patent owner's right to exclude others from his invention. Claim is the most important subject matter in the patent specification as it will be used in any litigation matters. Second, the Patent Act 1952 (J. M. Mueller, 2006) that required that the patent be *non-obvious*, which means that the patent must have an inventive step that is not obvious to experts in the technological field (Hall, et al., 2005). In the Patent Act 1952, there were also other provisions that have been amended from time to time to simplify the applications and lessen the burden on the U.S. patent office. The patent office in the U.S. is known as the United States Patent and Trademark Office (USPTO) that handles all patent and trademark related matters. It also handles two other types of IP which are copyright and geographical indication. Specifically relating to the treaties which have been discussed previously, the U.S. has become a member of both the Paris Convention on 30 May, 1887 (WIPO, 2010c) and the PCT on 24 January, 1978 (WIPO, 2010a).

In the U.S. there are three types of patents; utility patent, design patent and plant patent. The definitions of these patents given by USPTO (2010c) are:

1. *Utility patents may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof;*
2. *Design patents may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture; and*

3. *Plant patents may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.*

Out of these patents, utility patent is the most common (USPTO, 2010a; Hallenborg, Ceccagnoli, Clendenin, Gary, & Marie, 2008). It has a 20-year term of protection, similar to the Malaysian patent and utility innovation. The design patent in the U.S. also has a 20-year term of protection, unlike the plant patent that covers only 14 years of protection. In the U.S. patent system, the renewal maintenance fee for the utility and design patent is not due every year, but is due in three different intervals within the 20 year period, which are at 3.5 years, 7.5 years and 11.5 years. However, no renewal fee is needed for the plant patent.

2.3 The Similarities and Differences between the Malaysian and U.S. Patent Systems

2.3.1 The Similarities

It is evident from the above that similarities and differences exist between the two systems. Table 1 expands on the features of the patent system in both territories. The first similarity is based on the types and terms of protection for patent narrowly-defined (Malaysian patent system) and utility patent (U.S. patent system), which have similar definitions and 20-year terms of protection. Second, both systems accept English language as a filing language. Third, both systems recognize the PCT as another route to file for a patent, besides having a choice of going through the national phase. Fourth, the information regarding the application is published 18 months after the *filing date* or *priority date,* for the public to access. Filing date is the date when the application which meets the minimum requirement is received by the patent office (WIPO, 2009). While priority date is the date when the applicant claim priority to his invention before the filing date, which can be backdated of a maximum of 12 months (WIPO, 2007b, 2007a).

Finally, the fifth similarity is the *prior-art* or citations in the patent specification, where both patent systems require the applicant to cite any prior knowledge to his invention. Nevertheless, the final decision normally rests with the patent examiners (Hall, et al., 2005; Alcacer & Gittelman, 2006), since they are the ones that are expert in the area (Hall, et al., 2007). It is important to highlight the fifth similarity, as it is used as one of the variables in the empirical analysis in this study. It indicates the extent of knowledge diffusion from one setting to another from the patenting activity (Bessen, 2005; MacGarvie, 2005; Jaffe & Trajtenberg, 1999).

2.3.2 The Differences

While there are similarities, there are also differences in both patent systems. The Malaysian system accepts filing in its national language, *Bahasa Malaysia*. On the other hand, the U.S. system also accepts other languages but they must be translated into English within a two month period from the application date. In Malaysia, the applicant must publish the application information after 18 months of priority date or filing date. While in the U.S., the applicant can choose not to publish the application information. They can postpone publication until the patent is granted, as indicated in Table 2.1. This is normally called a *submarine* patent (J. M. Mueller, 2006). This strategy keeps the invention secret whilst filing the application and waiting for it to be granted. The subject matters excluded from patentability are also different between these two systems, which evident that Malaysia's system being more stringent. In addition, the Malaysia's system operates on a first-to-file rule which is similar to the rest of the world. This differs with the U.S. system that follows the first-to-invent rule (J. M. Mueller, 2006).

Table 2.1: The Malaysian and U.S. Patent Systems

	Malaysia	***U.S.***
Type and term of protection	1) Patent – 20 years 2) Utility innovation – 20 years	1) Utility Patent – 20 years 2) Design patent – 20 years 3) Plant patent – 14 years
Subject matters excluded from patentability or not considered to be inventions	-Discoveries, -Scientific theories and mathematical methods -Plants or animal varieties or essentially biological processes for the production of plants or animals -Other than man-made living micro-biological processes and the products of such micro-organism processes -Schemes, rules or methods for doing business -Performing purely mental acts or playing games -Methods for the treatment of a human or animal body by surgery or therapy, and diagnostic methods practiced on the human or animal body.	- Scientific theories/mathematical methods - Mental acts - Presentation of information - Traditional knowledge
Filing priority	First-to-File	First-to-Invent
Filing language	Bahasa Malaysia or English	Filing an application in languages other than an official language is possible. The time limit to provide translation into an official language is 2 months.
Certain requirements relating to filing	There is no provisional patent application in Malaysia. Malaysia joined the PCT in August 2006. Prior to that date, non-residents could also choose to go through the Paris Convention or direct to the national phase to apply for a patent.	It is possible to file provisional applications. An applicant may convert a provisional application to a non-provisional application and may claim priority for an earlier-filed provisional application. The life cycle of the provisional application is one year. The most frequent route used by foreign applicants to file patent applications is the Paris Convention.
Publication	18 months from the filing date or from the priority date.	18 months from the filing date or from the priority date or when the patent is granted.
Field of technology classification system	The patent classification system used is the International Patent Classification (IPC) system.	The patent classification system used is the United States patent classification (USPC) system.
Renewal fee	Must be paid every year within the 20 year period	Must be paid in 3.5, 7.5 and 11.5 years within the 20 year period
Prior art in the patent specification	The applicant needs to cite any prior knowledge to his invention, but the final decision rests with the patent examiner	The applicant needs to cite any prior knowledge to his invention, but the final decision rests with the patent examiner

Source: MyIPO, WIPO and USPTO websites.

There are several other differences between the Malaysian and U.S patent systems, besides those shown in Table 2.1, but those that need to be highlighted in this study are the patent definition, field of technology and renewal fee, as shown in Table 2.2. There are six types of IP in the Malaysian IP system handled by MyIPO which are patent/ utility innovation, trademark, industrial design, copyright, geographical indication and integrated circuit of layout design. On the other hand, in the U.S. IP system the USPTO also enforced six types of IP, which are the utility patent, design patent, plant patent, trademark, copyright and geographical indication. Since this study only focuses on patents, the definitions of patent in these two systems must be aligned in order to compare the same types of patent.

Table 2.2: The Differences between the Malaysian and U.S. Patent Systems

	Malaysia	***U.S.***
Types of IP	1) Patent/ utility innovation 2) Trademark; 3) Industrial design; 4) Copyright; 5) Geographical indication; 6) Integrated circuit of layout design	1) Utility patent 2) Design patent; 3) Plant patent; 4) Trademark; 5) Copyright; 6) Geographical indication
Field of Technology	The field of technology is classified using the international patent classification (IPC)	The field of technology is classified using the United States patent classification (USPC)
Renewal Fee	The renewal fee must be paid every year for a 20 year term to keep the patent in force	The renewal fee must be paid three times within a 20 year period, given certain intervals, to keep the patent in force

Source: MyIPO and USPTO website

The definition for industrial design in the Malaysian IP system matches the design patent in the U.S. patent system. The definition of industrial design given by MyIPO (2004) is:

"An industrial design is the ornamental or aesthetic aspect of an article. The design may consist of three-dimensional features such as the shape and configuration of an article, or two-dimensional features, such as pattern and ornamentation. The design features must be applied to an article by any industrial process or means of which the features in the finished article appeal to eye."

The definition of the design patent by USPTO (2010d) is:

"A design consists of the visual ornamental characteristics embodied in, or applied to, an article of manufacture. Since a design is manifested in appearance, the subject

matter of a design patent application may relate to the configuration or shape of an article, to the surface ornamentation applied to an article, or to the combination of configuration and surface ornamentation. A design for surface ornamentation is inseparable from the article to which it is applied and cannot exist alone. It must be a definite pattern of surface ornamentation, applied to an article of manufacture."

In this study only the patent (patent narrowly-defined and utility innovation) in the Malaysian patent system and the utility patent in the U.S patent system are taken into consideration. The design patent in the U.S. patent system is not taken into account as it matches the industrial design definition in the Malaysian IP system. As mentioned earlier, it is important to distinguish between the definitions of patent in order to compare between the two systems.

One of the basic written descriptions in the patent specification is the field of technology of the patent (J. M. Mueller, 2006). Most patent systems employ the international patent classification (IPC) to classify the patent's technological field. On the other hand, the U.S. patent system uses its own technological classification, known as the United States patent classification (USPC). However from 1969, the U.S. patent system included the IPC besides the USPC in its patent specification (Lerner, 1994). Therefore, the IPC will be used in this study. This is important to compare the technological fields between the two systems. As for the renewal fee, in the Malaysian patent system it has to be paid every year; while in the U.S., only three times at certain intervals within the 20-year term, as mentioned earlier. This is important to measure the variables accordingly when conducting the empirical analysis.

2.4 The Current Situation of Patenting Activity in Malaysia

The Ninth Malaysia Plan reported a higher average annual growth rate of 12% of patents applied for to domestic residents compared to only 5% to non-residents in terms of the science and technology (S&T) indicator. However, as shown in Table 2.3, the number of patents filed by Malaysian residents is still much lower than for non-residents (Malaysia, 2006). Malaysia's cumulative patent application and registration is dominated by foreigners, as demonstrated by the very large gap between residents and non-residents. In another statistic produced by MyIPO (2010b), of the total number of patent applications in Malaysia, only approximately 7% are applied for by Malaysian residents. On the other hand, out of the total number of patents granted in Malaysia, only 3% have been granted to Malaysian residents. Furthermore, the royalties paid to acquire foreign technological capability had an average annual growth rate of 29% compared to only 6% paid for local technology acquisition, as indicated in Table 2.3. With patenting activity and royalty earnings dominated by foreigners, it is apparent that Malaysia is still dependent on foreign technological capability (Ghapar, 2009).

Table 2.3: Science and Technology (S&T) Indicators in Malaysia

Indicators	***2002***	***2005***	***Average Annual Growth Rate***
Total Patents Filed (Residents)	322	522	12
Total Patents Filed (Non-Residents)	4615	5764	5
Royalties (Receipts – RM million)	74	98	6
Royalties (Payments – RM million)	2399	5851	29

Source: Ninth Malaysia Plan (2006)

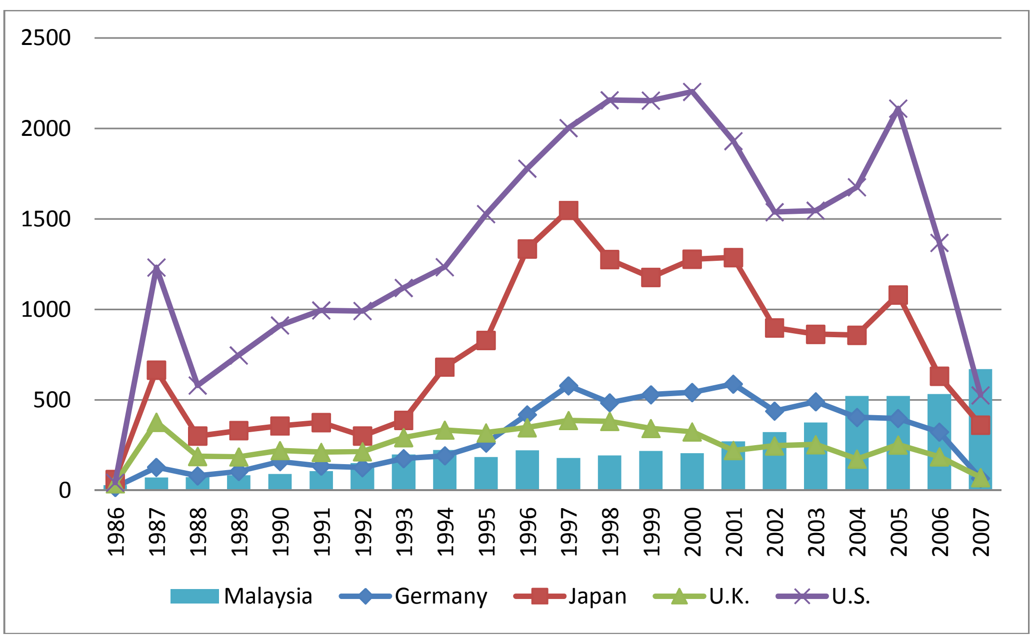
2.4.1 Patenting Activity by Malaysian Residents and Non-Residents

As mentioned in Chapter 1, the patent system is sometimes viewed as benefiting advanced economies more than emerging economies (Grandstrand, 2006; Matthews, 2002). According to WIPO in its World Patent Report (2008), patent applications by non-residents from advanced economies in emerging economies increased in 2007. This shows that non residents from advanced economies are taking advantage of the patent system in emerging economies. Advanced economies are more likely to have carried out patenting activity in emerging economies that are politically stable and economically sound, and Malaysia appears to fulfill these criteria.

The advanced economies often set up their manufacturing businesses in Malaysia in order to take advantage of low cost labor and other resources such as land and raw materials (Edwards, 1999; Lall, 1999). Malaysia has had a comparative advantage in these areas over the past three decades (Jomo & Felker, 1999; Lall, 1999; Edwards, 1999; Rasiah, 1999) and has actively promoted these resource advantages in inviting foreign countries to set up their businesses. This situation has led foreigners to secure their IP (Ghapar, 2009) to defend their invention from imitation by Malaysians. This is supported by Figure 2.1, which shows non-residents from the advanced economies dominating patent applications in Malaysia.

The highest patent applications by non-residents in Malaysia came from the U.S. followed by Japan, U.K. and Germany (MyIPO, 2010b), as evidenced in Figure 2.1. As reported in the Eighth Malaysia Plan, Japan and the U.S. had the highest level of imports into Malaysia with 27% and 16% respectively in 1995, and maintained this ranking 5 years later (Malaysia, 2001). Even though their shares have decreased, as reported in the Ninth Malaysia Plan, they still are the largest sources of imports at 15% for Japan and 13% for the U.S. (Malaysia, 2006). As discussed previously, these countries have also exported and manufactured their partial products into Malaysia. At the same time they protect their IP from local imitation before exporting their products to other parts of the world from Malaysia. This is due to these advanced economies having had the resources and the ability to make full use of the patent system in Malaysia.

Figure 2.1: Patent Applications in Malaysia by Malaysian and Selected Advanced Economies



Source: MyIPO (2010b)

In terms of technological field, Section C (chemistry; metallurgy) was the field in which the highest number of patents were granted followed by Section H (electricity), and Section B (performing operations; transporting). As discussed previously, foreigners have dominated Malaysian patent applications; hence, the technological fields were also influenced by the foreigners' technological fields. According to the Seventh and Eighth Malaysia Plan (1996, 2001) which reported Malaysia's progress between 1996 and 2005, technology inflows from foreigners came from electrical and electronics products; followed by chemical and chemicals products and transport equipment, 10 years in a row. The report matched with MyIPO data on patents granted based on technological field in Table 2.4. There is no doubt that Malaysia is still dependent on foreign technological capability. This is evidenced through the technology inflows from foreigners; royalties paid to foreigners to acquire their technology; and the patenting activity undertaken by foreigners rather than Malaysian residents.

Table 2.4: Patents Granted Based on Field of Technology in MyIPO

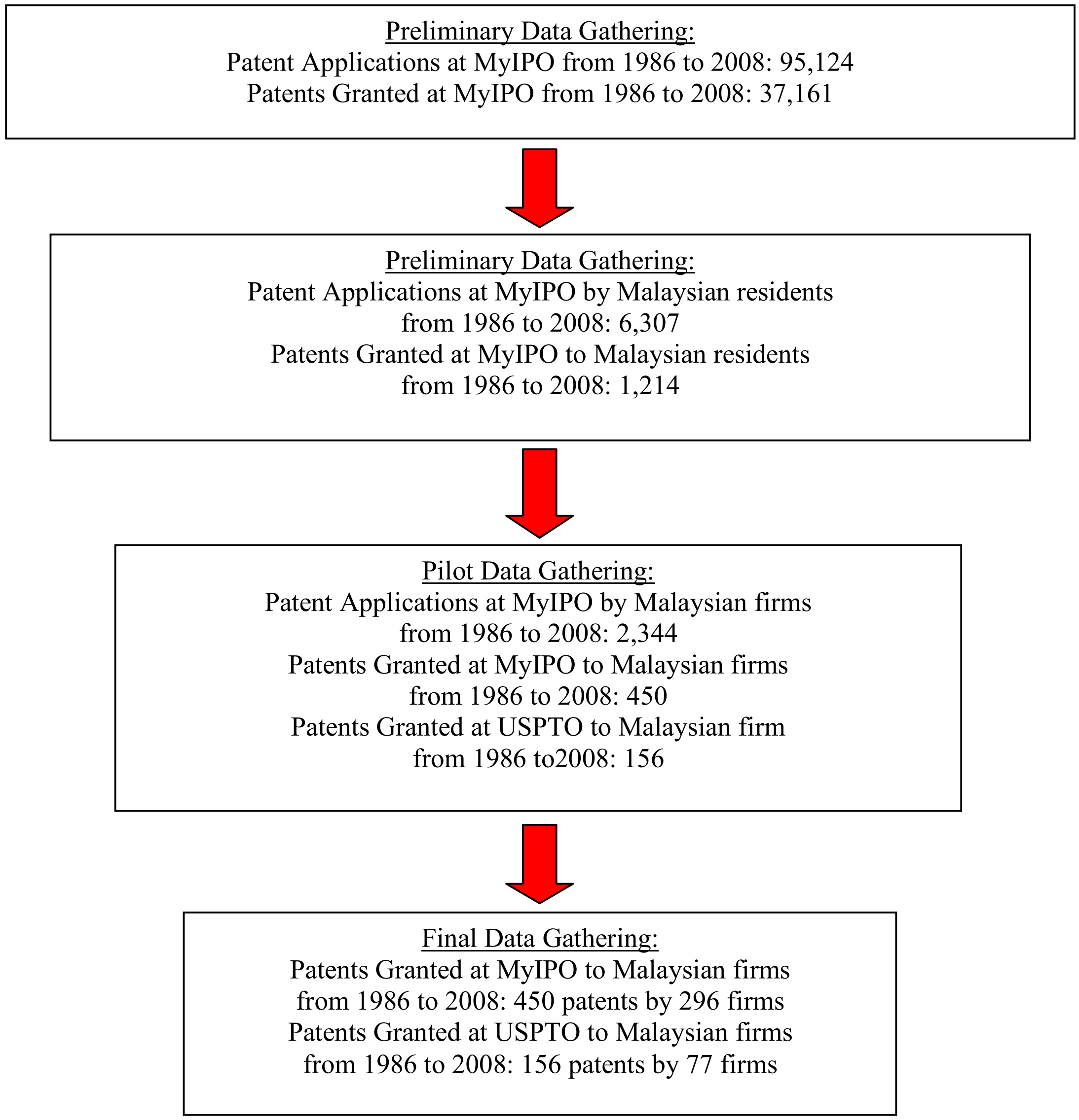
YEAR	SECTION								TOTAL
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	
1993	215	169	503	15	37	52	155	138	**1,284**
1994	260	267	505	12	71	79	192	243	**1,629**
1995	336	268	542	27	48	61	194	277	**1,753**
1996	285	323	483	31	76	103	178	322	**1,801**
1997	151	138	196	13	32	45	82	132	**789**
1998	104	98	141	4	18	31	64	106	**566**
1999	132	112	191	9	21	49	68	139	**721**
2000	61	59	110	8	19	42	36	70	**405**
2001	155	233	288	18	44	102	231	399	**1,470**
2002	206	236	334	19	42	104	228	323	**1,492**
2003	224	242	396	28	38	119	190	341	**1,578**
2004	325	377	625	25	50	132	321	492	**2,347**
2005	333	452	600	30	82	164	316	531	**2,508**
2006	948	1,155	1,275	101	197	448	1,042	1,583	**6,749**
2007	1,179	1,213	1,748	109	221	407	883	1,223	**6,983**
2008	423	421	451	33	98	159	293	364	**2,242**
TOTAL	**5337**	**5763**	**8388**	**482**	**1094**	**2097**	**4473**	**6683**	**34317**

Source: MyIPO (2010b)

2.4.2 Patenting Activity by Malaysian Firms

Empirical studies have been carried out at the relationship between firms' patenting activity and their financial performance in advanced economies. The magnitude of the relationship depends on the specification and estimation used. Most of the coefficients have had a positively significant relationship (Hall, et al., 2007; Connolly & Hirschey, 1988; Griliches, 1981), but some were found to have a negatively significant relationship (Hall, et al., 2005). Others have had a non-significant impact (Coombs & Bierly, 2006; Griffith, et al., 2005; Geroski, et al., 1997). However, the relationship has not yet been empirically tested with Malaysian firms. As shown in Figure 2.2, of more than 35,000 patents granted in Malaysia, only 450 have been granted to Malaysian firms. To describe the overall figures, out of 2,344 patent applications from private and public firms in Malaysia, only 450 patents have been granted in 1986 to 2008. Figure 2.2 shows the preliminary through to the final stage of data gathering for this study. This found that Malaysian firms have been granted 450 and 156 patents at MyIPO and USPTO respectively. However, further investigations are yet to be performed to determine if the patenting activity carried out by these firms has impacted their financial performance.

Figure 2.2: Data Gathering



Source: Preliminary data gathering from MyIPO were taken from the website and given by the MyIPO officer, while pilot and final data gathering were purchased from MyIPO. All data during the data gathering from USPTO were taken from the USPTO website. The above diagram has not yet been finalized for data cleaning and streamlining for the time-series dimension from 1994 to 2008. Further discussion about the sample size for this study is discussed in the methodology chapter.

Table 2.5 shows that firms actively applying for patents were predominantly privately limited rather than publicly listed. This is to be expected as there are a larger number of private than publicly listed firms registered in Malaysia. Of nearly 800,000 registered local firms in Malaysia, as reported to the Companies Commission of Malaysia (SSM, 2010), only 976 are listed in Bursa Malaysia (2010). Table 2.5 indicates that 88% of the patents were applied for by privately limited firms and only

12% by publicly listed firms. The success rate for the publicly listed firms was much lower with only 6% granted as compared to 94% for the privately limited firms.

Table 2.5: Number of Patents Applied for and Granted to Malaysian Firms in Malaysia

Firm Sector	*Number of Patent Applications*	*Percentage Applied For*	*Number of Patents Granted*	*Percentage Granted*
Privately Limited	2070	88	423	94
Publicly Listed	274	12	27	6
Total	**2344**	**100**	**450**	**100**

Source: MyIPO (2010b)

The firm sector needs to be introduced as a publicly listed firm is always regarded as a large firm, while a privately limited firm is normally small. The difference between large and small firms is important for this study as firms behave differently towards invention and innovation, depending on size (Jensen & Webster, 2006; Schumpeter, 1942) and this could impact their financial performance. The measurement of large and small firms in this study will be discussed in detail in the methodology chapter. Researchers that study patenting activity at the firm level (Bosworth & Rogers, 2001; Geroski, et al., 1997; Connolly & Hirschey, 1988; Griliches, 1981) are much more likely to use publicly listed firms, for which financial data are easier to obtain. On the other hand, this study is a challenge as more than 90% of the firms are privately limited, for which financial data are more difficult to acquire.

It is also important to introduce the industrial classification to which the firm belongs. This is because in the analysis of this study, the firms will be divided between manufacturing and non-manufacturing. The macro level data of the merchandise trade of Malaysian exports shows that manufacturing goods account for the largest proportion of exports, as indicated in Table 2.6. Even though it is known that not all exports are meant to be patented, Malaysian firms which have been granted patents in manufacturing might want to exploit them in new overseas markets. Despite the total percentages of manufacturing having a decreasing trend from 2000 to 2005, the sector has always held the highest percentage with more than 80% compared to other gross merchandise exports. Since the U.S. has been one of Malaysia's largest trading partners since the 1990's (Malaysia, 2006, 2001, 1996), this study will use the U.S. as another territory to analyze the patenting activity of Malaysian firms domestically and overseas.

Table 2.6: Malaysia's Gross Exports

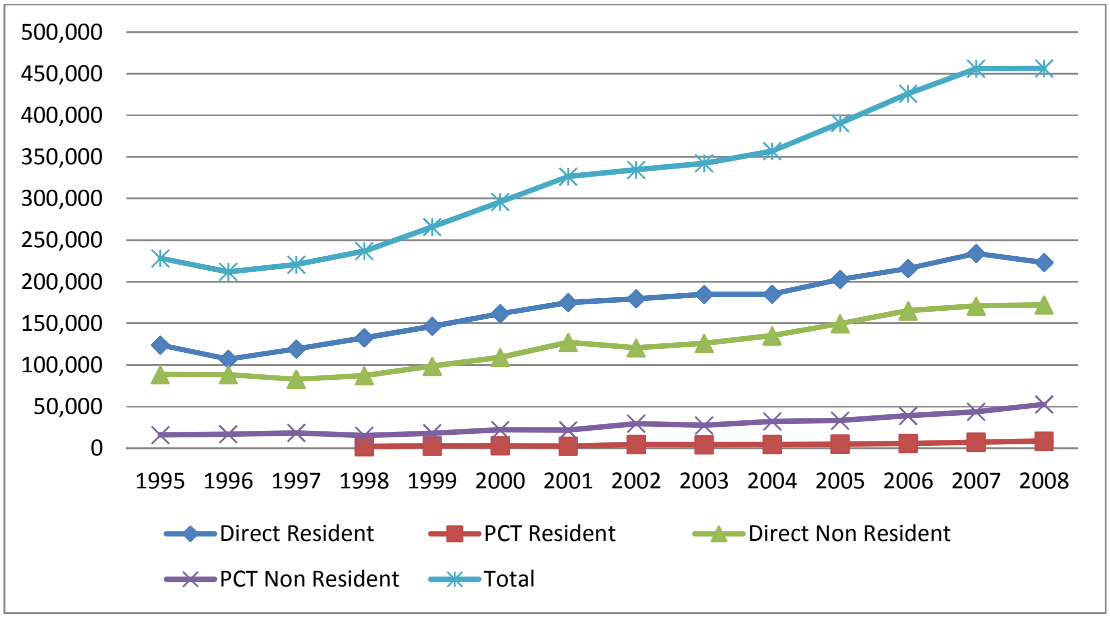
Item	*1995*		*2000*		*2005*	
	RM Million	*% of Total*	*RM Million*	*% of Total*	*RM Million*	*% of Total*
Gross Exports						
Agriculture	21, 642	11.7	22, 892	6.1	37, 421	7.0
Mining	10, 723	5.8	26, 877	7.2	52, 321	9.8
Manufacturing	147, 253	79.6	317, 908	85.2	429, 873	80.5
Others	5, 369	2.9	5, 593	1.5	14, 175	2.7
Total	184, 987	100.0	373, 270	100.0	533, 790	100.0

Source: The Seventh (1996), Eighth (2001) and Ninth (2006) Malaysia Plan

2.4.3 Patenting Activity by Malaysian Firms in the U.S.

As it is a rich country, professionals, investors and businesses around the world are willing to be part of the U.S. patent system (Trajtenberg, 2001). This leads to a tremendously high number of U.S. patent applications. Figure 2.3 shows the patent applications by U.S. residents and non-residents using the two filing routes which directly enter the national phase; and goes through the PCT. U.S. residents were identified as having dominated patenting activity in the U.S. compared to non-residents. They were also more likely to patent directly with their own patent office at the USPTO rather than going through the PCT. Surprisingly, non-residents also entered the U.S. national phase directly instead of going through the PCT. In other patent statistics from the U.S., reported by Griliches (1990), of 62,000 patents granted in 1980, 39% were granted to foreigners. This ratio has also been rising sharply, from 19% in the early 1960s to 48% in 1998. U.S. corporations held 73% of patents granted in 1998, with 2% granted to the U.S. government and the rest to individuals. Since 1995, patent applications in the U.S. have grown tremendously, with a total of more than 200,000 per annum as shown in Figure 2.3. The figures have never fallen and have consistently increased. This shows that securing patents in the U.S. territory may bring promising economic and financial benefits to the residents, non-residents, individuals and firms.

Figure 2.3: Patent Applications in the U.S. by Filing Routes/ Residents/ Non-Residents



Source: WIPO (2010b)

Given that this study is concentrating on the patenting activity of Malaysian firms which have been granted patents in the U.S. territory as well as domestically, this section introduces the patenting activity undertaken by Malaysian firms in the U.S. Even though the percentages are rather small compared to Figure 2.3, it shows that some Malaysian firms have successfully applied for patents in the U.S. From the USPTO website (USPTO, 2010e), it is found that Malaysian firms have two types of granted patents in the U.S. They are the utility and design patents during the period of 1976 until 2008, as shown in Table 2.7. The distribution between the utility patent and the design patent was quite even with 49% and 51% respectively. However, as discussed earlier in Section 2.3.2, the design patent will not be taken into consideration in this study as it is considered as another form of IP in the Malaysian patent system. This enables us to compare the same form of patent between the two territories. Whether the utility patent would significantly impact Malaysian firms' financial performance is yet to be determined.

Table 2.7: Number of Patents Granted to Malaysian Firms in the U.S.

Patent Type	*Number of Patents Granted*
Utility Patent	156
Design Patent	147
Total	**303**

Source: USPTO (2010e)

2.5 Chapter Summary

This chapter introduces the patent system. It starts with the evolution of the patent system and then discusses the systems in Malaysia and the U.S. The differences between these two patent systems are then highlighted in order to set the scene for the empirical analysis for this study. This chapter then ends with the current situation of patenting activity in Malaysia. It introduces the patenting activity by Malaysian residents and non-residents, then, narrows its focus to the patenting activity undertaken by Malaysian firms. The next chapter presents the review of literature which relates patenting activity and financial performance in advanced and emerging economies.

CHAPTER 3 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

3.0 Introduction

A simple patent count is a measure of innovative output, but it can also be an indicator of the value of intellectual property rights shaped by patent laws, with the latter normally measured by a value-weighted patent count. The measurement of both simple and value-weighted patent counts must be distinguished in order to obtain the most accurate measure to answer any research questions. In this study, we focus on the latter measurement. First, we analyze patent renewal and application measures. An invention must go through a thorough application process and, if successful, only then will the invention be granted a patent. Once the patent is granted, however, for the patent to be exploited further, a renewal fee must be paid in order to keep it in force. Second, we base our analysis on the patent quality measures. In the patent system, citation to other patents must be made which refers to the technological knowledge flows cited from earlier patents to the current patents. Patent claim is another indicator that justifies the patent owner's right to exclude others from the invention. On the other hand, *patent family* refers to the same invention which has been successfully granted a patent in more than one territory. Finally, a patent can be in its own technology classification or may involve a combination of several technology fields. Given all the above patent measures, the ultimate dimension relating to the patent system in this study is that the patent is territorial in nature (see Chapter 2).

The main research question posed in Chapter 1 requires examination of the relationship between patenting activity and financial performance at the Malaysian firm level. Thus, another measure that we are interested in exploring in this study is the financial performance at the firm level. As discussed in the preceding paragraph, measuring the patenting activity in this study is not based on a simple patent count, but from within the patent system, with the financial performance discussed in this chapter focusing on accounting-based measures rather than market-based measures. There is a lack of empirical studies that link the accounting-based measures with the value-weighted patent count measures. Most studies have been found to be associated with accounting-based measures rather than with the simple patent count. However, we found lack of studies that associated the accounting-based approach with the patent citations, claims, family and field of technology at the firm level. Thus, this study contributes to the empirical literature with respect to these measures. A further contribution is geographical in nature in that we use, for the first time, Malaysian firms which have been granted patents in Malaysia and the United States of America (U.S.).

The literature introduced in this chapter focuses on the measurement of patenting activity and financial performance, mostly at the firm level. Sections 3.1 and 3.2 introduce the measures of financial performance and patent respectively, while Section 3.3 discusses the literature on the relationship between these two measures. At the end of each section we develop the hypotheses to be empirically tested in this study. In Section 3.4 we present a summary in table form of the hypotheses developed for this study. As this study focuses on the firm level as its sample, Section 3.5 relates the patenting activity to the firm's characteristics. The issue of timing is also a concern when studying patenting activity, and this is discussed in Section 3.6. Finally, Section 3.7 examines literature on patenting activity in emerging economies.

3.1 Measures of Firm Performance

There are different ways to measure a firm's performance, one being to concentrate on the firm's financial performance. In turn, financial performance can be measured using either a market-based or accounting-based approach. Many studies that have analyzed the effect of patenting activity on financial performance at the firm level have focused on the market-based approach (Hall, et al., 2007; Greenhalgh & Rogers, 2006; Hall, et al., 2005; Lanjouw & Schankerman, 2004; Rogers, 2002), while other studies have used the accounting-based approach (Griffith, et al., 2005; Geroski, et al., 1997).

At the firm level, the market-based financial performance uses the firm's market capitalization in order to measure how much the market values the firm. Market capitalization requires the price of the stock market to be multiplied by the number of stocks outstanding. Griliches (1981), who pioneered the market value approach with patenting activity, modified the measurement of the market value of the firm (Tobin, 1969) to include not only traditional physical assets, but also intangible assets or the *stock of knowledge* (1981, p. 183). To measure intangible assets, Griliches used both the traditional accounting measure, the research and development (R&D) expenses taken from the financial statements, and the non-traditional accounting measure, the patent count taken from the patent's office (Pakes & Griliches, 1980). Griliches simplest model states that $V = q(A + K)$ where,

V = current market value of the firm at the end of the year;

A = current value of the firm's conventional assets, such as plant, equipment, inventories, and financial assets;

K = current value of the firm's intangible stock of knowledge which includes the R&D expenditures and number of patents applied for; and finally

q = current market value of the firm's assets

According to Griliches (1981) the q reflects the differential risk and monopoly position. The q is actually the firm's fixed effects in a two-way error component regression model. Thus, the q is further estimated by $\exp(x_i + d_t + u_{it})$, where x_i is the permanent firm effect; d_t is the overall market effect at time *t*; and u_{it} is the idiosyncratic error term.

Griliches's (1981) market value approach has been widely used by those who study patents and financial performance measured by market value, with some modifications to the base model (Hall, et al., 2007; Greenhalgh & Rogers, 2006; Hall, et al., 2005; Lanjouw & Schankerman, 2004; Rogers, 2002). Griliches's simple model measures not only both sides of the market valuation and accounting-based approaches to physical assets valuation, but also includes the intangible stock of knowledge of the firm. However, there are limitations to this approach. First, when studying market-based performance, only firms that are publicly listed can be studied (Coombs & Bierly, 2006). Hence, privately limited firms cannot be in the analysis with the market-based measure. This is a major limitation in our study as most patenting activity in Malaysia is undertaken by privately limited firms (see Chapter 2).

Second, market-based approach valuation has to rely on the efficiency of the stock market (Griliches, 1990; Griffith, et al., 2005), which assumes stock prices fully reflect all available information (Charest, 1978; Fama, 1970). However, this is not always the case as not everybody has all available information about the firm's reaction and behavior which could impact the stock prices. Furthermore, as Malaysia is an emerging market the assumption of stock market efficiency is particularly demanding (Tuck, 2005; Bauman, 1989). An empirical study conducted by Barnes (1986) examining 30 firms and six sectors from 1975 to 1980 found that compared to the London Stock Exchange (LSE), the Kuala Lumpur Stock Exchange (KLSE) surprisingly exhibited a high degree of efficiency even though it had fairly thin trading. However, a more recent study by Lim (2008) examining eight economic sectors from 1994 to 2006 in the Malaysian stock market found that during the 1997 Asian financial crisis all of the economic sectors had the highest inefficiency except for the tin and mining sector, and this trend continued thereafter. Since our study concentrates on panel data with the time-series dimension from 1994 to 2008 (see Chapter 2 Figure 2.2, and Chapter 4 Section 4.1), we therefore assume that the requirement of Malaysian stock market efficiency within this period was particularly demanding.

With these limitations, our study focuses on an accounting-based approach rather than a market-based approach. The accounting-based measure chosen for our study focuses on three variables, that is, the firm's sales, profits and profit margin. Given that our study's sample is at the firm level, its focus on profits follows the assumption that a firm's goal is to maximize profits (Mansfield, 1997). As such, the profit maximization behavior of a firm involves its total revenue, total cost and profit, with the total revenue engaging both the market demand and supply of the patented invention (Ernst, 2001; Scherer, 1965) in order to determine the price and quantity produced. In chapters 1 and 2 we stated that this study has two distinct territories to be analyzed, that is, Malaysia and the U.S. Clearly, the market demand between these two territories may have differing significant impacts on the firm's sales revenue. Furthermore, the sales figures capture the Malaysian firm's technological capability to supply these technologies in both territories. Baumol (1962) expanded the theory of the firm by introducing the sales-revenue maximization model and, according to Curwen (1976), gave precedence to sales-revenue maximization over the pursuit of profit maximization, specifically when he believed that the model required ownership to be separated from control. In this study, the privately limited firm constitutes a larger proportion of the sample than the publicly listed firm, thus making the separation of ownership from control less of an issue. Hence, the manager who owns the firm as well as having full control in managing the firm is interested in maximizing sales revenue in order to maximize profits.

In the profit maximization model, to earn profit the total cost must be deducted from the total revenue, and total revenue is the amount that a firm receives for the sale of its output. On the other hand, the total cost involves the fixed and variable costs, which also depend on the quantity produced. Additionally, these costs are related to the short run and long run operations in the firm. In the theory of the firm, a firm is not able to change its variable cost in the short run, but is able to do so in the long run. Thus, in the long run, if the firm is able to produce an increasing quantity but with decreasing average total cost (total cost per unit produced), it is said to have economies of scale (Harris, 1992). Relating to our study, the variable cost may involve the patent agent or attorney, application, and renewal fee (Hallenborg, et al., 2008), as well as the costs to produce the patented invention itself, such as labor and material costs. Since the goal of the firm is to maximize profits, the condition is for the firm to produce the quantity when its marginal revenue equals its marginal cost. Furthermore, given that the patent allows the firm to have monopoly power, theoretically in both the short and long run the firm may be able to earn supernormal profits.

The market condition is another important element in the profit maximization model. A firm will have to adjust its price, quantity supplied, and cost according to the market structure it faces in order to maximize its profits. Economists have classified markets into several types of market structure such as perfect competition, monopoly, monopolistic competition and oligopoly (Harris, 1992). Rogers's (2002) empirical study of patenting activity segregated the industries by competitive conditions. He found that industries with high profit persistence, or in other words with a monopoly market structure, had been involved in some innovative activity. This contrasts to no profit persistence industries or those that are in the competitive market structure that have no innovative activity at all. After segregating the firms into high profit persistence (monopoly) and no profit persistence (competitive) industries, Rogers's (2002) regressed his model specification which he adopted from Griliches (1981) to look at the impact of intellectual property (IP) on the firm's performance. In another study, Greenhalgh and Rogers (2006) found that the science-based sector had the lowest profit persistence compared to other sectors in their study such as information and production intensive sectors. This shows that in their sample of U.K. firms the science-based sectors can be categorized as having highly competitive conditions.

As mentioned previously, most studies of patenting activity use market-based financial performance, and the sales variable will normally be considered as one of the explanatory variables (Greenhalgh & Rogers, 2006) or as a control variable for the firm's size (Hall, et al., 2007). On the other hand, Griffith, Jensen and Webster (2005) used profits as the dependent variable in their study of patenting activity. They used the earnings before taxes as their dependent variable when studying the impact of IP on the firm's financial performance, with their data taken from the firm's financial statements. The most popular measure of the accounting-based approach as the dependent variable is the profit margin (Rogers, 2002; Geroski, et al., 1997; Geroski, Machin, & Van Reenen, 1993). A patent is a form of IP, which has the nearest definition to invention and innovation, compared to other forms of IP (see Chapter 2). We found that Geroski, Machin and Van Reenen (1993) analyzed the relationship between profit margin and innovation, but not patents specifically. On the other hand, Rogers (2002) used the profit margin to determine profit persistence so as to segregate the industry by market structure in his study of patenting activity, as discussed in the previous paragraph. In an earlier study, Geroski, Machin, and Van Reenen (1997) sought to capture the impact of the firm's innovation and patents on the firm's corporate growth by using the profit margin as their dependent variable.

3.2 Measures of Patent

A patent can be measured in many different ways. The early literature used a simple patent count, that is, the number of patents that the firms has (Bound, Cummins, Griliches, Hall, & Jaffe, 1982; Griliches, 1981). However, a simple patent count measure is typically highly skewed (Scherer & Harhoff, 2000; Lanjouw, 1998; Griliches, 1990) with regards to the patent value itself, as well as to the firm's financial performance. Researchers have since aimed to find other measures to mitigate this problem. Firstly, some researchers allowed the patent count to be depreciated (Hall, et al., 2007; Cockburn & Griliches, 1988) similar to the depreciation of R&D expenditure (Hall, 1993). Secondly, other researchers have used patent renewal (Schankerman & Pakes, 1986; Pakes & Schankerman, 1979), and application measures (Griffith, et al., 2005; Lanjouw, et al., 1998; Putnam, 1996). Thirdly, some researchers have used value-weighted measurement of the patents through the patent citation (Trajtenberg, 1990), claim (Lanjouw & Schankerman, 2004), family (Harhoff, Scherer, & Vopel, 2003), and technology field (Schankerman, 1998).

3.2.1 Patent Renewal and Application Measures

This section focuses on patent renewal and application measures. We learned in Chapter 2 that to keep a patent in force, a renewal fee must be paid. If it is not paid, the patent will no longer be protected by the patent laws. In other words, if a firm stops paying the renewal fee before the maturity date of a 20-year period, the patented invention may no longer provide any benefits to the firm. The patent renewal measures were empirically tested by Schankerman and Pakes (1986); however they applied it to all patents in several advanced economies rather than focusing it at the firm level. They conceptualized mathematically that a patent agent will have to stop paying the renewal fees if the annual return is less than the costs of renewal. Their idea was to derive the value of the patent rights and characterize the changes that occur over time, a concept that they empirically tested in the U.K., France and Germany from 1950 to 1978.

Our study, however, analyzes the patent renewal measures at the firm level, with the sample study being Malaysian firms. We assume that, if the firm is rational, it will only renew the patent provided that it accrues monetary benefits to the firm. Another important distinction between our study and Schankerman and Pakes (1986) study is that they used the renewal cost, age, and value of the patent as the basis for measurement, while we do not. Since we do not know the cost and value of each patent in our data, we have modified the measurement by measuring the patent renewal by the active patent lifespan which accounts for how long a single patent is renewed. The detailed measurement of our study is discussed in Chapter 5.

Putnam (1996) carried out a pioneer study that integrated application data on patents with an analysis of the value of patent protection. He extended the idea of Schankerman and Pakes (1986), but his study concentrated on the inventor's prior decision to apply for patent protection in several countries. Griffith, Jensen and Webster (2005) also had a similar idea in that they included patent application measures as well as patent renewal measures. The only difference is that Griffith, Jensen and Webster (2005) studied patents at the firm level, which is similar to our study, while Putnam (1996) and Schankerman and Pakes (1986) studied patents in specific countries.

3.2.2 Patent Quality Measures

The advantage of the value-weighted patent count is that it mitigates the fact that a simple patent count is dispersed and highly skewed. Other than the patent renewal and application measures, patents are measured based on the value-weighted patent counts with respect to the form of the patent citation (Trajtenberg, 1990), claim (Lanjouw & Schankerman, 2004), and family (Harhoff, et al., 2003). The measurement of each variable involves the ratio of the number of said variables to the number of patents. Lanjouw and Schankerman (2004) selected these three variables and named them as *patent quality*. They created a patent quality index with these variables, before relating them to the financial performance at the firm level (Hall, et al., 2007; Lanjouw & Schankerman, 2004). In this study, we also measure the patent quality based on the value-weighted patent counts with respect to the abovementioned variables: citation, claim, and family.

In academic research, there are two types of patent citation, known as backward citation and forward citation. The former is the number of references cited by the patent applicants, their attorney and patent examiners, and is also known as the *prior-art* in the patent system. This information is shown in the patent specification. The latter is differentiated from the former in terms of the number of citations a patent receives within the patent system. However, this information is not shown in the patent specification. The forward citation is a more common indicator of a patent value (Hall, et al., 2005; Trajtenberg, 1990) compared to the backward citation. The backward citation on the other hand is a proxy of a knowledge spillover or diffusion from one setting to another (Hu & Jaffe, 2003; Jaffe & Trajtenberg, 1999).

As discussed in Chapter 2, the claim is the most important subject matter in the patent specification as it will be used in any litigation (J. M. Mueller, 2006). The claim points out the patent owner's right to exclude others from the invention. However, in another setting, the claim can also show the quality of the patent, in the sense that it shows the novelty of the patent compared to others. Besides the forward and backward citations, Lanjouw and Schankerman (2004) added another variable, that is, the number of patent claims involved in creating a patent quality index. They used several methods such as the one factor model, weights and percentage reduction in variance, within-firm and between-firm regression in their analysis. Different methods produce different results in their tests. Their 2004 study was actually an expansion of an earlier study in 2001 using patent data based on citations, claims and technology fields to examine the characteristics of patent litigations (Lanjouw & Schankerman, 2001).

A patent is territorial in nature (WIPO, 2006a, 2007b; MyIPO, 2008). Thus, securing the same patent in more than one territory is named a *patent family*. There are empirical studies that have explored different territories as well as examined the family size of the patent. Sapsalis and Potterie (2007) have included two territories as one of their explanatory variables, that is, the Japan Patent Office (JPO), the United States Patent Office (USPTO), as well as the family size of these territories. In addition to studying the patent territory, Hall, Thoma and Torrisi (2007) studied the patent family in the USPTO and European Patent Office (EPO). Lanjouw and Schankerman's (2004) study on the other hand included patent family as part of a patent quality index. They studied the USPTO territory but with a more rigorous family size by analyzing 100,000 USPTO patents with family data.

3.3 Relationship between Patenting Activity and Firm Performance

As discussed earlier, many studies have used market-based financial performance and the simple patent count in their analysis. Griliches (1981), who pioneered the market-based approach, found that there is a positive significant relationship between market value of the firm and the intangible stock of knowledge, proxied by R&D expenditures and number of patent stocks. His research is based on longitudinal analysis in large U.S. firms. Bosworth and Rogers (2001) studied large Australian firms, and also found that patent application stocks have a positive and significant association with the firms' market value. However, at variance with these two studies, Rogers (2002) found that the patent application stock was not significantly associated with market value. He concluded that this situation may imply that a patent is either a poor proxy for innovative activity, or the stock market simply fails to recognize such values. Even though Bosworth and Rogers (2001) and Rogers (2002) both studied Australian firms, the differences in results may be due to the different samples in the respective analyses, as the former used only cross-sectional data for 1996, while the latter used an unbalanced panel over a four-year period.

Cockburn and Griliches (1988), and Hall, Thoma and Torrissi (2007), measured patent stocks allowing for depreciation. The depreciation rate is applied to the patent stock to capture the fact that a patent's value depreciates as time passes, similar to the R&D expenses variable (Hall, 1993). Both papers found that patent granted stocks have a positive and significant relationship with the firms' market value. Hall, Thoma and Torrissi also took into consideration the patent territory of the European firms' patenting activity at the EPO and USPTO. They found that a positive and significant relationship exists only when the European firms patent in the U.S., or in both the U.S. and Europe. Their study clearly shows that patenting in a different territory may impose a different, significant impact on the relationship between patenting activity and financial performance.

All of the abovementioned studies analyzed panel data using ordinary least squares (OLS), a fixed effects model (FEM), or random effects model (REM). Only Geroski, Machin, and Van Reenen (1997) used a dynamic panel model that applied the generalized method of moment (GMM) estimator. They argued that the dynamic panel model is needed in their study, as they believed that the current period of corporate growth rates is also dependent on past growth rates. However, the number of patents granted to the firms was not taken into account when using GMM estimation to examine the impact on a firm's corporate growth rate. Based on the OLS estimation, they found that there is a positive relationship between the firm's growth rate and patent grants. However, the relationship has a negative impact with two years lagged on the patent grant. This shows that patented inventions have their own lifespan and may provide a positive impact in the early years of their lifespan, but not in subsequent years.

Similar to the previous paragraph, all of the abovementioned studies (Hall, et al., 2007; Rogers, 2002; Bosworth & Rogers, 2001; Cockburn & Griliches, 1988), except for Geroski, Machin, and Van Reenen (1997), were based on Griliches' (1981) market value specification introduced earlier in the chapter. Nevertheless, as discussed, some studies have modified the measurement of the variable by using a depreciation rate (Hall, et al., 2007; Cockburn & Griliches, 1988). In the next sections, we focus on the relationship of the patenting activity derived from the patent laws which is measured by the patent renewal/ application and quality. The argument is also focused on the profit maximization behavior of the firm discussed in the preceding section in order to develop the hypotheses.

3.3.1 Relationship between Patent Renewal/ Application and Firm Performance

The renewal behavior model in empirical analysis was popularized by Schankerman and Pakes (1986), and Pakes and Schankerman (1979), as discussed earlier. By applying Federico's (1958) patent renewal dataset, they found that patent rights were sharply skewed and had very little economic value for all three countries under study, that is, the U.K., France and Germany. Putnam (1996), who extended Schankerman and Pakes (1986) renewal model to several countries, found that inventors would only apply for a patent in a country that generates positive returns. However, these two studies did not study patents at the firm level. Griffith, Jensen and Webster (2005), who studied IP in public and private Australian firms from 1989 to 2002, also believed that the proxy for innovation should be the lifespan of patents, as well as the simple patent count. However, they found that the relationship between the profits and stock of granted patents measured by a simple patent count has a higher coefficient compared to the lifespan of the patent. Patent pending is only positively significant with the OLS estimation, but insignificant when the FEM estimation is used.

The profit maximization model takes into account the sales revenue and cost, as well as the market condition, in order for the firm to maximize its profits, as discussed earlier. The sales revenue involves the firm having to adjust the price given the quantity demanded and the quantity supplied. Thus, in studying two patent territories (Malaysia and the U.S.), the demand of the patented invention may well be different. There are empirical studies that signify that the market demand for patented inventions in the U.S. is high during a period of economic growth, but declines during economic recession (Nicholas, 2010; Sokoloff & Khan, 1990). Nonetheless, no such studies are found in Malaysia. Lack of empirical studies with the patented invention in Malaysia is unsurprising as discussed in Chapter 2. Furthermore, some products have a limited technological life (Sirilli, 1987), and may well become obsolete as time passes (Schumpeter, 1942). It can take as little as two years or as long as five years or more for a patent to be granted (Michael, 2005). Therefore, the market demand may change by the time the patent is granted, or even while it is still pending to be granted. This situation will also change the quantity supplied by the firms. However, as mentioned in

Chapter 1, the Malaysian firms that have undertaken patenting activity must have been outstanding, and may well predict positive sales revenue generation. In addition, with the sales-revenue maximization model introduced by Baumol (1962), there is no doubt that firm gives precedence to sales-revenue maximization over the pursuit of profit maximization.

In the profit maximization model, the firm will be able to experience supernormal profits when the price is above the average total cost. We therefore assume that the firm should be able to control its costs to maximize its profits, even if changing the variable cost can be done in the long run rather than the short run, as discussed in Section 3.1. In Chapter 2, we pointed out that renewal fees need to be paid yearly in Malaysia, and in certain years of interval in the U.S. In addition, for Malaysian firms to patent in their own resident country of Malaysia, the patent application cost is much cheaper (MyIPO, 2010a) compared to the U.S. (USPTO, 2010b). These are costs which the firm may have to bear in the short run, even though it may suffer a loss. In the long run, however, if the loss is no longer bearable, the firm may have to choose to temporarily shut down its operation or exit the industry for good. Ex-ante, in the profit maximization model, we assume the firm is able to maximize its profits with the patenting activity undertaken.

As discussed previously, the market structure the firm rests on may also affect the profit maximization behavior of the firm, that is, if this market structure is competitive or a monopoly, in the short run the firm may experience supernormal profits. However, in the long run, in a competitive market structure the firm may experience normal or zero economic profits, while in a monopoly market structure, it may still have supernormal profits unless the patent has low demand due to obsolescence of the technology (Pakes & Schankerman, 1979; Schankerman & Pakes, 1986) or the patent protection simply has ended with the 20 year term (see Chapter 2). Also in Chapter 2, we learned that while a patent provides protection to the firm (WIPO, 2006a), *if secured,* [it] *may have to be used in order to justify investment* (Schumpeter, 1942, p. 88). In addition, our measurement is based on the patent renewal measure, in which only patents granted with an active lifespan are included in the analysis (see Section 5.1.1 of Chapter 5). Hence, the patent may give the firm monopoly power

(Schumpeter, 1942), in which ex-ante in the profit maximization model, the firm may use the patent to achieve supernormal profits.

The profit margin measures how much profit the firm receives given its sales. It also shows how much the market values the patented invention, since the sales may represent the market demand and supply (Ernst, 2001; Scherer, 1965) to determine the price and quantity produced. In addition, profits indicate the ability of the firm to handle its costs in the short run and long run depending on the market structure the firm faces (Greenhalgh & Rogers, 2006; Rogers, 2002) in order to maximize its profits. Therefore, we also anticipate that there will be a positive relationship between the patents applied for and granted to Malaysian firms and their profit margin.

Therefore, maintaining the unit of analysis with Malaysian firms which have been granted patent in two territories (Malaysia and the U.S.), and measuring the firm's financial performance with the accounting-based measure of sales, profits and profit margin, we developed the ensuing hypotheses following the above argument to answer the first subsidiary research question in Chapter 1:

H1: There is a positive significant relationship between patents applied for and granted to Malaysian firms in both Malaysia and the U.S. and their financial performance

3.3.2 Relationship between Patent Quality and Firm Performance

We highlighted earlier in this chapter the lack of studies that examine the relationship between patent quality measures and accounting-based financial performance measures at the firm level. Most studies that we found either associated the patent quality with the patent value itself (Sapsalis & Potterie, 2007; Harhoff, et al., 2003) or the firm's market value (Lanjouw & Schankerman, 2004; Hall, et al., 2007). A patent can represent the *stock of knowledge* (Griliches, 1981, p. 183) and, theoretically, some knowledge is said to be tacit, which according to Polanyi means, *we know more than we can tell* (1966, p. 4). Thus, *tacit knowledge* is somewhat difficult to transfer even when written down with paper and pencil (Teece, 2005). Conceptually however, patent citation is said to be the best measure to study how much knowledge travels from one setting to another (Hu & Jaffe, 2003). Normally backward citation is studied together with forward citation to examine the relationship between the quality of the patent and the firm's market value (Lanjouw & Schankerman, 2004; Hall, et al., 2007). When studying the forward or backward citation alone, it is normally associated with knowledge flows, spillover or diffusion (Hu & Jaffe, 2003; Jaffe & Trajtenberg, 1999; Jaffe, Fogarty, & Banks, 1998).

As mentioned earlier, the forward citation is a more common indicator of patent value. Most studies found a positive significant relationship between forward citations and financial performance. Trajtenberg (1990, 1987), who initially studied the value of a patent using patent citations, specifically focused on one type of breakthrough innovation, that is, Computed Tomography (CT) Scanners, and found that patents weighted by citations are highly correlated with the value of innovations, which generate further innovative activity. Jaffe, Fogarty, and Banks (1998) used forward citations to analyze the commercialization of the US government's related technology in samples taken from NASA and other federal labs. They concluded that patent citations can be proxies for both technology impact and knowledge spillovers among similar organizations with a similar technology field. Their study is also supported by Maurseth and Verspagen's (2002) European research.

Nevertheless, there are studies that have successfully used the backward citations in their analysis. Jaffe and Trajtenberg (1999) studied international knowledge flows by using evidence from patent citations from the UK, France, Germany and Japan. They found that inventors from the same country are more likely to cite each other than those from another country, which shows that there is a clear country-specific citations tendency. On the other hand, Hu and Jaffe (2003) examined the patterns of knowledge diffusion from the US and Japan to Korea and Taiwan. Their research on patent citations shows that the emerging economies of Korea and Taiwan are learning from the advanced economies of the U.S. and Japan. They also found the same result as Jaffe & Trajtenberg (1999) in terms of citing more from the same technology field compared to other fields. Hall, Jaffe and Trajtenberg (2005) went a step further in exploring the usefulness of patent citations as a measure of the importance of a firm's patents as indicated by the stock market valuation of the firm's intangible stock of knowledge. Their key finding was that citations to patents have a positive significant impact on market value.

Lanjouw and Schankerman (2004) used forward citations, backward citations, claims and family as measures of patent quality to examine the relationship between patents and firms' productivity and market value. In addition, they created an index with all the said measures and divided the sample into fields of technology to examine the impact differences. They found that the patent quality is positively related to the firms' market value, but negatively related to productivity. Sapsalis and Potterie (2007), on the other hand, used forward citations as their dependent variable and backward citations as one of their explanatory variables. In their full sample, they found a positive significant relationship between the backward citations and forward citations. However, when the backward citations were classified in detail, they found that backward citations to corporate patents and self-citations were negatively related with forward citations, while only citations from public organizations were positively associated with the forward citations. Harhoff, Scherer and Vopel (2003) combined both backward and forward citations as well as family size to value the patent rights. They had rich data on the patent value gathered through interviews, and hypothesized that a larger number of backward citations should bring low monetary value to the patent. However, their results found otherwise. As expected, forward citation and family size had a positive significant impact on the patent value.

Since our sample is Malaysian firms, we are more interested in examining the knowledge flows from the advanced economies to these Malaysian firms. This objective is achievable through backward citation data from the patent specification. Furthermore, due to unavailability of forward citation data (as discussed further in Chapter 4), we are unable to use forward citations to measure *patent quality* in terms of how many others have cited Malaysian firm patents. As introduced in Chapter 1 and further discussed in Chapter 2, the Malaysian patent office is flooded with patents from firms from advanced economies and, thus, Malaysian firms may learn implicitly or explicitly from these firms. In fact, almost all backward citations in our sample data were from advanced economies, with the U.S., U.K., Germany and Japan having the highest citations in Malaysian patent specifications from Malaysian firms. With these countries having the highest applications and number of granted patents in Malaysia, this situation is not a surprise (see Chapter 2). Turning to the U.S. territory, our sample data also shows that almost all citations in U.S. patent specifications from Malaysian firms come from the advanced economies, especially from the U.S. This is also unsurprising because, as discussed earlier, there is a clear country-specific citation tendency (Bacchiocchi & Montobbio, 2009; Jaffe & Trajtenberg, 1999). Furthermore, the patent examiner has the final decision as to the patent's prior-art (see Chapter 2). Regardless of these arguments, we still believe that patent citation is one of the best measures of patent quality with regards to knowledge flows.

Relating to the next variable of patent quality adopted in this study, that is, patent claim, conceptually it should have a positive significant impact on the firm's financial performance, as other firms are no longer able to legally imitate the claim. Theoretically, a patent claim can also represent a stock of knowledge. This is due to new knowledge the firm invented and claimed as being novel in the patent specification. As discussed earlier in the patent quality measures, the patent claim is important as it will be used in any litigation matters (J. M. Mueller, 2006). As also discussed above, Lanjouw and Schankerman (2004) added the number of patent claims to their model specification. Their study was an expansion of an earlier study using patent citations, claims, and technology field to examine the characteristics of patent litigations (Lanjouw & Schankerman, 2001). In their 2001 study, they hypothesized that a patent with a larger number of claims runs a greater risk of being litigated by their competitors. Their findings supported the hypothesis. Another recent study that contains claims as an explanatory variable is that by Hall, Thoma and Torrisi (2009). In contrast to the results of Lanjouw and Schankerman (2001), they failed to reject the hypothesis that more controversial patents having a higher number of claims were more likely to be opposed. Their study, however, concentrates on financial patenting in Europe, while Lanjouw and Schankerman's (2001) sample data were taken from the U.S. district courts and the USPTO. This shows that the geographical context and sample of the study could give different results. Nevertheless, all of the abovementioned studies demonstrate that the number of claims is a relevant variable to consider.

Moving to patent family as another indicator in our patent quality measure, there are empirical studies that have been done to include different territories, as well as to explore the family size of the patent. Conceptually, either the patent territory or family should have a positively significant relationship with the firms' financial performance. This shows that if the firm has the ability to invest in patenting activity in more than one territory, it may result in better financial performance compared to patenting only in one territory. Sapsalis and Potterie (2007) included two territories as one of their explanatory variables to model the relationship with the patent value for Belgian universities. They found no significant relationship between the patent family in the JPO and USPTO and the patent value. However, when the patent applications from these two patent offices were segregated, it was shown that patent applications from USPTO had a stronger effect on patent values when compared to JPO patent applications. They concluded that it is not the family size that matters; rather, it is the territory in which the patent is applied for.

Unlike Sapsalis and Potterie (2007) who relate patent territory with backward and forward citations in universities, Greenhalgh and Rogers (2006), and Hall, Thoma and Torrisi (2007), relate patent territory with market value in firms. The two latter studies found respective results that contradicted each other. While Greenhalgh and Rogers (2006) found that patenting activity had a positive significant impact on the market value of patents taken from the EPO, Hall, Thoma and Torrisi (2007) found otherwise. However, this may have been due to the different samples in the studies. Hall, Thoma and Torrisi (2007) studied all publicly traded firms headquartered in 33 European countries, while Greenhalgh and Rogers (2006) studied U.K. firms which applied for a patent direct from the national office in the U.K. and via the EPO. To be specific, Hall, Thoma and Torrisi (2007) found that the market value is significantly related with patent stock taken from the USPTO alone or the patent family from the USPTO and EPO, while Greenhalgh and Rogers (2006) found that EPO patents have a positive significant impact which raises the market value of the firm, but that there is no significant impact in firms that receive only the U.K. patents.

As mentioned earlier in this section, there is lack of studies that relate the accounting-based measures with the patent quality measures and, further, hypothesizes them based on the profit maximization model. We, however, expect that the patent quality measures will have the same expected sign with the patent renewal/ application measures in developing our hypothesis statement. We anticipate a positive relationship between the patent quality and the firm’s sales, as the firm may be able to adjust its price given the quantity demanded and its ability to supply the patented invention. Turning to the firm’s profits, ex-ante with the profit maximization model, the firm will be able to control its costs in order to maximize profits by charging a price above the average total cost.

In terms of patent quality, the costs may relate to the patent agent's charge in drafting the patent specifications. Even though the inventor (or as in this study, the firm) may well have done their patent search relating to the prior-art or backward citation (Kwa, 2004; Rottner, 2004), the patent agent has to double check the firm's application. This is to make sure that the invention is novel (Kwa, 2004) and is granted without too much difficulty (Rottner, 2004). Next is the cost relating to the patent claim, in which the higher the number of claims, the higher the costs of drafting the patent specifications (Tulloch, 2007). Finally, a firm that is willing to patent in more than one territory may well expect that the cost is higher than patenting in only one territory (Hallenborg, et al., 2008). Ex-ante with the profit maximization model, when a firm secures a patent it may expect higher benefits than the costs of patenting (Schumpeter, 1942). Furthermore, with a patent which allows the firm to gain monopoly power, the firm may achieve supernormal profits in the short run as well as in the long run.

Similar with hypothesis 1 (H1), maintaining the unit of analysis as Malaysian firms which have been granted patents in the two territories of Malaysia and the U.S., and measuring the firm's financial performance with the accounting-based measure of sales, profits and profit margin, we developed the following hypotheses following the above argument to answer the second subsidiary research question relating to patent quality in Chapter 1:

H2: There is a positive significant relationship between the broader number of backward citations, claims and having a patent family in patents granted to Malaysian firms in both Malaysia and the U.S. and their financial performance

3.3.3 Relationship between Patent Technology Field and Firm Performance

Griliches (1990) argued that caution must be taken when studying the classification system in a patent. A patent's technology field is not the same as the industrial classification mainly categorized by economists. Thus, a researcher must have a clear understanding of the differences between these two in an attempt to answer any research questions. This is due to the fact that one technology field can be patented by many industries, and vice versa. To complicate matters, a patent can exhibit a combination of several technology fields. Some researchers have measured the technology field based on the patent's international patent classification (IPC) (Schankerman, 1998; Lerner, 1994), others have successfully created their own technology field (Pavitt, 1984; Greenhalgh & Rogers, 2006); while others have based their classification on the industrial sector normally classified by economists (Hall, et al., 2005; Hall, 2005). The most popular measure is to segregate the patents based on the technology field (Lanjouw & Schankerman, 2004; Schankerman, 1998). However, other researchers have combined the technology field in an attempt to examine the dispersion of technology from its own traditional setting (Lerner, 1994), which may create a superior technology.

Conceptually, some technology fields have a shorter technological life than others. Normally, biotechnology and pharmaceuticals have a longer technological life, compared to technical products that deal with basic human necessities which may have a shorter technological life. With regard to the former, generally at the early stage of their invention these firms would apply for a patent for defensive purposes (Terziovski & Lai, 2007; Rimmer, 2004). Thus, there is no commercialization of patents taking place at the early stage of the invention. Nevertheless, once the invention is ready to go into the market, it may last for a longer time period and boost the firms' sales revenues and profits. There are studies that show that pharmaceuticals, biotechnology, chemicals and other inventions classified as science-based are more valuable compared to other technological fields (Fai & Tunzelmann, 2001; Lanjouw, et al., 1998). However, the value of technological fields may also depend on the patent territory (Bacchiocchi & Montobbio, 2010). Based on Pavitt (1984)'s concept of the technological area which is grounded in differences in the process of innovation rather than product-based industrial classification, Greenhalgh and Rogers (2006) found that the science-based technology field has the strongest effect on market value for UK patents. Schankerman (1998) realized a similar result to that of Greenhalgh and Rogers (2006) in his work on U.K. patents. However, he was more specific as he used the renewal behavior model (Schankerman & Pakes, 1986) across the technology field, and found that pharmaceuticals and chemicals have a slow decay in private returns compared to mechanical and electronic patents which have much faster obsolescence.

In Malaysia, the pharmaceuticals and biotechnology fields are relatively new and targeted as a new source of growth (Malaysia, 2006). The National Biotechnology Policy was launched in 2005 and divided into three main phases which end in 2020 (MABIC, 2011). Thus, we expect that it is highly unlikely that Malaysian firms would have many patents in this area (see Chapter 4). Our sample contains more technical and mechanical technological area patents than pharmaceutical, biotechnology or chemical field patents. For example, even though in Chapter 2 it is evident that Section C (chemistry and metallurgy) has the highest granted patents compared to other technology fields, the results in Chapter 4 show that in our sample Section C has the second lowest patents granted to Malaysian firms. This is unsurprising, as Section C in Chapter 2 involves all granted patents in Malaysia. Comparing with our sample, this situation obviously shows that foreign firms are dominating the Section C technology field in Malaysia. In Chapter 4, it is evident that our sample mostly comes from the human necessities, performing operations/ transporting, mechanical engineering, and electronics technology fields. This is to be expected as Malaysia has moved from post-colonial status to primary product exporter to being an industrially oriented economy (Ghapar, 2009; Jomo & Felker, 1999) in which these technology fields commonly rest in the aforementioned sectors. The composition of the technology field in our sample will be discussed further in Chapter 4.

Thus, based on the IPC and composition of technology fields of patents granted to Malaysian firms in the two territories of Malaysia and the U.S., we segregate our technology fields into two broad areas: 1) human necessities and performing operations, and 2) mechanicals and electronics. Motivated by the patent renewal and patent quality measures in Section 3.2, the two hypotheses in this section are similar to those in sections 3.3.1 and 3.3.2. We believe there is no significant difference between these two fields in terms of the impact of their patenting activity on the firms' financial performance relating to the sign and significance. This is because we expect these two fields, both with fast moving technology, to have a short technological life. Nevertheless, the reason we segregated these two fields is because the magnitude of their impacts may differ significantly.

3.4 Summary of Hypotheses Development

Tables 3.1 and 3.2 summarize the hypotheses which are motivated by the patent renewal/ application and patent quality measures respectively. The accounting-based financial performance is predicted following the profit maximization model with each having a positive expected sign. In Chapter 2, we learned that Malaysia has had extensive experience in the manufacturing and exporting industries. Therefore, our sample will also be hypothesized and analyzed based on those Malaysian manufacturing firms which have been granted patents. As discussed in the preceding paragraph, our sample will also be hypothesized and analyzed based on the patent technology field at the Malaysian firm level. The sample of this study is discussed further in Chapter 4.

Table 3.1: Hypotheses Development Motivated by Patent Renewal and Application Measures

Hypotheses Development	Sales	Profits	Profit Margin
	(Expected Sign)		
There is a positive significant relationship between patents applied for by Malaysian firms in both Malaysia and the U.S. and their financial performance.	(+)	(+)	(+)
There is a positive significant relationship between patents granted to Malaysian firms in both Malaysia and the U.S. and their financial performance.	(+)	(+)	(+)

Table 3.2: Hypotheses Development Motivated by Patent Quality Measures

Hypotheses Development	Sales	Profits	Profit Margin
	(Expected Sign)		
There is a positive significant relationship between the broader number of backward citations in patents granted to Malaysian firms in both Malaysia and the U.S. and their financial performance.	(+)	(+)	(+)
There is a positive significant relationship between the broader number of claims in patents granted to Malaysian firms in both Malaysia and the U.S. and their financial performance.	(+)	(+)	(+)
There is a positive significant relationship between having a patent family in Malaysia and the U.S. granted to Malaysian firms and their financial performance.	(+)	(+)	(+)

3.5 Patenting Activity and Firm Characteristics

3.5.1 Firm Size and Age

Patents are actually costly to enforce and acquire (Jensen & Webster, 2006), and it is often argued that small-medium sized enterprises (SMEs) are at a disadvantage in obtaining appropriate returns from their innovative efforts (WIPO, 2003; Macdonald, 2004). In 1942, Schumpeter contended that large firms are more likely to have monopoly power and reap benefits from innovation, and are the ones with more incentives to innovate. However, a study by Jensen and Webster (2006) revealed that given their innovative potential, SME Australian firms are more likely to apply for patents, trademarks, and industrial designs than large firms. The findings also show that there is no strong positive evidence supporting the argument that SME firms are at a disadvantage. In fact, an earlier study in the U.S. revealed similar results. Griliches (1990) found that at the cross-sectional level small firms appear to be more efficient, and receive a larger number of patents per R&D dollar.

However, data constraints limit the study of the relationship of IP in small firms with their market value. Therefore, large firms' data, especially those that are publicly traded, will be under study (Bosworth & Rogers, 2001; Rogers, 2002; Hall & Oriani, 2006). In Australia, Bosworth and Rogers (2001) found that R&D and patenting activity in large firms is significantly positively related to the market value. However, when studying firms in the U.S., Connolly and Hirschey (1990) found that firm size does not determine R&D effectiveness when measured using market value. In terms of patenting activity, one of the variables in their study - patent intensity - also delivered similar results to that of R&D effectiveness (Connolly & Hirschey, 1990). In addition, their previous study (Connolly & Hirschey, 1988) relating to market value and patents using the Bayesian approach, found a large, positive and statistically significant impact between the two variables.

In relation to the firm's age, an empirical study by Griffiths, Jensen and Webster (2005) found that for older firms the impact of IP stocks is lower on profits. However, taking into consideration being an old firm per se, older firms have a positive effect on annual profits. The authors suggested that this might due to the accumulated intangible capital in other forms like marketing and capital goodwill rather than IP stocks. Their results contradict the findings of Jensen, Webster and Buddlemeyer (2006), however, who found that patent stocks actually improve the survival rate for incumbent firms. From both studies, it can be interpreted that incumbent firms in the innovation and technology area can still survive, even if IP does not bring much in the way of profits.

3.5.2 Firm Sector

Another firm characteristic that exists is the nature of business. Since this study is concentrated on innovation and patenting activity, the nature of business can be traced through the type of industry or sector in which the firm resides. As discussed earlier, the sector can be classified according to the industry (Bosworth & Rogers, 2001; Hall, 2005), the technology field in the patent classifications (Schankerman, 1998; Lerner, 1994), or other sector classifications successfully created by some researchers (Pavitt, 1984).

According to Hall (2005), her study using publicly traded data in the United States from 1980 to 1989 shows that industries based on electrical and mechanical technologies have a positive market value for entrant firms in the post-1984 period. On the other hand, Trajtenberg's (1999) study was also based on mechanical and electrical technologies, but this time more technology fields were added, such as computers and communications, electrical and electronics, drugs and medicine, chemical, and mechanical. His study concentrated on Israelis innovators that secure U.S. patents and found that Israeli patents are on par with the U.S. in terms of the importance and quality of its technology field in all fields except for computers and communications, in which field Israeli patents are even better. However, this study has not linked these fields of technology with any firm's performance. In our study, besides considering the firm sector which will be discussed further in the methodology chapter, we will also investigate the impact of the patenting activity on the firms' financial performance.

In the industrial sector, some researchers have concentrated on studying the manufacturing sector where samples are taken from the manufacturing industry itself (Coombs & Bierly, 2006; Griliches, 1981), while others have taken the whole data set from all industries, and then segregated the firms by market structure (Rogers, 2002), patenting firms (Hall, et al., 2005) or even controlling for them by using dummies (Bosworth & Rogers, 2001). The patenting activity in the manufacturing sector, however, was chosen more often than others as a sample study. This might be due to the aggressive inventions which are then patented in the manufacturing industry within a competitive environment. Furthermore, patents are considered a more appropriate measure of innovation in the manufacturing industries (Griliches, 1990), compared to trademarks which are normally applied across all industries (Webster & Jensen, 2006; Posner, 2005).

3.6 Patenting Activity and the Issue of Timing

The timing issue is a big concern when studying patents. This is due to the renewal fee that is imposed on the patent holder (Schankerman & Pakes, 1986; Pakes, 1986; Pakes & Schankerman, 1979). Furthermore, when studying firms as the sample of this study, Schumpeter's (1942) views are recalled, that is, that the performance of a firm must be judged over time, because as time passes any possible advantages which the firm has had might be inferior in the long run (Schumpeter, 1942, p. 83). The fee payment obviously presumes that the inventions are being used (Schmookler, 1966); however, if the firm finds out that the costs of renewing the patent outweighs the benefits of maintaining the patent, they can always stop paying the renewal fees. This situation exemplifies that a patent may become inferior as time passes.

Another indicator also concerning the patenting activity and timing issues is the external factors which cannot be controlled from within the firm. As technology is always changing, existing technologies could be replaced in this situation leading to lower profits for a firm. Therefore, it is important for a firm or even a country to continue innovation so as to keep up with the latest technological phase and not be left behind. Other external factors such as government policy and global economic and financial crises may also affect a firm's profitability. In terms of Malaysia which endured the Asian financial crisis of 1997-1998, controlling for the time effect is crucial in this study, so that estimates are unbiased and consistent. There are also empirical studies in the patenting activity area which were conducted in advanced economies that had controlled for the time effect (Hall, et al., 2005; Rogers, 2002; Blundell, Griffith, & John, 1999; Schankerman, 1998).

3.7 Patenting Activity in the Emerging Economies

The literature in the previous section was mostly concerned with advanced economies. When academic research on patenting was conducted on emerging economies, it tended to focus on basic descriptive statistics (Fai, 2005; Rezapour, et al., 2007) or case studies (Cheeptham & Chantawannakul, 2001) of an organization that has patents. Besides the academic papers, other information specifically reporting on patents are from organizations that handle IP directly or indirectly (WIPO, 2007c, 2008; United Nations, 2007; OECD, 2004).

The lack of awareness of IP in the emerging economies is not surprising, as well as the focus on patents which involve only one type of IP. As introduced in Chapter 1, advanced economies are taking advantage of the IP system, whereas emerging economies tend not to. A case study conducted in Thailand (Cheeptham & Chantawannakul, 2001) gathered evidence that an American company sold genetically modified Thai rice with a different name which sounded similar and had moved towards patenting it. It is reported that Thailand was too slow in claiming ownership of its own resource, with the value lost in this case estimated to be USD910 million. In the same study, another case was reported that Thai medical herbs for stomach ache relief had been patented by the Japanese. This could be attributed to a lack of awareness of the importance of IP in Thailand. Given their results, Cheeptam and Chantawannakul (2001) proposed that IP awareness among Thai research institutions be upgraded by setting up a special IP department within each university.

Unlike Malaysia, Iran has more patents from its own residents compared to foreigners. However, according to Rezapour, Bagheri, Rashtchi, and Bakhtiari (2007), the number of foreign patents is increasing, thus showing sign of changes in patenting activity. In their recent study, (Bagheri, Moradpour, & Rezapour, 2009) discussed the new law modified in 1958 on the *patent and trademark law* when the law has been first enacted in 1924. However, there is no empirical evidence that this has been done in their study apart from reporting on the graphs taken from their patent office. We believe that it is not primarily the patenting system that results in Iranian residents having higher patenting activity than foreigners; rather, it is due to the economic system. Many sanctions have been imposed on Iran; thus its economic interaction with other parts of the world has been suppressed. Given this, foreigners - especially foreign firms - might see Iran as a less attractive country in which to conduct their patenting activity.

China provides another example where the patenting activity from of its own residents is higher than that of foreigners (Fai, 2005). Fai's study also discussed the descriptive statistics from the graph at the patent office, albeit with no empirical evidence of hypothesis testing. She divided patents into three types - invention, utility model and design, with *invention* having the lowest count compared to the other two measures. Even though Fai believed that the statistics provided by the patent office in China are dubious, she was even more doubtful about the trade data. She reported that the foreign firms were less likely to patent in China due to the infancy of that country's patenting system. Thus, even though foreigners traded in China, they were more likely to keep any innovative product or process secret and not bother with patent applications in that country.

Turkey is seen to be in a similar situation to that of Malaysia, in that it has higher patents from foreigners compared to its own residents. Dereli and Durmusoglu (2009) stated that from 1995 to 2006, of more than 30,000 patent applications 18% came from residents, while the remainder were from foreigners. The patenting trend is volatile in Turkey, with these authors arguing that it is because of macroeconomic conditions and national policies concerning innovations. While there is no empirical evidence that they have tested the situation, their argument is based on macroeconomic conditions in Turkey from 1998 to 2006 that dampened innovation, and supported by literature based on the advanced economies (Faber & Hesen, 2004).

However, there is a recent empirical study on one of the emerging economies, China. Choi, Lee and Williams (2011) studied China's firm ownership and innovation. They used patent counts as their dependent variable to represent a firm's innovativeness. With that, they have specified their model using a negative binomial regression. Their study, however, is based only on a cross-sectional dimension. Nevertheless, they have run three additional regressions with three different years of data to examine the differing impacts among those years. They found mixed results according to the different types of ownership concentration relating to innovation performance. By contrast, in our study we will be using the panel data model. This is discussed further in the methodology chapter.

In Malaysia, there are a few empirical studies that are related to innovation but not directly with patenting activity. Some were based on survey questionnaires (Chandran, Ghapar, & Veera, 2009) or secondary data (Lee, 2004), which then focused on R&D activity (Zainol, Nair, & Kasipillai, 2008) rather than the patenting activity. Studying the public universities in Malaysia, Chandran, Ghapar and Veera (2009) divided their specifications into two areas: research that has actually been commercialized, and research with the potential to be commercialized. They found that IP awareness plays a significant role, having the highest coefficients among other explanatory variables in both specifications. On the other hand, Lee (2004), who studied manufacturing firms as his sample, used survey questionnaires conducted by the Ministry of Science, Technology and Innovation (MOSTI). He found that publicly and privately traded firms in Malaysia were twice as likely to innovate than sole proprietorship firms. However, he also found that there is a negetive relationship between propensity to innovate and share of exports. Zainol, Nair and Kasipillai (2008), who studied the publicly listed firms in Malaysia with regards to R&D reporting practices, found that the consumer sector has a higher positively significant estimate compared to the industrial sector.

3.8 Chapter Summary

This chapter introduced the literature review and hypotheses development for this study. In addition to introducing literature on patenting activity that was measured based on a simple patent count, we focused on empirical literature that measured patenting activity based from within the patent system. The research questions presented in Chapter 1 have been expanded to hypotheses development following the profit maximization model and the review of literature in this chapter. Since this study focuses on Malaysia as one of the emerging economies, the patenting activity surrounding other emerging economies has also been introduced in this chapter. However, it is evident that little research to date has successfully explored patenting activity empirically in emerging economies. The following chapter on methodology will describe the data and methods for this study.

CHAPTER 4 DATA AND METHODS

4.0 Introduction

Patent data can sometimes be daunting, with further challenges added when these data are applied to emerging economies. Thus, one must overcome these challenges to match patent and financial data to answer the research questions empirically. The patent and financial data for this study were hand-collected, codified into soft copies and matched with each other. This took more than a year, since almost all primary data were in hard copies. The merging of patent and financial data of the Malaysian firms subsequently provided a base for empirical analysis.

This chapter describes the data and methods applied in our study. Section 4.1 starts with explaining the sample for this study. We then describe the variable selection for our study that is based on the literature review, hypotheses development, and the availability of data. Once these are determined, we present the descriptive statistics for the data of this study. Next, we present the analysis of competitive condition from the sample data selection. This is important as the study is based on the profit maximization model as discussed in Chapter 3. In this study, we applied the panel and dynamic panel model which is discussed in sections 4.2 and 4.3 respectively. Finally, Section 4.4 discusses the estimators that are employed in this study.

4.1 The Data

The sample of our study consists of Malaysian firms that were identified based on their being granted patents by the Intellectual Property Corporation of Malaysia (MyIPO) and the United States Patent and Trademark Office (USPTO). The patent data were obtained from the MyIPO office in Malaysia and the USPTO website, while the financial performance data were taken from the Companies Commission of Malaysia (CCM), respectively. During the preliminary data gathering, this study found that there were 95,124 patents applied for at MyIPO from 1986 to 2008 and that 37,161 were granted. Narrowing down the patent data further, of that figure only 7% were applied for by Malaysian residents and 3% were granted. During the pilot study data collection, we managed to segregate the patents applied for and granted to the Malaysian firms. From here it was found that only 1,214 patents had been applied for by Malaysian firms and from there, only 450 patents had been granted in the Malaysian territory and 156 patents in the U.S. territory, as shown in Figure 2.2 in Chapter 2.

The data provided by MyIPO are based on the name of the assignee. Concurring with the main research question in Chapter 1, this study is interested only in those Malaysian firms which have been granted patents. Therefore, we refined all the 37,161 granted patents based on the name of the assignee into Malaysian firms. A Malaysian firm is recognized on the basis that it is a privately limited and publicly listed firm in Malaysia. If a privately limited firm is incorporated in Malaysia, at the end of the firm's name the words *Sendirian Berhad* or the abbreviation *Sdn. Bhd.* are written, while the name of a publicly listed firm is followed by the words *Berhad* or abbreviation *Bhd.* For example, if the firm's name is Firm XYZ, when incorporated in Malaysia as privately limited, it is called Firm XYZ Sdn. Bhd. Thus, out of 37,161 patent applications based on name of assignee, individual names and organizations which did not end with *Sendirian Berhad, Sdn Bhd, Berhad* or *Bhd* (such as pty limited, pty ltd – foreign firms) were not taken into account.

From the refining of the data, 450 patents were found to have met the criteria mentioned above. With that, the granted patents were then again refined into the number of firms that had been granted the 450 patents. This is due to the fact that one firm can be granted several patents. From refining the granted patents data further into the number of firms, we found that there were 296 firms holding 793 patent applications, of which 450 were granted at MyIPO from 1986 to 2008. From a total of the 296 firms, only nine were found to be publicly listed firms, while another seven were publicly listed firms limited by shares. Since we also considered the patent territory in the U.S., it was found that there were 77 Malaysian firms with 156 granted patents at USPTO. With that, only 24 firms were totally new firms without any match to a firm that patents in Malaysia. Therefore, from refining the patent data taken from MyIPO and USPTO, the number of Malaysian firms which had been granted patents in these two territories totaled 320 firms. Table 4.1 shows the total number of firms gathered after the final data gathering.

Table 4.1: Total Number of Firms Gathered After the Final Data Gathering

	Patents Granted	Number of Firms	Subdivision of firms
MyIPO	450	296	9 publicly listed firms, 7 publicly listed firms limited by shares and 280 privately limited firms
USPTO	156	77	24 firms are totally new firms in which all of them are privately limited firms and the other 53 firms have also patented in MyIPO in which only 3 of them are publicly listed firms
Total number of firms gathered after the final data gathering			296 firms at MyIPO + 24 firms at USPTO = **320 firms**

Then we needed to match the firms' name with the financial statements gathered at CCM. However, there are procedures specified by CCM that must be undertaken before a firm's financial statements can be gathered. One is to submit the firm's registration number. Thus, in the next step we had to match the firm's name gathered at MyIPO and USPTO with the registration number gathered at CCM. In addition, the registration number can also be gathered at the Small Medium Industries Development Corporation of Malaysia (SMIDEC), now known as the Small Medium Enterprise Corporation of Malaysia (SME Corp Malaysia). Out of 320 firms, we found that 280 firms had registration codes that matched with the firms' names at MyIPO and USPTO.

The next challenge was the availability of data at CCM, as CCM discards old financial data. At the time of data collection, the financial statements available started in 1994. Thus, in this study, the time-series dimension starts in 1994 and ends in 2008. In addition to that, when matching the registration number at CCM for the 15 years time-series dimension with the patenting activity data from MyIPO and USPTO, some problems were found. Thus, the data needed to be cleaned before any analysis could be run. There were several reasons for data cleaning.

The first type of data cleaning involved firms that were extracted from the analysis. This was due to four factors. First, the financial statements were not available. According to the CCM officer, the financial statements could not be retrieved as some were not in the system, while some statements carried the disclaimer *Exempt Private*, whereby a firm was exempted from submitting its financial statement for those particular years. Second, there were only one or two years of financial statements available for the firm. Third, patent application/ granted dates were unmatched among data at MyIPO/ USPTO and CCM; and fourth, there were financial statements with no sales or zero sales, which may have been due to the firm being dormant.

The second type of data cleaning in which some observations in the firms were taken out was due to first, early years with no sales, which may have been due to firm start-up. Second, early years of sales with large jumps from the previous year to the next and third, end years of the sales with large jumps from the previous year to the next. The final type of data cleaning did not delete any firms or observations, but we added the missing financial data in the middle of the year. We applied the technique of extrapolating forward or backward data on the missing year to an adjacent year. However, this involved only 42 observations with 27 firms. Table 4.2 shows the total number of firms to be analyzed in this study.

Table 4.2: Total Number of Firms to be Analyzed

Explanation	**Number of Firms**
The number of firms found after the final data gathering at MyIPO and USPTO	320 firms
Matching patent data at MyIPO and USPTO with the registration code at CCM	280 matched firms
The first and second type of data cleaning involved extracting firms from the matched sample	77 firms extracted
Total number of firms to be analyzed	**203 firms**

4.1.1 Sample Selection

4.1.1.1 <u>All Firms with Granted Patents</u>

When taking all the above considerations into account in terms of data cleaning, the final count of firms that could be used in this study was 203 firms that had been granted patents in MyIPO and USPTO from 1994 to 2008, with 2225 observations. The panel data model was applied in this study and will be discussed further in Section 4.2.

4.1.1.2 Manufacturing Firms with Granted Patents

As discussed in Chapter 2, Malaysia is moving from being a primary product exporter to being an industrially oriented economy (Ghapar, 2009; Jomo & Felker, 1999), with the manufacturing sector having the highest percentages of Malaysia's gross export from the 1990's until 2008, the end of the study period (Malaysia, 2006, 2001, 1996). In addition, in Chapter 3, the manufacturing sector was seen as the most appropriate focus of patenting activity compared to other sectors (Jensen & Webster, 2006; Posner, 2005). Other studies have taken the manufacturing sector as their sample focus as well (Ornaghi, 2006; Blundell, et al., 1999) when studying patenting activity and financial performance.

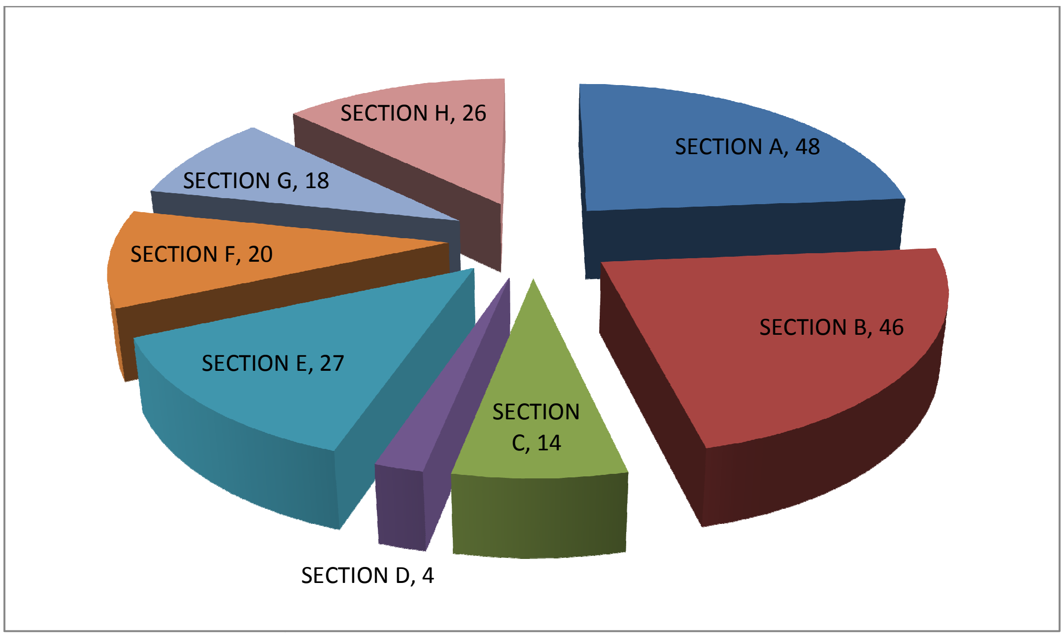
Thus, having obtained the final sample of the firms, we matched them with the industrial classification. First, using data from the Department of Statistics we tried to match these firms with the Malaysian Standard Industrial Classification (MSIC). Unfortunately, the MSIC code in the Department of Statistics is on a broader basis, which means that they do not have narrower matching data of the firm's name to the MSIC code. However, we were fortunate enough to have such matching data made available from the Malaysian Industrial Development Authority (MIDA) and SMIDEC database in order to identify the industrial classification of the manufacturing sector. Finally, for some firms which had no match with the MIDA or SMIDEC database, we successfully classified them through the firm's website. We found that there were 149 manufacturing firms in the sample size which accounted for 73% of all firms, and this is not a surprise. There were altogether 1694 observations for the 149 manufacturing firms from 1994 to 2008.

4.1.1.3 Patent Technology Field

In addition to segregating all the Malaysian firms which have been granted patents in the Malaysian and U.S. territories into the manufacturing industrial sector, we were also interested in examining the impact of the technology field on the firms' financial performance. Thus, with the data that we had, we rearranged all the firms based on the international patent classification (IPC). When segregating the firm into its technology field, we based this on the first single alphabetical classification of its patent. For example, H01S 3/083 is classified in Section H, that is, electricity; another example C10J 3/26 is classified in Section C, that is, chemistry/ metallurgy. Nevertheless, as mentioned before, a patent can have multiple classifications within the technology field (Griliches, 1990). In our study, we chose the majority number of classes in the patent specification to determine the classification of the technology field. This means that if there was a combination of two classes with only two fields, the first field classified in the patent specification was chosen. We found the following composition of technology classes based on the broad classification in the IPC, as shown in Figure 4.1.

Thus, to run the analysis with the patent renewal/ application and quality measure, we divided the technology field into two broad categories, that is, Section A to Section D and Section E to Section H. We then reclassified them as Human Necessities and Performing Operations, and Mechanical and Electronics, respectively. The former comprised 112 firms with 1178 observations, while the latter was made up of 91 firms with 1047 observations for the analysis.

Figure 4.1: Patent Technology Field Based on International Patent Classification (IPC)



Guide: Section A – Human Necessities; Section B – Performing Operations; Transporting; Section C – Chemistry; Metallurgy; Section D – Textiles; Paper; Section E – Fixed Constructions; Section F – Mechanical Engineering; Lighting; Heating; Weapons; Blasting; Section G – Physics; Section H – Electricity

4.1.2 Variable Selection

4.1.2.1 Financial Performance Variables

The financial performance variable was our dependent variable, with accounting-based performance used instead of market-based valuation. Since we based this variable on the profit maximization model, the differences between economic and accounting profits need to be highlighted. Economic profits take into account implicit costs, while accounting profits do not. Implicit costs involve opportunity costs to produce the products. Thus, economics profits are usually lesser than accounting profits as accounting profits minus only explicit costs. Even though in our study we based the argument on the theory of the firm that involves a profit maximization model, we measured our financial performance variable based on the accounting-based measure. This is due to the fact that the implicit cost could not be found in the financial statements. Furthermore, arguing with economics theory but empirically applying the financial or accounting data is tolerable in academic research (Glen, Lee, & Singh, 2001; D. C. Mueller, 1990; Lindenberg & Ross, 1981).

As discussed earlier, there were only nine firms which were publicly listed out of 320 firms. Therefore, the market capitalization data to measure the market value was unavailable for privately limited firms. Furthermore, as argued in Chapter 3, in studying Malaysia as an emerging economy that is still catching up with the financial markets, the assumptions of stock market efficiency to process information are quite demanding (Lim, 2008; Tuck, 2005; Bauman, 1989). Even though there is some criticism aimed at the accounting standards of emerging economies (Eng, Nabar, & Chng, 2005; Saudagaran & Diga, 2000), we believe that Malaysia has one of the best accounting practices among emerging economies, in that the accounting profession is regulated by the Malaysian Accounting Standard Boards (MASB) and enforced by the Companies Commission of Malaysia (CCM).

The financial performance variable which we used in this study is divided into three models - sales, profits and profit margin. They are transformed with a logarithmatic transformation and labeled LNSALES, LNPROFITS, and LNPM respectively. In the accounting system in Malaysia, sales or revenue is found in the income statement. The profits variable in this study is the loss/ profit before taxation, which is the second last item before the deduction of taxation to establish the net loss/ profit for the year.

Therefore, the earnings before taxes have deducted sales costs, selling expenses, administrative expenses, operating expenses, as well as finance costs. Finally, the profit margin is the ratio of earnings before taxes, or in this study, profit divided by the sales. All of the adopted accounting-based financial performance variables have been used in the literature as the dependent variable, as discussed in Chapter 3 (Griffith, et al., 2005; Rogers, 2002; Geroski, et al., 1997; Geroski, et al., 1993).

4.1.2.2 Patenting Activity Variables

Referring to the main research question in Chapter 1, throughout all the hypotheses development for this study, we have utilized patent data granted to Malaysian firms in the territories of both Malaysia and the U.S. To measure using patent renewal measures, we were required to have the yearly renewal data for the Malaysian patents and, at certain intervals, renewal data for the U.S. patents, as discussed in Chapter 2. However, as U.S. renewal data were unavailable to us, we had no choice but to assume that they renew, as for U.S. patents, until the 20-year term of maturity. On the other hand, MyIPO gave us extra information on the Malaysian patents during the pilot study data collection, specifically the renewal/ application *legal status* data of the patents for the final year in our time-series dimension, that is, 2008. Due to data limitation, we modified the renewal behavior model introduced by Schankerman and Pakes (1986), by combining the idea introduced by Putnam (1996), and Griffith, Jensen and Webster (2005). Besides the patent renewal measures, we also have the patent application measures as discussed in Chapter 3. Therefore, we segregated our patenting activity variable into four, that is, 1) patents applied for in Malaysia; 2) patents granted in Malaysia; 3) patents applied for in the U.S.; and 4) patents granted in the U.S. We labeled these variables as APPM, GRANM, APPS and GRANS, respectively. The measurement of the patent application and those which were granted follows the *pending* and *active lifespan*, respectively, of those patents over 365 days in one year; this will be discussed in detail in Chapter 5. From these variables, we were able to determine if, while the patents are pending to be granted, they have impacted the firms' financial performance. On the other hand, we also wanted to know when the patents are being granted and fees are being renewed, and whether or not they had impacted the firms' financial performance. The segregation between applications and granted patents are important, as we believe that there are differences between them, as hypothesized in Chapter 3.

To measure the patent quality, we selected only those variables that were available in the patent specification. Therefore, forward citation was not selected as the data were not written in the patent specification. In addition, MyIPO did not keep such information and it was not revealed on the USPTO website. Thus, only the patent backward citation, claim and family were selected as a proxy for patent quality. The Malaysian patent backward citations and claims were then labeled as MBWC and MCL; while the U.S. patent backward citations and claims were labeled SBWC and SCL. These variables were measured according to the ratio of the said variables to the patent stocks. Patent family on the other hand was labeled as FAM, and measured using a dummy variable. These measurements are discussed in detail in Chapter 6.

4.1.2.3 Control Variables

The control variables are the firm characteristics, fixed effects and time effects. As discussed in the literature review, the firm characteristics which are normally controlled for are firm size and age. In this study, the size was based on the tangible assets of the firm. It was transformed with a logarithmatic transformation and labeled as LNTGA. Since we had the date that the firm was incorporated, the variable that represented the firm's age would be its age since incorporation until the availability of the financial statements. We labeled the age as NAGE. As mentioned earlier, the firm's fixed effects and time effects were included as a control variable. This will be discussed further in Section 4.4.

4.1.3 Descriptive Statistics

Table 4.3 shows the descriptive statistics for the financial and control variables, while tables 4.4 and 4.5 show the patenting activity variables based on the patent renewal/ application measures and quality measures, respectively. These three tables report both the sample statistics for all firms, as well as the manufacturing firms in this study. The observations for each variable are the individual sample, instead of the common sample. As discussed previously, the total observations for all firms in this study were 2225, which also showed in the sales, tangible assets and age variable. However, for profit and profit margin, the dataset ended up with only 1689 observations. This is due to the log transformation of the figures, in which we were unable to apply logarithmatic transformation to a negative number or loss in the firms. This situation also applied to the manufacturing firm, whereby a lower number of observations were available for profits and the profit margin compared to the other financial variables. Even though the data showed that the mean exceeded the median for all financial variables, they are not very far apart.

On the other hand, the situation differs for almost all of the patenting activity variables shown in tables 4.5 and 4.6. They could be considered skewed, but this is not surprising as patenting activity variables are well known to be typically highly skewed. We believe that this problem is not extreme, however, as we alleviated the problem by applying renewal/ application measures and value-weighted patent counts of the quality measures. The patenting activity variables based on the patent renewal/ application measures in Table 4.4 are not as extreme when compared to the quality based measures in Table 4.5. Comparing this with the manufacturing firms, all patenting variables had almost the same magnitude of skewness except for backward citations in the U.S. patent specification, which was smaller. The highest degree of skewness can be seen in the number of claims in both territories and samples.

Tables 4.6 and 4.7 show the descriptive statistics for sample firms segregated by the field of technology. Similar to Table 4.3, the number of observations went down for the profits and profit margin compared to the sales variable for both technology fields, that is, between 20% and 25%. The patenting activity variables are all skewed, with the number of claims for both fields in both territories having the most extreme value as shown in tables 4.6 and 4.7, which is similar to the results reported in Table 4.5.

Table 4.3: Descriptive Statistics – Financial Performance and Control Variables

Label	Description	All Firms						Manufacturing Firms					
		Mean	Med.	Max.	Min.	Std. Dev.	Obs.	Mean	Med.	Max.	Min.	Std. Dev.	Obs.
LNSALES	Log transform of firm's sales	16.37	16.19	26.13	7.80	2.73	2225	16.67	16.50	23.59	8.01	2.38	1694
LNPROFITS	Log transform of firm's profits	14.13	13.98	25.28	4.47	2.92	1689	14.21	14.20	21.88	4.47	2.65	1329
LNPM	Log transform of firm's profit margin	-2.77	-2.65	6.06	-9.03	1.26	1689	-2.84	-2.67	2.33	-9.03	1.20	1329
LNTGA	Log transform of firm's tangible assets	16.50	16.26	26.50	6.61	2.56	2225	16.70	16.54	22.92	9.72	2.23	1694
NAGE	Number of firm's age since incorporation	20.69	19.00	50.00	3.00	8.42	2225	21.77	20.00	50.00	3.00	8.55	1694

Table 4.4: Descriptive Statistics – Patenting Activity Variables Based on Patent Renewal/ Application Measures

Label	Description	All Firms						Manufacturing Firms					
		Mean	Med.	Max.	Min.	Std. Dev.	Obs.	Mean	Med.	Max.	Min.	Std. Dev.	Obs.
APPM	Number of pending Malaysian patents application by fraction in 365 days	1.16	0.84	52.44	0.00	2.99	2225	1.06	0.61	41.19	0.00	2.54	1694
GRANM	Number of active lifespan Malaysian patents granted by fraction in 365 days	0.36	0.00	16.32	0.00	0.80	2225	0.37	0.00	16.32	0.00	0.83	1694
APPS	Number of pending U.S. patents application by fraction in 365 days	0.16	0.00	17.35	0.00	0.98	2225	0.16	0.00	17.35	0.00	1.05	1694
GRANS	Number of active lifespan U.S. patents application by fraction in 365 days	0.19	0.00	13.04	0.00	0.76	2225	0.16	0.00	13.04	0.00	0.67	1694

Table 4.5: Descriptive Statistics – Patenting Activity Variables Based on Patent Quality Measures

Label	Description	All Firms						Manufacturing Firms					
		Mean	Med.	Max.	Min.	Std. Dev.	Obs.	Mean	Med.	Max.	Min.	Std. Dev.	Obs.
MBWC	Ratio of number of backward citations to number of patent stocks in Malaysian patent	2.71	2.00	47.00	0.00	4.41	2225	2.53	2.00	38.00	0.00	3.84	1694
SBWC	Ratio of number of backward citations to number of patent stocks in U.S. patent	4.06	0.00	249.0	0.00	17.56	2225	2.85	0.00	96.00	0.00	9.89	1694
MCL	Ratio of number of claims to number of patent stocks in Malaysian patent	10.38	5.00	176.0	0.00	17.80	2225	9.33	4.00	176.0	0.00	16.77	1694
SCL	Ratio of number of claims to number of patent stocks in U.S. patent	4.64	0.00	223.0	0.00	20.85	2225	3.14	0.00	202.0	0.00	13.66	1694
FAM	Dummy variable of having a family and not having a family	0.02	0.00	1.00	0.00	0.14	2225	0.02	0.00	1.00	0.00	0.14	1694

Table 4.6: Descriptive Statistics Based on Human Necessities and Performing Operations Technology Field

Label	Mean	Med.	Max.	Min.	Std. Dev.	Obs.
LNSALES	16.12	16.08	23.06	7.80	2.45	1178
LNPROFITS	13.85	13.86	21.88	4.47	2.54	893
LNPM	-2.83	-2.73	2.33	-8.64	1.20	893
APPM	0.91	0.42	37.58	0.00	1.81	1178
GRANM	0.35	0.00	5.60	0.00	0.66	1178
APPS	0.08	0.00	8.93	0.00	0.53	1178
GRANS	0.11	0.00	8.18	0.00	0.55	1178
MBWC	2.21	1.00	19.00	0.00	2.71	1178
SBWC	2.37	0.00	136.00	0.00	10.67	1178
MCL	7.86	4.00	134.00	0.00	12.43	1178
SCL	3.27	0.00	223.00	0.00	18.10	1178
FAM	0.01	0.00	1.00	0.00	0.09	1178
LNTGA	16.20	16.20	22.92	6.61	2.21	1178
NAGE	20.51	19.00	49.00	4.00	8.48	1178

Table 4.7: Descriptive Statistics Based on Mechanicals and Electronics Technology Field

Label	Mean	Med.	Max.	Min.	Std. Dev.	Obs.
LNSALES	16.66	16.36	26.13	8.59	2.98	1047
LNPROFITS	14.44	14.13	25.28	6.91	3.26	796
LNPM	-2.70	-2.54	6.06	-9.03	1.33	796
APPM	1.45	1.00	52.44	0.00	3.89	1047
GRANM	0.38	0.00	16.32	0.00	0.93	1047
APPS	0.26	0.00	17.35	0.00	1.30	1047
GRANS	0.27	0.00	13.04	0.00	0.93	1047
MBWC	3.27	2.00	47.00	0.00	5.71	1047
SBWC	5.96	0.00	249.00	0.00	22.82	1047
MCL	13.21	6.00	176.00	0.00	22.01	1047
SCL	6.17	0.00	202.00	0.00	23.48	1047
FAM	0.03	0.00	1.00	0.00	0.18	1047
LNTGA	16.83	16.31	26.50	9.12	2.87	1047
NAGE	20.89	19.00	50.00	3.00	8.36	1047

4.1.4 Analysis of Competitive Condition

In Chapter 3, we learned that the market condition is another important element in the profit maximization model. Thus, the sample selection in Section 4.1.1 was tested to examine the market condition of firms. The competitive condition in a market can be tested using the profit persistence measure. It is based on the assumption that all firms will experience profit shocks and the degree of competition from other firms determines how long these shocks will persist (D. C. Mueller, 1990). The profit persistence measure is measured using firm level data and can be applied to analyze the competitive condition in industrial groups (Rogers, 2002; Waring, 1996), sectoral based (Greenhalgh & Rogers, 2006), or even at a country level (Glen, et al., 2001). The profit persistence was measured using Equation (4.1):

$$\pi_{it} = \alpha_i + \beta\pi_{i,t-1} + \varepsilon_{it} \qquad (4.1)$$

where π_{it} is firm *i*'s profit margin in year *t*, α_i is the firm's fixed effects, β is the firm's profit shock and ε_{it} is the standard error term. The given formula says as β nears 0 it suggests a competitive environment and if $\beta>0$ the competitive condition is less strong. According to Greenhalgh and Rogers (2006), the advantage of profit persistence measure is that the β-coefficient should cover all aspects of competition such as from rivals within the same industry, overseas firms or even threats from new firm entry.

Thus, in our study, we ran Equation (4.1) with all of our sample data selection that was divided into all firms; manufacturing firms; firms with patents in the human necessities and performing operations technology field; and firms with patents in the mechanical and electronics technology field. The equation was run with a panel model from 1994 to 2008. When the equation involves a dynamic panel model, Nickell (1981) suggests that there is a need to correct for the asymptotic (downward) bias. Therefore, we ran Equation (4.1) with Generalized Method of Moments (GMM), as the GMM procedures produce substantial efficiency gains (Judson & Owen, 1999; Arellano & Bond, 1991). The result in Table 4.8 is arranged from high to low profit persistence, which means from low to high competitive condition.

Table 4.8: Analysis of Competitive Condition

	All firms sample	Mechanical and electronics	Manufacturing firms	Human necessities and performing operations
Profit persistence (β-coefficient)	0.34***	0.33***	0.25***	0.15***

*** Significant at 1% level

Table 4.8 shows that firms in the human necessities and performing operations technology field had the highest competitive condition compared to other firms. Even though we learned in the preceding Section 4.1.1 that the manufacturing firms sample accounted for 73% from the all firms sample, the competitive condition was not similar. The result shows that the manufacturing firms were more competitive when compared to all Malaysian firms that had undertaken patenting activity in Malaysia and the U.S.

4.2 Panel Data Model

We employed the panel data model with a time-series dimension for 15 years from 1994 to 2008, and a cross-section dimension for the 203 firms. With those dimensions, the number of observation for this study with a balanced panel would have been 3045, that is, 15 years x 203 firms. However, not all 203 firms had a complete 15 years of financial statements from 1994 to 2008. Some started operations after the year 2000, and some firms stopped operation early. The least number of firm years that has been included in this study is 3 years; however, that involves only 2 firms. Given this, the study had to employ unbalanced panel data (Woolridge, 2006), instead of the balanced panel. Thus, when the data was arranged with the EViews software version 7, the total number of observations for this study turned out to be 2225 observations. Since our sample was also segregated into manufacturing firms only, the total number of firms involved was 149 firms for 15 years, with a total of 1694 observations.

The basic regression model for panel data is shown in Equation (4.2):

$$Y_{it} = \alpha + \beta X_{it} + u_{it} \qquad (4.2)$$

where *i* denotes cross-sections and *t* denotes time-periods with *i* = 1, 2, …. N, and *t* = 1, 2, …., T. α and β are the parameters and the explanatory variables are *X*. Under the error components specification, the disturbance term takes the form of:

$$u_{it} = \mu_i + \nu_{it} \qquad (4.3)$$

where μ_i are the cross-section specific components and ν_{it} are the remainder effects. μ_i can be the managerial expertise in the firm, for example, and these effects are regarded as time-invariant (Baltagi, 2008).

However, there are some econometrics issues that need to be addressed with the panel data model discussed in Equation (4.2). Since the financial performance follows the accounting-based performance, the lagged term must also be taken into account. There are two types of models that relate to lags, that is, the distributed lag model and the autoregressive model. The former includes lag terms of the explanatory variables, while the latter includes lagged terms of the dependent variable, which is also known as the dynamic panel model.

4.3 Dynamic Panel Data Model

In this study, the autoregressive model was taken into consideration. Most of the previous literature has used market value (Bosworth & Rogers, 2001; Rogers, 2002) instead of accounting-based financial performance, in which the former has already taken into consideration the projection of future profits, based on the existing profits. Nevertheless, by using market value as the dependent variable, Griliches (1981) successfully used the autoregressive specification in one of his models. Even though he commented that it raised a statistical problem of potential endogeneity, it is a relatively minor issue as his time-series dimension is not too small; specifically he had 7 years of data.

Furthermore, previous literature (Griffith, et al., 2005; Coombs & Bierly, 2006) that has studied accounting-based financial performance with regards to patenting activity has not taken into consideration the autoregressive specification, except for one study by Geroski, Machin, and Walters (1997), which was discussed in Chapter 3. These authors argue that the dynamic panel model is needed in their study, as their accounting-based measure, that is, the current period of corporate growth rates, also depend on past growth rates. Since we applied the accounting-based measure as our dependent variable, the dynamic panel model was also taken into consideration in our study. Therefore, the basic econometric Equation (4.4) as for the autoregressive model is:

$$y_{it} = \delta y_{i,t-1} + x_{it}\beta + \mu_i + \nu_{it} \quad (4.4)$$

where $y_{i,t-1}$ is the past value of the dependent variable, δ is the parameter for the past value of $y_{i,t-1}$, β is the coefficient for the explanatory variable x_{it}. μ_i is the cross-section specific error component, while the ν_{it}'s are the error terms following the classical assumptions, namely, $E(u_{it}) \sim N(0, \sigma^2)$.

4.4 Model Estimation

4.4.1 Panel Least Square

In the panel data model, several specifications of model could be used such as the pooled model, the fixed effects model, and the random effects model. With the pooling model, the basic idea is that all firms will have the same characteristics. This is also known as the pooling assumptions, whereby the modeling is undertaken by pooling all individual observations together into one dataset and imposing a common set of parameters among them (Asteriou & Hall, 2007). This is known as the ordinary least squares (OLS). Since our study used the panel data model, we estimated the least-squares with a panel model known as panel least squares (PLS). This is different from OLS in the sense that we arranged our data by stacking each cross section on top of another in each row, rather than treating it as a separate series for each variable for each cross section. With that, we only have a single series for each variable. As mentioned before, this study used EViews Version 7, which recognized this as panel data, to conduct the analysis. Furthermore, EViews automatically recognized that our data was an unbalanced panel, as discussed in Section 4.2. Thus this was the first step of our estimation, without adding any effects specification.

4.4.2 Fixed Effects Model / Random Effects Model

The main difference between fixed effects and random effects is the treatment of the μ_i cross-section specific error component. The fixed effects model examines if the intercepts vary across groups or time periods, and allows the μ_i cross-section specific error component to be correlated with the explanatory variables (Gujarati, 2003). For example, this study did not taken into account management style as one of the explanatory variables in its model specification. Therefore, management style in the firm was included in the cross-section specific error component in the model specification. With that, the management style could lead to higher and more quality patenting activity in the firm. Given this, it is permissible that they be correlated with the explanatory variables in the fixed effects model.

Besides the treatment of the μ_i cross-section specific error component, the difference between fixed and random effects lies in the role of dummies (Park, 2008). If dummies are considered as part of the intercept, it is known as a fixed effects model. Therefore the basic econometric equation for fixed effects is shown in Equation (4.5):

$$y_{it} = \alpha + X_{it}\beta + \sum_{i=1}^{N} \mu_i D_i + \nu_{it} \quad (4.5)$$

where i denotes cross-section and t denotes time-periods with i = 1, 2, …. N, and t = 1, 2, …., T. α is the scalar, and β is the coefficient for the explanatory variable *X*. D_i is a dummy variable for the i-th firm. Not all dummies are included so as not to create the dummy variable trap, whereby one is dropped or by imposing restriction on the μ's given by $\sum_{i=1}^{N} \mu_i = 0$. The ν_{it}'s are the error terms that follow the classical assumptions, namely, $E(u_{it}) \sim N(0, \sigma^2)$. However, with EViews, we could include the cross-section effect specification without having to arrange separate cross-section dummies into our dataset.

On the other hand, dummies can also be used for the time effect. This allows the function of sales and profits to shift over time as shown in previous literature. The time effect is important in the sense that external factors such as adjustment in government regulation and policies, wars, political conflicts or even technology changes over time can be captured (Gujarati, 2003). Therefore, besides taking the internal factors of the firm being heterogeneous into consideration, the external factors were also taken into consideration. Accordingly, there are 15-year dummies in this study. As mentioned before, with EViews, we were able to include the period effect specification without having to arrange separate time dummies into our dataset. Thus, when dummies are used both in the firm's characteristics and time effect, this is known as the *two-way fixed model* (Park, 2008).

The random effects model, in contrast, explores differences in the error variances. The μ_i cross-section specific error component and explanatory variable are assumed not to be correlated with each other (Gujarati, 2003). Thus, besides running the estimation with fixed effects, our analysis was conducted with random effects. In our sample the N is larger than the T, and we did not know if the assumption of the μ_i and explanatory variable not being correlated with each other would hold, so we needed to decide which model would be the best. Since our data was an unbalanced panel, Baltagi (2008) has recommended using the Amemiya (1971) procedure (which in EViews is named Wansbeek and Kapteyn (1989)) to run the random effects model. To decide which was the best model, the Hausman (1978) test was conducted in this study. Nevertheless, with the random effect model, the two-way random effects are not allowed with an unbalanced panel, unlike fixed effects. Thus, we included the cross-section and period effect specification separately into our specifications with the random effects model.

4.4.3 Generalized Method of Moments

Besides the PLS, FEM and REM, we were also interested in examining the dynamic relationship of the model specification. Thus, these dynamic relationships are characterized by the presence of a lagged dependent variable among the explanatory variables (Baltagi, 2008), as shown in Equation (4.4). According to Nickell (1981), the dynamic models with OLS or fixed effects estimator bring bias and inconsistent results. Therefore, the estimation for the autoregressive model for this study followed the Generalized Method of Moments (GMM), as the GMM procedures produce substantial efficiency gains (Judson & Owen, 1999; Arellano & Bond, 1991). GMM procedures removed the individual effect by differencing Equation (4.4) to obtain Equation (4.6).

$$(y_{it} - y_{i,t-1}) = \gamma\,(y_{i,t-1} - y_{i,t-2}) + (x_{it} - x_{i,t-1})'\beta + (\nu_{it} - \nu_{i,t-1}) \qquad (4.6)$$

However, in the differenced equation, the error $(\nu_{it} - \nu_{i,t-1})$ was then correlated with the lagged dependent variable as the explanatory variable of $(y_{i,t-1} - y_{i,t-2})$, and with that a new estimator was introduced to obtain the consistent estimation result, known as instrumental-variables (IV). In theory, the GMM method requires that the parameters satisfy the orthogonality conditions, which means that the sample correlations between the explanatory variables and the IV are as close to zero as possible. Thus, the orthogonality conditions allow for efficient estimation in the presence of heteroskedasticity of unknown form. In GMM procedures, IV uses all available lagged values of the dependent variables plus the lagged values of the exogenous regressors (Judson & Owen, 1999). As long as the error terms are not serially correlated with the instruments, they can be considered as healthy instruments. Therefore, a Sargan test was performed to test the overidentification restrictions (Baltagi, 2008).

There are many approaches to GMM estimation, but in this study we focused on only two basic approaches, specifically Arellano and Bond (1991), and Arellano and Bover (1995). They differ in terms of the how the individual effects are modeled. A transformation is applied to the specification of a dynamic panel model to remove the cross-section fixed effects. Arellano and Bond (1991) use differencing, while Arellano and Bover (1995) use orthogonal deviations. The former assumes that the original disturbances in Equation (4.1) and (4.2) are serially uncorrelated and that the differenced error is MA(1) with unit root, while the latter is better at modeling non-stationary data.

4.5 Chapter Summary

This chapter discussed the data and methods used in this study. The data was hand-collected from several organizations in Malaysia, while the only data from the U.S. was gathered through the USPTO website. From there, the samples for this study were selected and the variables then determined. This study used panel data models and considered three different estimators. The subsequent chapters provide the results of testing the hypotheses developed in Chapter 3 using the modeling outlined in this chapter. Chapters 5, 6 and 7 discuss the results based on the impact of patent renewal/ application stocks, patent quality, and patent technology fields, respectively, on the Malaysian firms' financial performance.

CHAPTER 5 PATENT RENEWAL/ APPLICATION STOCKS AND FINANCIAL PERFORMANCE

5.0 Introduction

This chapter answers the first subsidiary research question in Chapter 1 as to the relationship between the patent application/ granted stocks and financial performance at the Malaysian firm level. Therefore, it will answer Hypothesis 1 developed in Chapter 3 relating to the patent renewal and application measures. Section 5.1 introduces the model specification and measurement of the variables. Section 5.2 tests if we have violated the regression assumptions and measures taken to overcome any violations. This is to make sure that our results are robust, unbiased and consistent. Sections 5.3 and 5.4 describe the results for the panel and dynamic panel data model, respectively. The panel model is estimated with panel least squares (PLS), fixed effects model (FEM), and random effects model (REM), while the dynamic panel is estimated with generalized method of moments (GMM). The results are reported separately for the two samples in our study, 1) all firms; and 2) manufacturing firms which have been granted patents. Finally, Section 5.5 summarizes our results based on the types of estimations and hypotheses development. The former focuses on the estimations with statistically significant variables and the magnitude of the variables in the two samples of our study. The latter ties up the results, focusing on comparing the estimated sign with the expected sign developed in the hypotheses development.

5.1 Model Specification

From the literature review and hypotheses development, we employ three different models, each representing different dependent variables. Models 1, 2 and 3 take the firm's sales, profits, and profit margin as the dependent variable.

Model 1: Y_{it} = Firm *i* sales at time *t* $t = 1, 2, 3, \ldots, T$

Model 2: Y_{it} = Firm *i* profits at time *t* $t = 1, 2, 3, \ldots, T$

Model 3: Y_{it} = Firm *i* profit margin at time *t* $t = 1, 2, 3, \ldots, T$

The basic econometric model is established in Equation (5.1), which corresponds to Hypothesis 1 developed in Chapter 3.

$$Y_{it} = c_0 + \beta_1 APPM_{it} + \beta_2 GRANM_{it} + \beta_3 APPS_{it} + \beta_4 GRANS_{it} + \delta_1 LNTGA_{it} + \delta_2 NAGE_{it} + \mu_{it} \tag{5.1}$$

where c_0 is the constant; APPM and GRANM is the number of patent application and granted stocks in the Malaysian territory; APPS and GRANS is the number of patent application and granted stocks in the U.S. territory; LNTGA is the tangible assets of the firm which has been log transformed; and, finally, NAGE is the firm's age since incorporation. The measurement of these variables will be discussed next. i = 1,2,3,…. N specific firms over t = 1,2,3,…..T time periods with $\mu_{it} = u_i + v_{it}$ where u's describe the firm-specific time invariant effect, and v's are the idiosyncratic error terms. The idiosyncratic error terms will be assumed to come from normal distributions, independent of each other. As discussed in Chapter 4, since we employed both the fixed and random effects estimation in our study, the u_i is treated differently between the two estimations. The fixed effects model allows the u_i cross-section specific error component to be correlated to the explanatory variables, while the random effects model assumes the μ_i not be correlated with each other (Gujarati, 2003).

5.1.1 Measurement of Variables

The dependent variable is a continuous variable. The figures were taken from the sales and profits out of the financial statements at CCM. All the financial data has been log transformed to overcome the violations to the equal variance assumptions. This includes one of the control variables which is LNTGA, representing the firm size measured using the firm's tangible assets taken from the firm's financial statements. NAGE is another control variable and represents the firms age measured using the number of years since incorporation until the availability of financial data for the analysis. This means that if the firm was incorporated in 1990 and the availability of the firm's financial data was until 2008, the NAGE would be 19 years.

The explanatory variables are the APPM, GRANM, APPS and GRANS. APPM and APPS are the number of patent application stocks based on the patent application measure in the Malaysian and U.S. territory respectively, which are still pending to be granted, while GRANM and GRANS are the number of patent granted stocks which have active life spans. The measurement of the explanatory variables is based on the number of patent stocks by fraction of 365 days. For example, if a patent has been applied for on 24 July1999, the stock of the application for 1999 is 161 days / 365 days, equivalent to 0.44 years of application stock. Thus, for the following years, the number of that particular patent pending to be granted is 1, which is 365 days/ 365 days, until it is granted. Once the patent is granted, let's say on 14 May 2003, its application stock for that year would be 133 days / 365 days, equivalent to 0.36 years of application stock or APPM. This means that after this date (14 May 2003), the number of patent application stock of this firm is zero, which basically means it is no longer pending to be granted. Nevertheless, the GRANM now will start to be calculated from this date (14 May 2003) until 31 Dec 2008, similarly based on the number of granted stocks by fraction of 365 days. Since our study applies the panel dataset, which also includes the time-series dimension as well as the cross-sectional dimension, the measurement of the patent stocks will be very detailed. This is because a firm can apply for more than one patent in our time-series dimension of 15 years. Thus, the measurement of the data is calculated using an Excel spreadsheet, before being transferred to EViews version 7 for analysis.

As mentioned in Chapter 4, since the yearly renewal fee payment from the patents were not available to us from MyIPO, we replaced this with other information on the latest year of renewal legal status in our final year of the time-series dimension, that is, 2008. We segregated the legal status into three, in which the first two are granted patents and the third is the application alone. Firstly, the legal status for granted patents is called *granted and published*, which means that the patent is active and renewed until 2008. Secondly, the granted patents are non-active and can have the following legal status that is, *to renew; expired; lapsed and published; definitely lapsed and protection ended*. Thirdly, before a patent is granted, there are eight types of legal status, that is: *deemed refused, adverse full subs exam, deemed withdrawn, refusal after full exam, full/modified exam to do, clear preliminary exam, withdrawn* and finally *refused*. As mentioned before, the third set of the legal status was also important to us, as our patent application variable includes patent application pending to be granted.

From the explanation in the previous paragraph, differences in the measurement relate to when the patent will be granted (patent pending), and when the renewal fees are paid (active lifespan). Therefore, the active patents were calculated until the end of year

2008; while the non-active patents were assumed to be active until a period of 5 years had elapsed from the granted date. The five year period of patent renewals has back-up from the literature (Schankerman & Pakes, 1986; Schmookler, 1966), in that most patents were active within the 5 year period. However, for the legal status of *protection ended* in the non-active patent category, the renewal of the patent was calculated for 20 years from the granted date. This has already been discussed in Chapter 2, where the maximum protection in the patent system is shown to be 20 years of patent protection. As for patents in the U.S. territory, since no renewal data can be found from the website, we assumed that the patent is renewed until 2008.

Earlier in Chapter 1, we mentioned that we were only interested in analyzing Malaysian firms which had been granted patents in Malaysia and the U.S. We successfully identified those firms, as discussed in Chapter 4. However, we must not forget that these firms also had patents that were pending to be granted. Thus, for the patents that had not yet been granted patent, the measurement of pending patent was calculated until the end of the time-series dimension, that is, 2008, except for the *withdrawn* legal status. According to the Assistant Registrar of Patent at MyIPO, the pending legal status could be considered patent pending except for the legal status of *withdrawn*. Normally, in Malaysia, once it is withdrawn, there is no more follow up that needs to be done. Thus, the legal status of *withdrawn* was calculated as patent application stock for only 2 years. Similar to the Malaysian territory assumptions, the pending patent in the U.S. territory was also measured until 2008.

5.2 Relaxing the Assumptions

It was important to meet certain regression assumptions to make sure that the results were robust, unbiased and consistent. Therefore, we explored whether some regression assumptions had been violated.

5.2.1 Multicollinearity

As a preliminary step, the correlation matrix was calculated. Multicollinearity is designed to identify the existence of a perfect or exact linear relationship among some or all of the explanatory variables in a regression model (Gujarati, 2003). From here, the correlation matrix in tables 5.1 and 5.2 are presented to diagnose the multicollinearity problem for the two samples in our study, all firms and manufacturing firms. Both tables show there is no perfect, exact or serious multicollinearity problem that exists among the explanatory variables.

5.2.2 Autocorrelation

Autocorrelation violates the assumptions of the error terms being independently distributed with each other (Gujarati, 2003). The presence of serial correlation can be tested using many tests, but the most frequently used is the Durbin-Watson (DW) test. To use the DW test, certain assumptions must be met: 1) the regression includes a constant; 2) serial correlation is assumed to be first-order only; and 3) the equation does not include a lagged dependent variable as one of the explanatory variables (Asteriou & Hall, 2007). Since our panel model also includes the autoregressive model, we therefore applied the DW test only for the non-autoregressive model. We found that our panel model suffers from autocorrelation. We therefore corrected the first-order serial correlation with autoregressive errors of order 1 – AR(1). As for the dynamic panel model, we did not have to worry about the autocorrelation, since we used the generalized method of moments (GMM) estimation in which the autocorrelation problems had been taken care of in the estimation. This situation has indirectly been mentioned in Chapter 4, that is, in our study we applied two types of cross section transformation, specifically Arellano and Bond (1991) and Arellano and Bover (1995), in which the former differenced error is MA(1) with a unit root, while the latter is better at modeling non-stationary data.

Table 5.1: Correlation Matrix – All Firms

	LNSALES	LNPROFITS	LNPM	APPM	GRANM	APPS	GRANS	LNTGA	NAGE
LNSALES	1								
LNPROFITS	0.901357	1							
LNPM	0.007449	0.439779	1						
APPM	0.255349	0.22003	-0.02149	1					
GRANM	0.10236	0.07832	-0.03143	0.366274	1				
APPS	0.195348	0.179356	0.009024	0.134377	0.085961	1			
GRANS	0.216196	0.168699	-0.05882	0.084399	0.062973	0.295901	1		
LNTGA	0.935174	0.907508	0.156087	0.257948	0.115208	0.183804	0.213895	1	
NAGE	0.266472	0.260124	0.04802	0.003155	0.126697	0.056097	0.039878	0.278645	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; APPM, GRANM, APPS and GRANS are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age.

Table 5.2: Correlation Matrix – Manufacturing Firms

	LNSALES	LNPROFITS	LNPM	APPM	GRANM	APPS	GRANS	LNTGA	NAGE
LNSALES	1								
LNPROFITS	0.89135	1							
LNPM	0.068096	0.512961	1						
APPM	0.246718	0.165319	-0.10335	1					
GRANM	0.093269	0.061175	-0.04198	0.413089	1				
APPS	0.230432	0.201946	0.0081	0.184663	0.127919	1			
GRANS	0.276657	0.204648	-0.07349	0.056322	0.005986	0.317551	1		
LNTGA	0.928987	0.889883	0.19934	0.223326	0.111022	0.222996	0.277281	1	
NAGE	0.211725	0.218275	0.079461	-0.00014	0.141634	0.022032	0.006268	0.228841	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; APPM, GRANM, APPS and GRANS are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age.

5.2.3 Heteroskedasticity

Heteroskedasticity violates the assumptions of equal variances of the disturbance term (Gujarati, 2003). There are many tests available to detect if heteroskedasticity exists, such as the Breusch-Pagan, Glesjer, Harvey-Godfrey and White tests. Our data is a panel model; hence all the mentioned tests were not available in EViews. We suspected, however, that there might have been a heteroskedasticity problem. To correct the problem in a panel model, the correction can be carried out by giving a heteroskedasticity consistence covariance of which there are many types, including seemingly unrelated regression (SUR) and panel corrected standard error (PCSE). Nevertheless, we chose the White Cross-Section coefficient covariance method to correct for heteroskedasticity in our panel model, and White Period correction in our dynamic panel model. This is because the White's coefficient covariance method gave us the majority of statistically significant explanatory variables compared to the SUR and PCSE approaches.

5.2.4 Misspecification

Misspecification would be one of the most important problems in any empirical study. The model specification can be conceptualized following the theory, but in reality when the fieldwork is undertaken, some data simply do not exist. This leads to consequences of omitting influential variables; including non-influential variables; omission and inclusion of relevant and irrelevant variables at the same time; using incorrect functional forms; and measurement errors (Asteriou & Hall, 2007). In terms of our study this is not a surprise, as most empirical studies discussed in Chapter 3 were from the advanced economies. When empirically analyzing the Malaysian context, some common variables found in the literature were replaced to fit the geographical context. The central modification involved the accounting-based measure, which was used instead of the market-based measure or the value of the patent itself to proxy as the financial performance at the firm level. The reason has been discussed carefully in Chapter 3. Another modification relating to this Chapter is that as the firm's yearly renewal fees of the granted patents were not available to us, this was replaced with the renewal legal status at the end of our time dimension. This situation has also been described carefully in Section 5.1.1.

Despite these challenges, we have specified our model to answer the research questions through hypotheses development given data availability. The test for a general model misspecification involves the Regressions Specification and Error Test (RESET) and normality of the residuals. This can be done through the Ramsey (1969) test and Jarque-Bera (1980) statistic, respectively. The former involves various powers on $\hat{Y}$, which is the predicted value of Y to be included as one of the regressors to capture possible non-linear relationships. In this study, we inserted $\hat{Y}^2$ as an additional regressor to Equation (5.1) to obtain Equation (5.2). Equation (5.1) and (5.2) is also known as the restricted and unrestricted model, respectively.

$$Y_{it} = c_0 + \beta_1 APPM_{it} + \beta_2 GRANM_{it} + \beta_3 APPS_{it} + \beta_4 GRANS_{it} + \delta_1 LNTGA_{it} + \delta_2 NAGE_{it} + \varphi \hat{Y}_{it}^2 + \mu_{it} \quad (5.2)$$

Since our data is an unbalanced panel, we had to calculate the F statistic manually because EViews version 7 has no ability to automatically construct this variable. We then calculated the F statistic for these two models, and compared it to the F-critical value found in the *F* tables. If the F statistic is less than the F-critical value, we fail to reject the null of no misspecification. Table 5.3 shows the result of the RESET test. In the all firms sample, only model 1 with the PLS and REM estimations show the model is not misspecified. In the manufacturing firms sample, however, model 1 is shown not to be misspecified with the FEM estimation. The result is quite interesting as it shows that model 1 is not misspecified when the internal factors (μ_i unobservable individual effect) and external factors (λ_t unobservable time effect) in the all firms sample are not correlated with the explanatory variables, unlike in the manufacturing firms sample, in which both the cross-section and period effects are permitted to be correlated with the explanatory variables. Nevertheless, models 2 and 3 with profits and profit margin as the dependent variable, show that the model is misspecified with all three types of estimation, the PLS, FEM and REM. The downside of the RESET test is, if the model is misspecified, it does not provide us with alternative models which are correct (Asteriou & Hall, 2007).

Further, we found the Jarque-Bera (1980) normality residual test was not met in all of our specifications. Nevertheless, since our observations were large, we followed the central limit theorem (CLT) assumptions. The CLT shows that if there is a large number of independent and identically distributed random variables, then with few exceptions the distribution of their sums tends to a normal distribution as the number of such variables increases indefinitely (Gujarati, 2003).

Table 5.3: RESET Test

RESET Test	Null Hypotheses: No Model Misspecification									
Sample	All Firms					Manufacturing Firms				
Estimation	PLS	FEM	FEM	REM	REM	PLS	FEM	FEM	REM	REM
Effects Specification	-	cross-section fixed	cross-section & period fixed	cross-section random	period random	-	cross-section fixed	cross-section & period fixed	cross-section random	period random
Model 1: Sales	Do not reject null	Reject null	Reject null	Do not reject null	Do not reject null	Reject null	Do not reject null	Do not reject null	Reject null	Reject null
Model 2: Profits	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null
Model 3: Profit Margin	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

5.3 Panel Model Results

As discussed in Chapter 4, our panel model was estimated using panel least squares (PLS), fixed effects model (FEM), and random effects model (REM). The model specifications were run with two separate samples which consisted of all firms and manufacturing firms with granted patents. The results are drawn separately in different tables between these two samples.

5.3.1 Panel Least Square

All specifications using panel least square (PLS) in our study were run with White's corrected standard error to correct for heteroskedasticity. Then, in a separate specification, we initially ran without correction for autocorrelation (see Column 1 of tables 5.4 to 5.9), then ran with the AR(1) correction (see Column 2 of tables 5.4 to 5.9). Comparing the regression without and with the AR(1) correction, the R-squared shows an improvement with the AR(1) correction. In the all firms sample, models 1 and 2 both have an R-squared of more than 80% (see columns 1 and 2 of tables 5.4 and 5.5). Interestingly, however, model 3 with profit margin as the dependent variable has the highest increase of its R-squared from 4% to 44%, with the AR(1) correction (see columns 1 and 2 of Table 5.6). For the manufacturing firms, it is shown that without an AR(1) correction and with this correction in tables 5.7, 5.8 and 5.9, the results are quite similar for all firms in our sample. The R-squared is more than 80% for both models 1 and 2, but model 3 had a slight increase from 8% to 45% in the specification without and with an AR(1) correction respectively (see columns 1 and 2 of tables 5.7 to 5.9). On the other hand, the control variables of LNTGA and NAGE were found to have a positively statistically significant impact on the dependent variable in almost all three model specifications (see tables 5.4 to 5.9).

5.3.1.1 <u>All Firms</u>

Moving to specific explanatory variables in the specification of model 1, APPM is positively statistically significant at the 1% level. It shows that a unit increase in the pending patent application in the Malaysian territory increases the firm's sales by 2% and 3% (see Column 1 and 2 of Table 5.4). On the other hand, APPS is positively statistically significant at the 1% level with a slightly higher coefficient than APPM. This gives an impact of a 4% increase to the firm's sales when autocorrelation is corrected (see Column 2 of Table 5.4). Focusing on the granted patents, GRANM shows no significant results, but GRANS is statistically significant at the 5% and 1% level for specifications without and with an AR(1) correction respectively. The impact shows that a unit increase in the active lifespan of the granted patent in the U.S. territory increases the firm's sales by 4% and 8% respectively (see columns 1 and 2 of Table 5.4).

As for model 2 with profits as the dependent variable, only APPS is positively statistically significant at the 1% level without the AR(1) correction (see Column 1 of Table 5.5). GRANM and GRANS, however, both have a negatively statistically significant impact at the 10% and 1% level in the specification without an AR(1) correction. This shows that a unit increase in the active lifespan of granted patents decreases the firm's profits by 9% and 14% in the Malaysian territory and the U.S. territory, respectively (see Column 1 of Table 5.5). Model 3 with profit margin as the dependent variable, on the other hand, shows that there is no sign of a positively statistically significant relationship, rather, there is a negatively statistically significant relationship with the explanatory variables (see Table 5.6). A unit increase in the pending patent application in the Malaysian territory decreases the firm's profit margin by 2%, for both the model without and with an AR(1) correction at the 1% and 5% level respectively (see columns 1 and 2 of Table 5.6). GRANS decreases the firm's sales by 19% in the specification without the AR(1) correction at a statistically significant 1% level (see Column 1 of Table 5.6).

5.3.1.2 __Manufacturing Firms__

When focusing on each of the explanatory variables, some differences are apparent. Some of the results may only show a difference between the magnitudes of the coefficients of both samples, but some show a different statistically significant sign. For example in model 1, while a unit increase in the pending patent application in the Malaysia territory increases the firm's sales by 2% to 3% with all firms sample (see columns 1 and 2 of Table 5.4), the magnitude is slightly larger with manufacturing firms at 5% (see columns 1 and 2 of Table 5.7). Interestingly, however, the GRANM had a negatively statistically significant coefficient at the 1% level without an AR(1) correction specification which gives an impact of 7% decreases in sales (see Column 1 of Table 5.7) but no significant result in the all firms sample (see columns 1 and 2 of Table 5.4). GRANM in the all firms sample has no sign of a significant relationship but a negatively statistically significant relationship with manufacturing firms. On the other hand, the APPS in the manufacturing firms sample had a statistically significant result with a different sign when run without and with an AR(1) correction. It shows that a unit increase of pending patent application in the U.S. decreases the firm's sales by 5% without the AR(1), correction but increases the firm's sales by 3% with the AR(1) correction (see columns 1 and 2 of Table 5.7).

As for model 2, the manufacturing firms sample had all explanatory variables negatively statistically significant; only APPS had a positively statistically significant at the 1% level in the specification without AR(1) correction (see Column 1 of Table 5.8). This situation is similar with the all firms sample, but the only difference in terms of the significant results is that APPM had no significant relationship in the all firms sample compared to the manufacturing firms sample with a negatively statistically significant impact at the 10% level (see Column 1 of Table 5.8). Almost all coefficients had similar magnitudes except for GRANS in the manufacturing firms which had a larger decrease in profits by 27% (see Column 1 of Table 5.8), while the all firms showed a decrease in the firm's profits by 14% (see Column 1 of Table 5.5).

Finally, model 3 in the manufacturing firms sample had similar results with the all firms sample in terms of statistically significant variables, which are the APPM and GRANS (see columns 1 and 3 of Table 5.6 and 5.9). The only difference is the magnitude of the coefficients in which the manufacturing firms had a larger impact. While a unit increase in the pending patent application in the Malaysian territory decreases the manufacturing firm's profit margin by 7% and 6% without and with an AR(1) correction respectively (see columns 1 and 2 of Table 5.9), the all firms sample had a decrease by 2% (see columns 1 and 2 of Table 5.5). The active lifespan of granted patent in the U.S., on the other hand, decreases the manufacturing firm's profit margin by 34% and 23% without and with an AR(1) correction respectively (see columns 1 and 2 of Table 5.9), but with a smaller magnitude of 19% and 14% in the all firms sample (see columns 1 and 2 of Table 5.6).

5.3.2 Fixed Effects Model / Random Effects Model

Three specifications were run with the fixed effect model (FEM) using White's corrected standard error to correct for heteroskedasticity. All three were given a cross-section fixed effects specification, but for the third specification a two-way fixed effect model was added with a period fixed effect. The difference between the first and the second specification is that an AR(1) correction was added to the second specification. As for the random effects (REM), only two separate specifications were run, first with cross section random effects and second with period random effects specifications. The results for FEM are shown in columns 3, 4 and 5 of tables 5.4 to 5.9, while the REM results are shown in columns 6 and 7 of tables 5.4 to 5.9.

The R-squared for all three specifications in the all firms sample are high with more than 90% for FEM, but slightly lower for REM with 83% for the two specifications in model 1 and model 2 (see columns 3 to 7 of tables 5.4 and 5.5). Model 3 with profit margin as the dependent variable shows a much lower R-squared with 50% to 60% with the FEM (see columns 3 to 5 of Table 5.5) and a very low R-squared with the REM of only 4% (see columns 6 and 7 of Table 5.6). On the other hand, the manufacturing firms sample had a similar R-squared to the all firms sample, except at a much higher rate of 8% for model 3 (see columns 3 to 7 of tables 5.7 to 5.9). Similar to the all firms sample, the control variables of LNTGA and NAGE had a positively statistically significant impact on the dependent variable in almost all three model specifications (see tables 5.7 to 5.9).

5.3.2.1 <u>All Firms</u>

Moving into specific explanatory variables, in model 1, APPM and GRANS show positively statistically significant results at the 1% and 5% level for all three effects specifications in FEM, as well as REM (see columns 3 to 7 of Table 5.4). The coefficient of APPM is also similar for both FEM and REM in all specifications, but varies slightly for the GRANS coefficients. As for the APPM, a unit increase in the pending patent application in the Malaysian territory increases the firm's sales by 2% (see columns 3 to 7 of Table 5.4). On the other hand, GRANS (as for FEM) had the highest coefficients in the first specification without the AR(1) correction, followed by the specification with the AR(1) correction, and the least magnitude is seen in the two-way fixed effects model, where a unit increase in the active lifespan of granted patents in the U.S. territory increases the firm's sales by 8%, 6.27% and 6% respectively (see columns 3 to 5 of Table 5.4). REM, however, was positively statistically significant in the cross section random effects specifications, with a unit increase in active lifespan of granted patents in the U.S. territory increasing the firm's sales by 4% (see Column 6 of Table 5.4)

Interestingly, model 2 shows that none of the explanatory variables are statistically significant for FEM; however, three explanatory variables are found to be statistically significant with the REM (see columns 3 to 7 of Table 5.5). GRANM and GRANS both were negatively statistically significant at the 1% level, except for the period random effects specification where significance was found at the 5% level. It shows a unit increase in the active lifespan of granted patents in the Malaysian territory decreases the firm's profits by 9%, while this is slightly higher in the U.S. territory with a decrease of 14% for both effects specifications in REM estimation (see columns 6 and 7 of Table 5.5). Nevertheless, APPS has a positively statistically significant impact at the 1% and 5% level for cross section and period random effects specification respectively, with a unit increase in the pending patent application in the U.S. territory increasing the firm's profits by 10% (see columns 6 and 7 of Table 5.5)

As for model 3 with profit margin as the dependent variable, both FEM and REM estimations have given APPM and GRANS a negatively statistically significant impact ranging across the 1% to 5% level, except for FEM with a two-way effects specification which shows no significant impact (see columns 3 to 7 of Table 5.6). Comparing between APPM and GRANS, GRANS has a higher impact in both estimation of FEM and REM with a unit increase in active lifespan of patent granted in the U.S. territory decreasing the firm's profit margin by 15% to 21%. This declining impact is lower in APPM with a unit increase in the pending patent application in the Malaysian territory decreasing the firm's profit margin by only 2% (see columns 3 to 7 of Table 5.6).

5.3.2.2 ***Manufacturing Firms***

Focusing on the explanatory variables, for model 1 with sales as the dependent variable, only APPM and GRANM have a statistically significant impact at either the 1% to 5% level for both FEM and REM estimation (see columns 3 to 7 of Table 5.7). However, both variables have a contradictory sign of positive for APPM and negative for GRANM. Comparing both estimations for the APPM variable, REM has a higher impact than FEM. It shows that a unit increase in the pending patent application in the Malaysian territory increases the manufacturing firm's sales by 5% in the REM estimation and 2% to 3% in the FEM estimation (see columns 3 to 7 of Table 5.7). On the other hand, the GRANM has a negative impact on the manufacturing firm's sales with a unit increase in the active lifespan of granted patents in the Malaysian territory decreasing its sales by 7% with the REM (see columns 6 and 7 of Table 5.7). However, as for the FEM, when an AR(1) correction is made, no statistically significant coefficient was found for GRANM. Only the two-way fixed effects specification is found to be negatively statistically significant at the 1% level with a lower declining impact on its sales by 5% (see Column 5 of Table 5.7).

Model 2, with profits as the dependent variable, shows that only GRANS had a statistically significant impact for both FEM and REM estimations with a negative sign. It shows that a unit increase in the active lifespan of granted patents in the U.S. territory decreases the manufacturing firm's profits by 3% (see columns 3 to 7 of Table 5.8). Interestingly, however, the REM estimation has all four explanatory variables with negatively statistically significant results except for APPS which has a positive significant impact. It shows that a unit increase in the pending patent application in the U.S. territory increases the firm's profits by 11% (see columns 6 and 7 of Table 5.8). Finally, model 3 shows a negatively statistically significant coefficient at either the 1% to 5% level for both the FEM and REM for the APPM and GRANS variables (see columns 3 to 7 of Table 5.9). However, comparing the magnitude of the coefficients between the all firms and manufacturing firms sample, the manufacturing firms sample has a larger impact. A unit increase in active lifespan of granted patent in the U.S. territory decreases the firm's profit margin by more than 30% in the manufacturing samples (see columns 3 to 7 of Table 5.9), but a 15% to 21% decrease in the all firms sample (see columns 3 to 7 of Table 5.6).

Table 5.4: Panel Model Result for Model 1 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.343644**	3.997458***	-1.117453	-4.081959	-1.731454	0.343644***	0.345479**
	(0.136393)	(0.886189)	(3.953361)	(4.404663)	(4.390946)	(0.091715)	(0.156289)
APPM	0.020814***	0.027056***	0.018598***	0.016533***	0.020373***	0.020814***	0.021894**
	(0.003654)	(0.00847)	(0.005003)	(0.005985)	(0.005199)	(0.005049)	(0.008585)
GRANM	-0.034277	0.027709	0.020477	0.025163	-0.01905	-0.034277*	-0.037636
	(0.030802)	(0.01723)	(0.015767)	(0.01652)	(0.021086)	(0.018351)	(0.031795)
APPS	-0.011345	0.040536***	0.003055	-0.00139	0.003019	-0.011345	-0.009944
	(0.014372)	(0.015648)	(0.018959)	(0.01863)	(0.018479)	(0.015774)	(0.026703)
GRANS	0.04249**	0.077827***	0.081021***	0.062704**	0.059963**	0.04249**	0.041914
	(0.018739)	(0.028436)	(0.024378)	(0.031049)	(0.023515)	(0.020311)	(0.034585)
LNTGA	0.949541***	0.713487***	0.748779***	0.641732***	0.731876***	0.949541***	0.950225***
	(0.008771)	(0.05978)	(0.032343)	(0.061889)	(0.040665)	(0.005989)	(0.010145)
NAGE	0.016668***	0.032298***	0.246114	0.474477**	0.290061	0.016668***	0.016351***
	(0.002615)	(0.010257)	(0.195559)	(0.208648)	(0.211161)	(0.001746)	(0.002959)
R-Squared	0.840763	0.941865	0.949618	0.959516	0.95023	0.840763	0.840951
Number of Observations	2225	2022	2225	2022	2225	2225	2225

The dependent variable is sales. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 5.5: Panel Model Result for Model 2 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-3.605686***	-3.673533***	-6.229413	-6.299975	-8.933208**	-3.605686***	-3.595746***
	(0.201759)	(0.64838)	(4.440139)	(5.494171)	(4.505291)	(0.164764)	(0.210109)
APPM	-0.00557	-0.001337	0.002789	-0.001113	0.009013	-0.00557	-0.00356
	(0.006842)	(0.009342)	(0.007039)	(0.006993)	(0.007519)	(0.007853)	(0.009991)
GRANM	-0.087732*	0.000604	0.019461	0.045147	-0.026955	-0.087732***	-0.091937**
	(0.05194)	(0.046238)	(0.031993)	(0.028688)	(0.025992)	(0.029858)	(0.038822)
APPS	0.101649***	0.02378	0.014256	0.002801	0.021028	0.101649***	0.105057**
	(0.033754)	(0.051362)	(0.037923)	(0.053392)	(0.038458)	(0.036652)	(0.046407)
GRANS	-0.14003***	-0.071055	-0.089654	-0.132268	-0.096152*	-0.14003***	-0.13527***
	(0.041099)	(0.101443)	(0.059)	(0.100068)	(0.050908)	(0.037873)	(0.048295)
LNTGA	1.050382***	1.037059***	0.734014***	0.649125***	0.739191***	1.050382***	1.05035***
	(0.012466)	(0.032853)	(0.041538)	(0.075296)	(0.065338)	(0.010247)	(0.012981)
NAGE	0.00318	0.012898*	0.363048*	0.425702*	0.482548**	0.00318	0.002915
	(0.00253)	(0.007193)	(0.20723)	(0.223072)	(0.209056)	(0.002921)	(0.0037)
R-Squared	0.825498	0.897064	0.904066	0.926056	0.905745	0.825498	0.825907
Number of Observations	1689	1366	1689	1366	1689	1689	1689

The dependent variable is profits. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 5.6: Panel Model Result for Model 3 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.311472***	-5.053688***	-4.704755**	-2.619392	-8.038677***	-4.311472***	-4.311472***
	(0.170838)	(0.556518)	(2.131186)	(2.884565)	(2.242425)	(0.160823)	(0.21277)
APPM	-0.02037***	-0.019761**	-0.012611	-0.015524**	-0.006864	-0.02037***	-0.02037**
	(0.007205)	(0.0079)	(0.006885)	(0.00612)	(0.006646)	(0.007666)	(0.010142)
GRANM	-0.042951	0.026463	0.008129	0.025787	-0.012989	-0.042951	-0.042951
	(0.032075)	(0.033635)	(0.032687)	(0.029946)	(0.025312)	(0.029144)	(0.038558)
APPS	0.022714	-0.018225	0.031926	0.00947	0.038317	0.022714	0.022714
	(0.02725)	(0.03878)	(0.037393)	(0.047084)	(0.038953)	(0.035775)	(0.04733)
GRANS	-0.186466***	-0.142326	-0.159839***	-0.207664**	-0.148801***	-0.186466***	-0.186466***
	(0.042417)	(0.099947)	(0.057919)	(0.099353)	(0.051132)	(0.036967)	(0.048908)
LNTGA	0.09543***	0.122368***	-0.066243**	0.046832	-0.017841	0.09543***	0.09543***
	(0.012162)	(0.033879)	(0.033016)	(0.056392)	(0.049074)	(0.010002)	(0.013232)
NAGE	0.00026	0.008054	0.140585	-0.039894	0.255045***	0.00026	0.00026
	(0.002599)	(0.007604)	(0.089733)	(0.098073)	(0.084948)	(0.002851)	(0.003772)
R-Squared	0.037827	0.441541	0.51271	0.608241	0.517701	0.037827	0.037827
Number of Observations	1689	1366	1689	1366	1689	1689	1689

The dependent variable is profit margin. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 5.7: Panel Model Result for Model 1 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.509942***	4.222387***	-2.346649	-6.229002	-3.000975	0.509942***	0.509942***
	(0.090751)	(1.057307)	(4.696777)	(4.799163)	(5.017408)	(0.107428)	(0.185842)
APPM	0.048164***	0.050837***	0.023904***	0.026394***	0.026062***	0.048164***	0.048164***
	(0.004601)	(0.015305)	(0.005888)	(0.007435)	(0.007845)	(0.006082)	(0.010522)
GRANM	-0.067366***	0.00433	-0.020507**	-0.010942	-0.049667***	-0.067366***	-0.067366**
	(0.019069)	(0.013561)	(0.009381)	(0.009645)	(0.015204)	(0.018093)	(0.0313)
APPS	-0.04607***	0.033191**	0.015259	0.00401	0.013492	-0.04607***	-0.04607*
	(0.015738)	(0.013642)	(0.025375)	(0.021173)	(0.025733)	(0.015687)	(0.027138)
GRANS	0.040963	0.052818	0.087399*	0.061169	0.064716	0.040963*	0.040963
	(0.032871)	(0.046319)	(0.047819)	(0.054925)	(0.047303)	(0.024293)	(0.042024)
LNTGA	0.950332***	0.721012***	0.83199***	0.70166***	0.81383***	0.950332***	0.950332***
	(0.005417)	(0.064933)	(0.031371)	(0.062326)	(0.041937)	(0.006825)	(0.011807)
NAGE	0.011735***	0.021536***	0.23333	0.510632**	0.277893	0.011735***	0.011735***
	(0.001464)	(0.007964)	(0.227278)	(0.224145)	(0.238979)	(0.001708)	(0.002955)
R-Squared	0.832721	0.942472	0.948985	0.958991	0.949705	0.832721	0.832721
Number of Observations	1694	1545	1694	1545	1694	1694	1694

The dependent variable is sales. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 5.8: Panel Model Result for Model 2 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.492672***	-4.699591***	-7.141456	-8.313634	-10.91372**	-4.492672***	-4.501777***
	(0.314049)	(0.655423)	(4.960235)	(6.023201)	(5.084312)	(0.215024)	(0.273842)
APPM	-0.023192*	-0.014915	-0.002915	-0.003862	0.007483	-0.023192**	-0.021056
	(0.011912)	(0.010217)	(0.012697)	(0.016367)	(0.015491)	(0.010636)	(0.013534)
GRANM	-0.102814**	-0.02737	-0.003035	0.019646	-0.041728	-0.102814***	-0.100914**
	(0.042216)	(0.043274)	(0.030447)	(0.026397)	(0.031021)	(0.032491)	(0.04217)
APPS	0.106038***	-0.006691	-0.000453	-0.042811	-0.001681	0.106038**	0.105976*
	(0.034402)	(0.043902)	(0.039758)	(0.043487)	(0.041078)	(0.043847)	(0.055502)
GRANS	-0.266232***	-0.118238	-0.302201***	-0.256022**	-0.283924***	-0.266232***	-0.247926***
	(0.077962)	(0.127346)	(0.110377)	(0.126596)	(0.10111)	(0.05353)	(0.068349)
LNTGA	1.102082***	1.091645***	0.792759***	0.730775***	0.816394***	1.102082***	1.102821***
	(0.019976)	(0.037984)	(0.03751)	(0.068517)	(0.063531)	(0.013173)	(0.01671)
NAGE	0.004986*	0.018054**	0.347119	0.438439*	0.494124**	0.004986	0.004738
	(0.002968)	(0.007612)	(0.224032)	(0.242535)	(0.228407)	(0.003185)	(0.004036)
R-Squared	0.79654	0.878944	0.88738	0.908686	0.889249	0.79654	0.796987
Number of Observations	1329	1101	1329	1101	1329	1329	1329

The dependent variable is profits. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 5.9: Panel Model Result for Model 3 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-5.272273***	-6.257989***	-4.647401**	-2.895164	-9.382415***	-5.272273***	-5.282284***
	(0.320739)	(0.616602)	(2.148134)	(2.736979)	(1.884082)	(0.20339)	(0.264347)
APPM	-0.066932***	-0.059164***	-0.02329**	-0.027865**	-0.015477	-0.066932***	-0.06519***
	(0.009317)	(0.012974)	(0.011796)	(0.012713)	(0.011715)	(0.010061)	(0.013066)
GRANM	-0.018076	0.007884	0.020199	0.023238	0.01344	-0.018076	-0.012396
	(0.028)	(0.031255)	(0.028138)	(0.029175)	(0.026037)	(0.030733)	(0.040686)
APPS	0.04717	-0.025808	0.002626	-0.033237	0.001133	0.04717	0.047738
	(0.029605)	(0.034102)	(0.03219)	(0.032486)	(0.033562)	(0.041475)	(0.053591)
GRANS	-0.335633***	-0.232756*	-0.373466***	-0.330797***	-0.318044***	-0.335633***	-0.315038***
	(0.078686)	(0.12258)	(0.101169)	(0.116798)	(0.092868)	(0.050634)	(0.065979)
LNTGA	0.146899***	0.185965***	-0.043859**	0.062087	0.039623	0.146899***	0.147545***
	(0.019361)	(0.037307)	(0.019552)	(0.045683)	(0.031192)	(0.01246)	(0.016134)
NAGE	0.002978	0.012831	0.114444	-0.038758	0.258537***	0.002978	0.002709
	(0.003421)	(0.009516)	(0.085073)	(0.094044)	(0.07039)	(0.003013)	(0.003897)
R-Squared	0.081935	0.451925	0.511933	0.598947	0.519874	0.081935	0.079974
Number of Observations	1329	1101	1329	1101	1329	1329	1329

The dependent variable is profit margin. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

5.3.3 Hausman Test

The Hausman test was conducted to determine which model is preferred between the FEM and REM. In the Hausman test, the null hypothesis favored the REM rather than the FEM. The results in Table 5.10 show that for the cross-section random effects specifications, the null hypothesis of favoring REM can be rejected for both samples at the 1% significance level. In contrast, we found otherwise in the period random effects specifications if we were to use the 1% significance level, as shown in Table 5.10. As discussed in Chapter 4, this clearly shows that there is a significant correlation between the individual effects in the cross-section effects specification and the regressors. However, there is no such correlation between the time effects in the period effects specification with the regressors. This may show that, in terms of this Chapter, individual effects such as the firm's managerial decision to patent, an investment decision to pay the renewal fee, or to advertise promotions on the patented products, for example, are correlated with the regressors. Nevertheless, the time effect such as the financial and economic crisis or changes in the government policy, for example, are not correlated with the regressors.

Table 5.10: Hausman Test

Hausman Test	Null hypothesis: REM is favored			
Sample	All Firms		Manufacturing Firms	
Effects Specification	cross-section random	period random	cross-section random	period random
Model 1: Sales	Reject null at 1% significance level	Reject null at 5% significance level	Reject at 1% significance level	Reject null at 10% significance level
Model 2: Profits	Reject null at 1% significance level	Do not reject null	Reject at 1% significance level	Do not reject null
Model 3: Profit Margin	Reject null at 1% significance level	Do not reject null	Reject at 1% significance level	Reject null at 10% significance level

5.4 Dynamic Panel Model Results

The dynamic panel model is estimated with generalized method of moments (GMM) estimation, as discussed in Chapter 4. Similar to the panel model result, the specifications were run with two separate samples which consisted of all firms and manufacturing firms which had been granted patents. The results are presented and discussed separately.

5.4.1 Generalized Method of Moments

As discussed in Chapter 4, we ran the GMM estimation with two types of cross-section transformation, specifically, first differences (Arellano & Bond, 1991) and orthogonal deviations (Arellano & Bover, 1995). In addition, the specifications were also run with a one-step cross-section fixed effects and a two-step cross-section and period fixed effects. After running the specifications, we also ran the Sargan test to ensure that the error terms were not serially correlated with the instruments, to determine if the instruments can be considered as healthy instruments. For the instrumental variable (IV), we used all available lagged values of the dependent variables plus the values of the regressors (Judson & Owen, 1999). The results show that all of the specifications in this study meet the Sargan test requirements. The results also show that the single lagged dependent variable had a positively statistically significant impact at the 1% level in all specifications.

5.4.1.1 All Firms

Focusing on the explanatory variables, model 1 gives a positively statistically significant result at the 1% and 5% level for APPM and GRANS. As for APPM, the one-step fixed effect has a higher coefficient compared to the two-step fixed effects in both the first difference and orthogonal deviations transformation (see columns 1 to 4 of Table 5.11). However, only the orthogonal deviations transformation has a positively statistically significant result at the 1% level for GRANS (see columns 3 and 4 of Table 5.11).

Moving on to model 2 and 3, we had a slight problem with the orthogonal deviations transformation. EViews would not estimate the model specification and reported a *near singular matrix*. This basically meant that the regressors may have had an exact collinearity problem among each other. Since we tested for multicollinearity earlier in the chapter and found no exact collinearity among the regressors, we anticipated that this situation may have been due to the constant having an exact collinearity with one of the regressors. We then found NAGE had to be omitted from the orthogonal deviation model to obtain the parameter estimates (see columns 3 and 4 of tables 5.12 to 5.13). Nevertheless, we did not have this problem for model 1 (see columns 3 and 4 of Table 5.11).

In model 2, we found that GRANM and GRANS have a statistically significant result ranging across the 1% to 5% level. The only difference was that while GRANM has a positively statistically significant relationship with profits; GRANS was found otherwise (see Table 5.12). It showed that a unit increase of active lifespan of granted patents in the Malaysian territory increased the firm's profits by 4% to 6% (see columns 1, 3 and 4 of Table 5.12); while in the U.S. territory it decreased the firm's profits by 11% to 18% (see columns 1 to 4 of Table 5.12). Model 3, on the other hand, has almost all explanatory variables as being statistically significant ranging across the 1% to 10% level. Among all the explanatory variables, the APPM, GRANM, APPS, and GRANS, only GRANM is positively statistically significant at the 1% level (see Table 5.13). The first difference transformation had a higher positive impact of GRANM on the firm's profits, that is, 7% (see Column 1 of Table 5.13) compared to the orthogonal deviations, that is, 4% (see Column 3 of Table 5.13). The highest magnitude for the negatively statistically significant is found in GRANS, with a unit increase in the active lifespan of granted patents in the U.S. territory decreasing the firm's profits by 14% to 23% (see Table 5.13).

5.4.1.2 Manufacturing Firms

In the manufacturing firms sample, model 1 has three explanatory variables that were statistically significant (see Table 5.14), compared to the all firms sample which has only two variables that are statistically significant (see Table 5.11). Similar to the all firms sample, APPM is found to have a positive relationship with sales; while GRANS is also found to have a positive relationship only with the orthogonal deviation transformation (see Table 5.14). GRANM, which is not found to be statistically significant in the all firms sample (see Table 5.10), is found to be negatively statistically significant at the 1% level for the manufacturing firms sample (see Table 5.14). It shows that in the manufacturing firms sample, a unit increase in the active lifespan of granted patents in the Malaysian territory decreases its sales by 3% (see columns 2, 3 and 4 of Table 5.14).

Model 2 with profits as the dependent variable had quite similar statistically significant results in manufacturing firms as compared to the all firms sample (see tables 5.12 and 5.15). APPM, APPS and GRANS have negatively statistically significant results ranging across the 1% to 10% level. GRANM is the only variable which is positively statistically significant with the first difference transformation with a cross-section fixed effects specification (see Column 1 of Table 5.15). It shows that a unit increase in the active lifespan of granted patent in the Malaysian territory increases the firm's profits by 6%.

Finally, model 3 has a higher number of statistically significant results in manufacturing firms compared to the all firms sample (see tables 5.12 and 5.16). In the manufacturing firms sample, both APPM and APPS are negatively statistically significant ranging across the 1% to 5% level, with APPS giving a higher impact of decrease profits. It shows that a unit increase in the pending patent application in the Malaysian territory decreases the manufacturing firm's profit margin by 2% to 3% (see columns 1, 3 and 4 of Table 5.16), while manufacturing firm's profit margin decreased by 12% in the U.S. territory (see columns 1 and 2 of Table 5.16). GRANM is the only explanatory variable which was positively statistically significant at the 1% level, with a unit increase in the active lifespan of granted patents in the Malaysian territory increasing the manufacturing firm's profit margin by 3% to 4%. Nevertheless, comparing the active lifespan of granted patents in the U.S. territory decreases the manufacturing firm's profits at a higher magnitude, that is, by 12% to 31% (see Table 5.16).

Table 5.11: Dynamic Panel Model Result for Model 1 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.144945***	0.251665***	0.043071	0.233136***
	(0.02602)	(0.019092)	(0.027651)	(0.022069)
APPM	0.018335***	0.011139**	0.016092***	0.013254***
	(0.004095)	(0.004662)	(0.004044)	(0.00314)
GRANM	0.009416	-0.013198	0.008772	0.004738
	(0.010826)	(0.011415)	(0.013026)	(0.014571)
APPS	0.015812	0.013418	0.002259	0.0055
	(0.011991)	(0.011138)	(0.013271)	(0.010536)
GRANS	0.028749	0.017211	0.057945***	0.055057***
	(0.01893)	(0.014869)	(0.016696)	(0.011388)
LNTGA	0.498335***	0.441702***	0.695103***	0.596549***
	(0.031338)	(0.034479)	(0.028353)	(0.024939)
NAGE	0.507041**	0.766407**	1.054711	0.069094
	(0.19701)	(0.298421)	(1.214274)	(0.047635)
Number of Observations	1819	1819	1819	1819

The dependent variable is sales. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 5.12: Dynamic Panel Model Result for Model 2 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.159471***	0.395088***	0.233827***	0.411672***
	(0.040753)	(0.035059)	(0.029015)	(0.03726)
APPM	-0.007816	-0.028741**	0.000484	-0.004634
	(0.010223)	(0.012137)	(0.005704)	(0.004574)
GRANM	0.059957***	-0.030664	0.049763***	0.037621**
	(0.019971)	(0.029039)	(0.015894)	(0.018178)
APPS	-0.037065	-0.084138***	-0.011073	-0.005777
	(0.043845)	(0.040177)	(0.028982)	(0.020574)
GRANS	-0.112699**	-0.137507***	-0.181105***	-0.127065***
	(0.050363)	(0.052644)	(0.03471)	(0.028276)
LNTGA	0.428168***	0.278166***	0.567661***	0.497538***
	(0.049297)	(0.05583)	(0.044305)	(0.04734)
NAGE	0.266814***	0.165728		
	(0.064369)	(0.105221)		
Number of Observations	1185	1185	1185	1185

The dependent variable is profits. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 5.13: Dynamic Panel Model Result for Model 3 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.289064***	0.342638***	0.352907***	0.424967***
	(0.028281)	(0.019645)	(0.025225)	(0.018885)
APPM	-0.028559***	-0.02841***	-0.008387*	-0.007023*
	(0.006571)	(0.008043)	(0.004447)	(0.004131)
GRANM	0.07252***	0.007161	0.039432***	0.025685*
	(0.016678)	(0.023177)	(0.011137)	(0.014563)
APPS	-0.113181***	-0.097964***	0.01564	0.02456
	(0.038731)	(0.03474)	(0.020161)	(0.019807)
GRANS	-0.225827***	-0.196481***	-0.194334***	-0.139468***
	(0.061768)	(0.056759)	(0.033208)	(0.030533)
LNTGA	0.037721	0.00844	0.019425	0.084481**
	(0.034661)	(0.049554)	(0.023424)	(0.034078)
NAGE	-0.173542***	-0.028401		
	(0.032207)	(0.090138)		
Number of Observations	1185	1185	1185	1185

The dependent variable is profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 5.14: Dynamic Panel Model Result for Model 1 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.192314***	0.282568***	0.202914***	0.264584***
	(0.009027)	(0.009285)	(0.00792)	(0.00972)
APPM	0.041114***	0.01494*	0.015069***	0.013277***
	(0.010508)	(0.008201)	(0.004343)	(0.004711)
GRANM	0.000504	-0.031456***	-0.027755***	-0.027488***
	(0.00862)	(0.01177)	(0.006429)	(0.00932)
APPS	0.014545	0.004774	0.003366	-0.001296
	(0.011194)	(0.013213)	(0.007637)	(0.007184)
GRANS	0.002502	-0.030236**	0.063745***	0.050983***
	(0.012124)	(0.014629)	(0.010719)	(0.011164)
LNTGA	0.55036***	0.56272***	0.651814***	0.6425***
	(0.017431)	(0.028279)	(0.014252)	(0.020455)
NAGE	0.541553***	1.009272***		
	(0.100742)	(0.24276)		
Number of Observations	1396	1396	1396	1396

The dependent variable is sales. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 5.15: Dynamic Panel Model Result for Model 2 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.188112***	0.307808***	0.276916***	0.328089***
	(0.015081)	(0.019449)	(0.010659)	(0.01462)
APPM	-0.012619	-0.030623	-0.011593***	-0.010897*
	(0.014363)	(0.019684)	(0.003481)	(0.005991)
GRANM	0.059996***	-0.022188	0.004963	0.018712
	(0.012373)	(0.033287)	(0.018461)	(0.013775)
APPS	-0.119546***	-0.153855***	-0.038064**	-0.036186**
	(0.023141)	(0.026749)	(0.016057)	(0.015934)
GRANS	-0.133709**	-0.12361*	-0.229992***	-0.15161***
	(0.066556)	(0.067331)	(0.030074)	(0.024341)
LNTGA	0.452295***	0.464955***	0.570936***	0.66074***
	(0.031452)	(0.047821)	(0.030903)	(0.035582)
NAGE	0.197394	0.343901***		
	(0.188632)	(0.121237)		
Number of Observations	967	967	967	967

The dependent variable is profits. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 5.16: Dynamic Panel Model Result for Model 3 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.20689***	0.327053***	0.220792***	0.35785***
	(0.014597)	(0.015245)	(0.013374)	(0.01291)
APPM	-0.033021***	-0.008841	-0.021347***	-0.015126***
	(0.012301)	(0.009663)	(0.004794)	(0.003098)
GRANM	0.048064***	0.00161	0.036879***	0.033175***
	(0.012285)	(0.01446)	(0.00913)	(0.005895)
APPS	-0.121749***	-0.121783***	-0.001532	-0.019203*
	(0.01498)	(0.017258)	(0.010509)	(0.010632)
GRANS	-0.260366***	-0.116312**	-0.312577***	-0.173559***
	(0.054425)	(0.045316)	(0.03509)	(0.025708)
LNTGA	0.038429	0.049985	0.006908	0.106743***
	(0.023989)	(0.042239)	(0.012915)	(0.016941)
NAGE	-0.14194***	0.018216		
	(0.045694)	(0.075637)		
Number of Observations	967	967	967	967

The dependent variable is profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

5.5 Summary of Findings

We summarize our findings by separating them into two components which are based on estimation and hypotheses development.

5.5.1 Summary of Findings Based on Estimation

To summarize our findings based on the estimation results, we divided them into two components the 1) PLS/ FEM/ REM and; 2) GMM. This is because the former estimates are a static panel model, while the latter uses a dynamic panel model. We believe that the significance of the results may differ somewhat between the two estimation approaches. Besides the significant variables, we are also interested in examining the magnitude of the coefficient estimates to see how much an impact the patenting activity variable has on the financial performance of the firms. Since we have a number of static panel estimations, the selection of PLS in this summary is based on the PLS estimation with the AR(1) correction, due to higher value of the R-squared. Between the FEM and REM, we based our selection on the Hausman test. In the summary, only two or more significant variables are taken into account. Thus, in the GMM estimation, if only two significant variables are found from the orthogonal deviations transformation but none in the first difference transformation, we would consider the variables to be included in this summary.

When comparing between the two approaches, GMM gives a higher number of significant variables compared to PLS/ FEM/ REM in both the all firms and manufacturing firms samples. The sign of the significant variables are very similar, and the coefficients have only a slight different between the static and dynamic specifications. Table 5.17 shows the summary of findings based on the set of estimation results.

5.5.1.1 All Firms

In the all firms sample, APPM and GRANS have a positively statistically significant relationship with the firm's sales. Nevertheless, GMM estimation has slightly lower coefficients compared to PLS/ FEM/ REM. Moving to model 2, GMM estimation has given a positive statistically significant relationship with profits with coefficients ranges from 0.04 to 0.06, but no significant impact in the PLS/ FEM/ REM estimation. Moving into model 3 in the GMM estimation, all the explanatory variables are found to be significant, compared to only two variables in the PLS/ FEM/ REM estimation, that is, the APPM and GRANS. Unlike the PLS/ FEM/ REM models which show no significant impact in the GMM estimation, GRANM is found to have a positively statistically significant relationship with profit margin with coefficients ranges from 0.02 to 0.11, while APPS and profit margin have a negatively statistically significant relationship with coefficients ranges from -0.113 to -0.098.

5.5.1.2 Manufacturing Firms

In the manufacturing firms sample, we found there were some variables that were not significant in the all firms sample, but that are significant in the manufacturing firms sample. Model 1 and model 2 show the differences. In model 1, GRANM has a negatively statistically significant relationship in all types of estimation, with coefficient ranges from -0.07 to -0.03. This situation is not seen in the all firms sample. On the other hand, in model 2 APPS has a negatively statistically significant relationship in the manufacturing firms sample, with coefficients ranges from -0.15 to -0.04, while there is no significant impact in the all firms sample. Nevertheless, GRANM is found to be positively statistically significant in the all firms sample with coefficients ranges from 0.04 to 0.06, while there is no significant impact in the manufacturing firms sample. Finally, model 3 (similar to the all firms sample) has all variables negatively statistically significant except for GRANM with a positive sign.

5.5.1.3 <u>Overall Summary</u>

We believe that the results reported for the dynamic panel model using the GMM estimator are better than the panel model estimated using PLS/ FEM/ REM. This is because in the real world firms base their decisions on historical values of sales, profits and profit margin to run their businesses. Since our data is yearly data, we chose only a single lagged dependent variable. The results of the first lagged dependent variable show positive and large coefficients in all of our specifications. Furthermore, GMM estimation, as discussed in Chapter 4, produced substantial efficiency gains (Judson & Owen, 1999; Arellano & Bond, 1991), whereby the instrumental-variables (IV) was introduced to obtain a consistent estimation result, compared to the traditional fixed effects estimator.

Thus, based on the GMM estimation, the manufacturing firms sample has coefficients with a higher magnitude compared to the all firms sample. Our analysis also confirms that the magnitude of the coefficients between the Malaysian and U.S. territory differs, with the U.S. having a higher magnitude. Furthermore, there are more statistically significant variables in the manufacturing firms sample compared to the all firms sample. To us, this is quite interesting as manufacturing firms are actually also included in the all firms sample. However, when the firms are segregated, the result differs even if by not a large margin. Thus, when referring back to the literature in Chapter 3, there are more sample studies that came from the manufacturing firm when studying patenting activity. This is because patents are considered to be a more appropriate measure of innovation in the manufacturing industries (Griliches, 1990) compared to trademarks which are normally applied across all industries (Webster &

Jensen, 2006; Posner, 2005). Our results confirm that this situation is also happening in Malaysia based on the patenting activity undertaken by the Malaysian firms.

Table 5.17: Summary of Findings Based on Estimations

Estimations	Explanatory Variables	All Firms			Manufacturing Firms		
		Model 1: Sales	Model 2: Profits	Model 3: Profit Margin	Model 1: Sales	Model 2: Profits	Model 3: Profit Margin
PLS/ FEM/ REM	APPM	(+) 0.02~0.03		(–) 0.020~0.016	(+) 0.03~0.05		(–) 0.07~0.03
	GRANM				(–) 0.07~0.05		
	APPS						
	GRANS	(+) 0.06~0.08	(–) 0.14~0.10	(–) 0.21~0.15		(–) 0.29~0.25	(–) 0.33~0.23
GMM	APPM	(+) 0.011~0.018		(–) 0.03~0.01	(+) 0.013~0.015	(–) 0.011~0.010	(–) 0.033~0.015
	GRANM		(+) 0.04~0.06	(+) 0.02~0.11	(–) 0.031~0.027		(+) 0.03~0.05
	APPS			(–) 0.113~0.098		(–) 0.15~0.04	(–) 0.12~0.02
	GRANS	(+) 0.055~0.057	(–) 0.18~0.11	(–) 0.23~0.14	(+) 0.05~0.06	(–) 0.23~0.12	(–) 0.31~0.12

Only significant variables are reported; (+) means positive relationship between the dependent and explanatory variables; (–) means negative relationship between the dependent and explanatory variables; the values shown below the sign are the coefficient estimates from the lowest to the highest.

5.5.2 Summary of Findings Based on Hypotheses Development

In this chapter, we answered subsidiary research question 1 and Hypothesis 1 developed in chapters 1 and 3, respectively. We expected that there would a positive significant relationship between patents applied for and granted to Malaysian firms and their financial performance, in both Malaysia and the U.S. Nevertheless, we found mixed results to the reported sign and significance of the variables. In the previous section, the summary of findings is based only on statistically significant variables and the magnitude of the coefficients, while in this section the findings focus on the expected sign in our hypotheses development. Similar to the previous section, we summarize our findings based on the samples shown in Table 5.18 for all firms and Table 5.19 for manufacturing firms.

5.5.2.1 All Firms

In the all firms sample, all the variables were found to have a positive relationship with the firm's sales, but only two variables were statistically significant, that is, the APPM and GRANS. Given the reported signs in model 1, all variables matched our expected sign, even though only two were found to be statistically significant. Relating to the argument based on the profit maximization model, this situation may show that Malaysian firms patented invention have a place both in Malaysian and U.S. markets. The most favorable finding is that the demand of the Malaysian firms patented invention and the ability of the Malaysian firms to supply the patented invention is long lasting until the granted stage, especially in the U.S., where the result is shown to be statistically significant. In other words, the Malaysian patented invention in the U.S. territory is not yet obsolete by the time the patent is granted, and continues to give a positively statistically significant impact on sales even after the granting stage, since the measurement is based on the patent active lifespan.

Moving to model 2 with profits as the dependent variable, only GRANM provided a positively statistically significant relationship with the firms' sales. The other statistically significant variable is GRANS, but with a negative sign. Relating to the profit maximization model, we argue that the firm may have to adjust the price, cost and quantity supplied of the patented product in order to maximize profits. The price may have suited the market demand and supply as we saw a positive sign to the sales;

however, the negative sign may empirically show that the costs may well not be adjusted for, especially in the U.S. where the costs of patenting activity are much higher, as argued in Chapter 3. Relating to this chapter, the costs may be due to the higher maintenance of the renewal fees in the U.S., as GRANS demonstrated the statistically negative significant result.

We have the same result in model 3 with profit margin as the dependent variable, but the only difference with model 2 is that all of the variables are statistically significant. Again, this is an interesting result as the patent application in both territories (APPM and APPS) had a negatively statistically significant relationship with the firms' profit margin. This may show that the negative profits (or loss) received cannot cover the positive sales earned. This situation may signal that the firm is trying to adjust with the initial costs of the patenting activity, that is, the costs associated with applying for the patent, such as patent attorney or agent and application costs. Furthermore, the application stage may also show that the firm is operating during the short run period, as discussed in Chapter 3, during which time the firm may not be able to change any of the variable costs and may have to bear the costs. On the other hand, the negative GRANS may show that the Malaysian firms are able to sell the patented invention in the U.S.; however the firms' costs, in addition to patent renewal fees such as administrative and operative costs, may be relatively higher compared to the home country Malaysia, and may result in a negative impact on the profit margin in the U.S.

5.5.2.2 Manufacturing Firms

Unsurprisingly, almost all of the signs in the manufacturing firms sample matched the all firms sample and, further, more statistically significant variables were found in the manufacturing firms samples compared to the all firms sample. In Chapter 4 we learned that the manufacturing firms sample contains 149 firms, which accounted for 73% of 203 firms in the all firms sample. In Chapter 3, on the other hand, we learned that many studies relate patenting activity with manufacturing firms. Hence, it is unsurprising to have found more statistically significant variables in the manufacturing firms sample. The only difference in reported sign with the all firms sample was the patent granted in Malaysia (GRANM), with the manufacturing firms sample having a negative sign, unlike the positive sign in the all firms sample. Since the firms are manufacturing firms, the negative results of granted patents in the Malaysia territory may have been due to the firms renewing their patent in the Malaysian territory for exporting purposes, as argued earlier in Section 5.5.1.3. Thus, the patented invention was not meant to be sold in Malaysia, which gave a negative impact on their sales. Our anticipation can also be supported due to the fact that Malaysia has had extensive experience in the manufacturing and exporting industries. Therefore, this may be the reason why renewal fees in the Malaysian territory continued to be paid, even though the sales were found to be negatively and significantly related. The export market of the patented invention in the manufacturing firms may also be the reason why the sales were positively related to the granted patents in the U.S. territory, which is similar to the all firms sample.

There is one interesting finding that must also be explained further relating to the manufacturing firms sample in our study, that is, the GRANM variable. Even though the result for sales was found earlier on to be negatively related and statistically significant, the profits of the firms were found to be positively related but not statistically significant. Thus, the profit margin has not only given a statistically significant result, but a positive sign. To explain why the result turned out in this way, in Chapter 2 we learned that while a patent can be a product, it can also be a process. In the manufacturing firms there must be some processes which can reduce operating costs. Thus, we expect that these manufacturing firms must have patented the manufacturing processes to reduce the business costs, so that they could be more efficient in selling their manufacturing products (which had also been patented) in the overseas market. This may explain why the profit margin was positively related with the patents granted in the Malaysian territory, but negatively with the sales.

5.5.2.3 Overall Summary

As an overall summary, we have answered the first subsidiary research question in Chapter 1, that is, there is a statistically significant relationship between the patents applied for and granted to Malaysian firms in both Malaysia and the U.S. and their financial performance. However, depending on the variable selection, measurement, estimation, and sample under study, the sign may give a positive or negative result. The sales variable which represents the demand and supply of the patented invention in both territories were all positive with the explanatory variables, except in the manufacturing firm sample for the granted patent in the Malaysian territory (see previous paragraph for the reason). This simply shows that the Malaysian patented invention has a place in both territories. While we anticipated a positive relationship ex-ante with the theoretical basis of the profit maximizing model, having negative profits when empirically tested with the ex-post data was not a surprise. This is because in Chapter 1 we learned that Malaysian is still in its infancy stage in terms of patenting activity.

Furthermore, in Chapter 4 we learned that even though our study is based on economics theory, our empirical data comes from the financial statements of the firm. Therefore, we basically were measuring accounting profits empirically. In relation to the market condition analyzed in Chapter 4, having negative profit (loss) is not a surprise. This is because the market condition analysis in Chapter 4 shows that both samples (the all firms and manufacturing firms sample) had a competitive market condition. This means, theoretically, that the firms may experience normal or less than normal economic profits both in the short and long run.

Table 5.18: Summary of Findings Based on Hypotheses Development – All Firms

Hypotheses Statements	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between Malaysian patent applied for by Malaysian firms and their financial performance.	APPM (+)	**APPM (+)**	APPM (+)	APPM (–)	APPM (+)	**APPM (–)**
There is a positive significant relationship between Malaysian patent granted to Malaysian firms and their financial performance.	GRANM (+)	GRANM (+)	GRANM (+)	**GRANM (+)**	GRANM (+)	**GRANM (+)**
There is a positive significant relationship between U.S. patent applied for by Malaysian firms and their financial performance.	APPS (+)	APPS (+)	APPS (+)	APPS (–)	APPS (+)	**APPS (–)**
There is a positive significant relationship between U.S. patent granted to Malaysian firms and their financial performance.	GRANS (+)	**GRANS (+)**	GRANS (+)	**GRANS (–)**	GRANS (+)	**GRANS (–)**

The boldface variables and signs are statistically significant based on Table 5.17. The statistically insignificant signs are based on the majority of cases. Please refer table 5.4, 5.5, 5.6, 5.11, 5.12 and 5.13 for detail results.

Table 5.19: Summary of Findings Based on Hypotheses Development – Manufacturing Firms

Hypotheses Statements	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between Malaysian patent applied for by Malaysian firms and their financial performance.	APPM (+)	**APPM (+)**	APPM (+)	APPM (–)	APPM (+)	**APPM (–)**
There is a positive significant relationship between Malaysian patent granted to Malaysian firms and their financial performance.	GRANM (+)	**GRANM (–)**	GRANM (+)	GRANM (+)	GRANM (+)	**GRANM (+)**
There is a positive significant relationship between U.S. patent applied for by Malaysian firms and their financial performance.	APPS (+)	APPS (+)	APPS (+)	**APPS (–)**	APPS (+)	**APPS (–)**
There is a positive significant relationship between U.S. patent granted to Malaysian firms and their financial performance.	GRANS (+)	**GRANS (+)**	GRANS (+)	**GRANS (–)**	GRANS (+)	**GRANS (–)**

The boldface variables and signs are statistically significant based on Table 5.17. The statistically insignificant signs are based on the majority of cases. Please refer to tables 5.7, 5.8, 5.9, 5.14, 5.15 and 5.16 for detailed results.

5.6 Chapter Summary

This chapter answered the first subsidiary research question of this study. In the beginning of Chapter 1, the research question seemed to be very straightforward and simple to answer. However, this chapter has proved that it is not as simple as it may seem. With two types of samples, two types of panel model, and four types of estimators, we have successfully answered our first subsidiary research question, which also mean answering Hypothesis 1. The next chapter will answer the second subsidiary research question posited in Chapter 1 as to what is the relationship between patent quality and financial performance at the Malaysian firm level for firms which have been granted patents in Malaysia and the U.S.

CHAPTER 6 PATENT QUALITY AND FINANCIAL PERFORMANCE

6.0 Introduction

This chapter answers the second subsidiary research question in Chapter 1 as to the relationship between patent quality and financial performance at the Malaysian firm level. Therefore, it will answer Hypothesis 2 developed in Chapter 3 relating to the patent quality measures. The division of the subsections of this chapter is similar to that of Chapter 5. Section 6.1 introduces the model specification and measurement of the variables. Section 6.2 tests if we have violated the regression assumptions and measures taken to overcome the violations. This is to make sure that our results are robust, unbiased and consistent. Sections 6.3 and 6.4 describe the results for the panel and dynamic panel data model, respectively. The panel model is estimated with panel least squares (PLS), fixed effects model (FEM) and random effects model (REM), while the dynamic panel is estimated with generalized method of moments (GMM). The results are reported separately for the two samples in our study, 1) all firms; and 2) manufacturing firms which have been granted patents. Finally, Section 6.5 summarizes our results based on the types of estimations and hypotheses development. The former focuses on the estimations with statistically significant variables and the magnitude of the variables in the two samples of our study. The latter ties up the results focusing on the reported sign, with the expected sign developed in the hypotheses development.

6.1 Model Specification

Similar to Chapter 5, we employ three different models, each representing different dependent variables: sales (Model 1), profits (Model 2), and profit margin (Model 3). The control variables of the firm size and age will also be similar to those in Chapter 5, and the only differences are the explanatory variables, the backward citation, claim, and family. The basic econometric model is established in Equation (6.1), which corresponds to Hypothesis 2 developed in Chapter 3.

$$Y_{it} = c_0 + \beta_1 MBWC_{it} + \beta_2 SBWC_{it} + \beta_3 MCL_{it} + \beta_4 SCL_{it} + \beta_5 FAM_{it} + \delta_1 LNTGA_{it} + \delta_2 NAGE_{it} + \mu_{it} \tag{6.1}$$

where c_0 is the constant; MBWC and SBWC is the number of backward citations in the Malaysian and U.S. patent system respectively; MCL and SCL is the number of patent claims in the Malaysian and U.S. patent system respectively; FAM is the patent family; LNTGA is the tangible assets of the firm which has been log transformed; and NAGE is the number of the firm's age since incorporation. The measurement of these variables will be discussed next. i = 1,2,3,…. N specific firms over t = 1,2,3,…..T time periods with $\mu_{it} = u_i + \nu_{it}$ where u's describe the firm-specific time invariant effect and ν's are the idiosyncratic error terms. The idiosyncratic error terms are assumed to come from normal distributions, independent of each other. As discussed in Chapter 4, since we employed both the fixed and random effects estimation in our study, the u_i is treated differently between the two estimations. The fixed effects model allows the u_i cross-section specific error component to be correlated with the explanatory variables, while the random effects model assumed μ_i not to be correlated with each other (Gujarati, 2003).

6.1.1 Measurement of Variables

As mentioned earlier, the dependent and control variables are similar to those in Chapter 5. The only differences are the explanatory variables MBWC, SBWC, MCL, SCL, and FAM. MBWC and SBWC are measured by the number of backward citations in the patent specification to the number of patent stocks in the Malaysian and U.S. territory respectively. MCL and SCL are measured by the number of claims in the patent specification to the number of patent stocks in the Malaysian and U.S. territory respectively. Since we had access only to those patent specifications which had been granted patents both in the Malaysian and U.S. territory, only granted patents were taken into account. Thus, this situation differs from Chapter 5, which also takes into consideration patents that are pending to be granted. In addition, the measurement of the number of patent stocks needs to be highlighted. The calculation of the patent stocks begins when the patent is applied for and continues to be calculated while it is being granted and until the end of the time series dimension. This is because the explanatory variables which are the backward citations and claims are the proxy of knowledge which the firms have, as discussed in Chapter 3. Thus, we believe that once the patent is applied for, the knowledge comes along with the invention and stays with the firm. We were interested to learn, however, whether the knowledge from the patented invention would bring a significant result to the firm's financial performance.

Unlike Chapter 5, in which the measurement of the patent stocks are based on application or granted date and in a fraction of 365 days, here we calculate the patent stocks which are value-weighted with the backward citation and claim. The measurement of the patent starts with the year of application. For example, if a particular patent was applied for in year 2000 and had 5 backward citations, the ratio for that backward citation to the patent stock is 5. It will be measured as 5 until the end of the time series dimension of that particular firm. Since a firm can apply for more than one patent, the backward citations will be added up and divided by the additional number of patent stocks for the firm. This simple weighting scheme is applied to the number of backward citations (MBWC and SBWC) and claims (MCL and SCL) in both territories. On the other hand, FAM is recognized by matching the *priority data* in both territories. It is measured using the dummy variable of the patent having a family and not having a family in the Malaysian and U.S. territories. Since we employ panel data, the calculation with the measurement only starts when the priority data finds a match in both territories. For instance, if a particular patent is first granted in 1999 in Malaysia but the same patent is only granted in the U.S. in 2001, the FAM variable will only start to be calculated as having a family in 2001. The measurement of the data is calculated using an Excel spreadsheet, before being transferred to EViews version 7 for analysis.

6.2 Relaxing the Assumptions

As mentioned in Chapter 5, it is important to meet certain regression assumptions to make sure that the results are robust, unbiased and consistent. Therefore, we explore whether some regression assumptions have been violated.

6.2.1 Multicollinearity

Unlike the model specification in Chapter 5 in which we found no perfect, near, or serious multicollinearity problem, we found a high correlation of 0.70 to 0.90 between the backward citations and claims in both territories, as shown in tables 6.1 and 6.2. As argued in Chapter 3, this is not a surprise as both variables may resemble the stock of knowledge, that is, the knowledge flows in backward citation and the new knowledge for claims. Therefore, we conducted another analysis to diagnose the seriousness of the multicollinearity, that is, the variance inflation factor (VIF), which is defined in

Equation (6.2). The VIF shows how the variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2003).

$$VIF = \frac{1}{(1-R_j^2)} \tag{6.2}$$

The R_j^2 is the result of an auxiliary regression that tests each explanatory variable with the regressors in Equation (6.1). As a rule-of-thumb, Marquardt (1980) suggests that if VIF is greater than 10, there is too much correlation between the X_j and the other regressors. This situation also means that the multicollinearity is serious. Since we have PLS, FEM and REM as our estimations, we tested the auxiliary regressions with all three specifications. Table 6.3 shows the VIF for the PLS and REM in the all firms sample; these were all below 2, while in FEM they were all below 6. This test confirms that all of our explanatory variables in the all firms sample do not suffer from a serious multicollinearity problem. The VIF results in the manufacturing samples are similar with the all firms sample, except for MBWC in the FEM estimation which is nearly 10. Nevertheless, we do not have to worry further as the figure is less than 10. Furthermore, the F-test in the model specifications for the FEM estimation for the manufacturing sample shows a significant result. The F-test is to test the significance for the overall model specification. The t-statistics also shows that at least one of the explanatory variables has a significant impact on the dependent variable.

Table 6.1: Correlation Matrix – All Firms

	LNSALES	LNPROFITS	LNPM	MBWC	SBWC	MCL	SCL	FAM	LNTGA	NAGE
LNSALES	1									
LNPROFITS	0.901357	1								
LNPM	0.007449	0.439779	1							
MBWC	0.255847	0.224754	-0.01162	1						
SBWC	0.215583	0.174965	-0.04308	0.161426	1					
MCL	0.225278	0.184325	-0.04157	0.782423	0.210795	1				
SCL	0.184446	0.157943	-0.01781	0.120852	0.82611	0.188819	1			
FAM	0.185923	0.172135	0.011896	0.22052	0.122033	0.192377	0.276516	1		
LNTGA	0.935174	0.907508	0.156087	0.264607	0.201301	0.229397	0.174761	0.197376	1	
NAGE	0.266472	0.260124	0.04802	0.040248	0.073739	-0.02455	0.084871	0.099868	0.278645	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; MBWC, SBWC, MCL, SCL and FAM are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age.

Table 6.2: Correlation Matrix – Manufacturing Firms

	LNSALES	LNPROFITS	LNPM	MBWC	SBWC	MCL	SCL	FAMILY	LNTGA	NAGE
LNSALES	1									
LNPROFITS	0.89135	1								
LNPM	0.068096	0.512961	1							
MBWC	0.162377	0.076131	-0.13993	1						
SBWC	0.337241	0.266038	-0.0531	0.333568	1					
MCL	0.181092	0.087317	-0.15075	0.782202	0.356336	1				
SCL	0.298649	0.240844	-0.03547	0.018753	0.651403	0.105015	1			
FAM	0.139514	0.111319	-0.01919	-0.00121	0.159249	0.060892	0.495944	1		
LNTGA	0.928987	0.889883	0.19934	0.134229	0.304672	0.150804	0.289505	0.149235	1	
NAGE	0.211725	0.218275	0.079461	-0.02472	-0.01695	-0.04691	0.046803	0.070115	0.228841	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; MBWC, SBWC, MCL, SCL and FAM are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age.

Table 6.3: Variance Inflation Factor (VIF) – All Firms

Estimations	PLS		FEM		REM	
Explanatory Variables	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF
MBWC	0.580374	1.507918	0.912341	5.965381	0.668825	1.809388
SBWC	0.680257	1.861329	0.883865	4.570746	0.625063	1.641238
MCL	0.607775	1.585767	0.908794	5.744041	0.684833	1.883226
SCL	0.709324	2.012642	0.874721	4.257798	0.662683	1.783004
FAM	0.188607	1.036885	0.560805	1.458794	0.133505	1.018147

Table 6.4: Variance Inflation Factor (VIF) – Manufacturing Firms

Estimations	PLS		FEM		REM	
Explanatory Variables	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF
MBWC	0.604845	1.576883	0.944015	9.188163	0.727106	2.121715
SBWC	0.660106	1.772232	0.883421	4.554411	0.605855	1.579929
MCL	0.630307	1.659164	0.923957	6.835108	0.732655	2.158817
SCL	0.714836	2.04495	0.896946	5.115407	0.676041	1.841727
FAM	0.327141	1.119847	0.632567	1.667058	0.248958	1.066075

6.2.2 Autocorrelation

As explained in Chapter 5, the DW test is used to test if autocorrelation exists for the panel data model. We found that serial autocorrelation was present, and therefore corrected the first-order serial correlation with autoregressive errors of order 1 or an AR(1) model. As for the dynamic panel, following the explanation in Chapter 5, the GMM estimation has taken care of the autocorrelation problem.

6.2.3 Heteroskedasticity

As explained in Chapter 5, we took measures to correct for the heteroskedasticity problem. We chose the White Cross-Section coefficient covariance method to correct for heteroskedasticity in our panel model, and White Period in our dynamic panel model. This is due to the fact that the White's coefficient covariance method gave us the majority of statistically significant explanatory variables compared to seemingly unrelated regression (SUR) and panel corrected standard error (PCSE).

6.2.4 Misspecification

In this chapter, the potential misspecification of the model surrounds the patent citation. As discussed in Chapter 3, previous literature includes the forward citation to measure the patent quality. Nevertheless, as discussed in Chapter 4, the forward citation data was unavailable to us in both territories. Another important variable which we may have misclassified relates to the patent family. For this study, we were unable to search for the same patent that has also been patented in areas of the world other than the Malaysian and U.S. territories. For example, the firm may also have applied for patent protection for the same patent in Japan, Australia or Europe. We tested for a general misspecification using the Ramsey (1969) Regressions Specification and Error Test (RESET) and normality of the residuals test of Jarque-Bera (1980).

A similar RESET test result with the patent renewal and application measures (see Chapter 5, Table 5.3) was found. For model 1 with the REM estimation, the model was not misspecified in the all firms sample and with FEM estimation in the manufacturing firms sample. Nevertheless, with the cross-section fixed effects specification in the manufacturing firms sample, the F statistic had a value of 3.95 which was slightly higher than the F-critical value of 3.85 for us not to reject the null of no model misspecification. On the other hand, similar to Chapter 5, we found the Jarque-Bera (1980) normality residual test was not met in all of our specifications. Nevertheless, since our observations were large, we followed the central limit theorem (CLT) assumptions. The CLT shows that if there is a large number of independent and identically distributed random variables, then with few exceptions the distribution of their sums tends to a normal distribution as the number of such variables increases indefinitely (Gujarati, 2003).

Table 6.5: RESET Test

RESET Test	Null Hypotheses: No Model Misspecification									
Sample	All Firms					Manufacturing Firms				
Estimation	PLS	FEM	FEM	REM	REM	PLS	FEM	FEM	REM	REM
Effects Specification	-	cross-section fixed	cross-section & period fixed	cross-section random	period random	-	cross-section fixed	cross-section & period fixed	cross-section random	period random
Model 1: Sales	Do not reject null	Reject null	Reject null	Do not reject null	Do not reject null	Reject null	Reject null	Do not reject null	Reject null	Reject null
Model 2: Profits	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null
Model 3: Profit Margin	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

6.3 Panel Model Results

As discussed in Chapter 4, our panel model was estimated using panel least squares (PLS), a fixed effects model (FEM), and a random effects model (REM). The model specifications were run with two separate samples which consisted of all firms and manufacturing firms with granted patents. The results of these two samples are presented separately in different tables.

6.3.1 Panel Least Square

All specifications using panel least square (PLS) in our study were run with White's corrected standard error to correct for heteroskedasticity. In a separate specification, we first ran without the correction for autocorrelation (see Column 1 of tables 6.6 to 6.11), then ran with the AR(1) correction (see Column 2 of tables 6.6 to 6.11). In the all firms sample, the R-squared shows an improvement with the AR(1) correction, when comparing the regression without the AR(1) correction. The increase of R-squared in model 1 was more than 10% while model 2 shows an increase of 9%, even though the number of observations dropped by 9% and 19% respectively (see columns 1 and 2 of tables 6.6 and 6.7). Similar to Chapter 5, model 3 with profit margin as the dependent variable has the highest increase of its R-squared from 4% to 44%, with the AR(1) correction (see columns 1 and 2 of Table 6.8). In the manufacturing firms sample, the R-squared is found to be similar with the all firms sample (see columns 1 and 2 of tables 6.9 to 6.11). On the other hand, the control variables of LNTGA and NAGE are found to have a positively statistically significant impact on the dependent variable in almost all of the three model specifications (see tables 6.6 to 6.11).

6.3.1.1 <u>All Firms</u>

Moving into specific explanatory variables in the specification of model 1, MCL is found to be positively statistically significant at the 10% level (see Column 2 of Table 6.6). Since FAM is a dummy variable, the size of the coefficients relative to the constant shows that having a patent family in both territories increases the firm's sales by 0.07% (see Column 2 of Table 6.6). In model 2, on the other hand, MCL is found to have a negatively significant impact with the firm's profits at the 1% level; however, the magnitude is very small. It shows that a unit increase in the backward citation in the Malaysian patent specification decreases the firm's profits by 0.4% (see Column 1 of Table 6.7). Since the constant is statistically significant, the size of the coefficients in the FAM relative to the constant shows that having a patent family in both territories decreases the firm's profits by 4% (see Column 1 and 2 of Table 6.7). Moving into model 3, SBWC and MCL are found to be negatively statistically significant ranging across the 5% to 10% level with the PLS. Nevertheless, the magnitude of the coefficients of the significant variables is very small. Both variables have a similar magnitude with a unit increase in either the backward citation in the U.S. patent specification or claim in the Malaysian patent specification decreasing the firm's profit margin by 5% to 8% (see columns 1 and 2 of Table 6.8). Similar to model 2, since the constant is statistically significant, the size of the coefficients in the FAM relative to the constant shows that having a patent family in both territories decreases the firm's profit margin by 4% to 5% (see columns 1 and 2 of Table 6.8).

6.3.1.2 Manufacturing Firms

As in the manufacturing firms sample, MCL and FAM in model 1 are found to be positively significant ranging across the 1% to 5% level. A unit increase in the claim in the Malaysian patent specification increases the firm's sales by 0.2% to 0.9% (see columns 1 and 2 of Table 6.9). The size of the coefficients in the FAM on the other hand relative to the constant shows that having a patent family in both territories increases the firm's sales by 0.28% to 4.7% (see Column 1 of Table 6.9). In model 2 on the other hand, and interestingly, there are four explanatory variables which are statistically significant - SBWC has a positive impact, but MCL, SCL and FAM have a negative impact. The negative significant impact is larger with the claim in the U.S. patent specification compared to the Malaysian patent specification. However, the differences are only in half percentages, where a unit increase in claims in U.S. patent specification decreases the firm's profits by 1% compared to Malaysian patent specification by only 0.5% (see columns 1 and 2 of Table 6.10). With the FAM, the size of the coefficients relative to the constant shows that having a patent family in both territories decreases the firm's profit margin by 5% (see columns 1 and 2 of Table 6.10). Model 3, on the other hand, also has MCL and SCL as having a negatively statistically significant impact at the 1% level. The coefficient magnitude is also very low with a unit increase in a claim either in the U.S. or Malaysian patent specification decreasing the firm's profit margin by 1% (see columns 1 and 2 of Table 6.11). Similar to model 2, the size of the coefficients in FAM relative to the constant shows that having a patent family in both territories decreases the firm's profit margin by 5% to 6% (see columns 1 and 2 of Table 6.11).

6.3.2 Fixed Effects Model / Random Effects Model

Three specifications were run with the fixed effect model (FEM) using White's corrected standard error to correct for heteroskedasticity. All three were given a cross-section fixed effects specification, but for the third specification a two-way fixed effect model was added with a period fixed effect. The difference between the first and the second specification is that an AR(1) correction was added to the second specification. As for the random effects (REM), only two separate specifications were run, first with cross section random effects and second with period random effects specifications. The results for FEM are shown in columns 3, 4 and 5, while the REM results are shown in columns 6 and 7 in tables 6.6 to 6.11.

The R-squared for all three specifications in the all firms sample are high with more than 90% for FEM, but slightly lower for REM with 84% and 82% for the two specifications in model 1 and model 2, respectively (see columns 3 to 7 of tables 6.6 and 6.7). Model 3 with profit margin as the dependent variable shows a much lower R-squared with 52% to 61% with the FEM (see columns 3 to 5 of Table 6.8) and a very low R-squared with the REM of only 4% (see columns 6 and 7 of Table 6.8). The manufacturing firms sample, on the other hand, has a slightly lower R-squared compared to the all firms sample, except for the higher value of 8% for model 3 (see columns 3 to 7 of tables 6.9 to 6.11). Similar to the all firms sample, the control variables of LNTGA and NAGE have a positively statistically significant impact on the dependent variable in almost all of the three model specifications (see tables 6.6 to 6.11).

6.3.2.1 <u>All Firms</u>

Similar to PLS, the FEM and REM estimations have similar variables with a statistically significant impact on the dependent variables across the three models - the sales, profits, and profit margin. In model 1, only MCL has a positively statistically significant impact ranging across the 1% to 5% level with the FEM, but no significant impact in the REM (see columns 4 to 7 of Table 6.6). Model 2 has the claim in patent specifications in Malaysia having a negatively significant relationship with a unit increase in claim decreasing the firm's profits by 1% with the FEM (see columns 3 to 5 of Table 6.7) and a much lower magnitude of 0.4 to 0.5% with the REM (see columns 6 and 7 of Table 6.7). However, the MBWC provides a positively statistically significant impact at the 1% level. It shows that a unit increase in the backward citation in the Malaysian patent specification increases the firm's profits by 4% (see columns 4 and 5 of Table 6.7). Nevertheless, SBWC gives a negatively significantly relationship but only with the FEM estimation, with an AR(1) correction at the 5% level. Interestingly, however, this time with the FEM estimation, the FAM starts to give a significantly statistically relationship with profits. Since FAM is a dummy variable, the size of the coefficients relative to the constant shows that having a patent family in both territories decreased the firm's profits by 7% to 9% (see columns 3 to 5 of Table 6.7).

In model 3, the size of the coefficients relative to the constant in FAM has a much lower effect where having a patent family in both territories decreases the firm's profits by 4% to 8% (see columns 3 to 5 of Table 6.8). Other than the FAM variable which has a significant impact in model 3, the MBWC and MCL both have a positively and negatively statistically significant impact respectively, ranging across the 1% to 10% level. The magnitude, however, is slightly higher for MBWC with a 3% increase, compared to MCL with a 1% to 2% decrease on the firm's profit margin (see columns 3 to 5 of Table 6.8).

6.3.2.2 Manufacturing Firms

Unlike the all firms sample in which only MCL is found to be statistically significant, in the manufacturing firms sample all of the explanatory variables are found to be statistically significant in at least one of the FEM/REM estimations. MBWC, SBWC and MCL are found to have a positive impact on the firm's sales, with MBWC having the highest impact of 4% followed by SBWC and MCL with an impact of 1% (see columns 3 to 7 of Table 6.9). SCL, however, has given a contradicting sign to the coefficients across the model specifications with REM a negative impact, and FEM a positive impact. However, the magnitude is small for both estimations with FEM having a 2% increase and REM a 0.3% decrease (see columns 5 and 6 of Table 6.9). The size of the coefficients in the FAM on the other hand relative to the constant shows that having a patent family in both territories has a contradicting sign between the FEM and REM specifications. In the FEM estimation, having a family increases the firm's sales by 3% to 6% (see columns 4 and 5 of Table 6.9), while in the REM estimation having a family decreases the firm's sales by 0.28% (see columns 6 and 7 of Table 6.9).

Moving to model 2, only backward citation in the U.S. patent specification has given a positively statistically significant impact at the 1% to 5% level with the REM estimations (see columns 6 and 7 of Table 6.10). Other explanatory variables in model 2, however, show a negatively statistically significant relationship, with having a patent family displaying the highest decrease ranging across 5% to 10%, followed by claim in both territories having a negative impact of 1% on the firm's profits (see columns 3 to 7 of Table 6.10). Model 3, on the other hand, also shows a similar result to model 2, except for SBWC with no statistically significant impact. The other explanatory variables have a negatively statistically significant impact ranging across 1% to 10% level. Similar to the results for model 2, model 3 also shows that having a patent family has the highest decrease ranging across 5% to 10%, followed by a claim in both territories having a negative impact of 1% to the firm's profit margin (see columns 3 to 7 of Table 6.11).

Table 6.6: Panel Model Result for Model 1 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.309255**	4.10343***	-1.479949	-4.363738	-1.490573	0.309255***	0.311541**
	(0.154617)	(0.913606)	(3.886675)	(4.344316)	(4.21884)	(0.092014)	(0.15703)
MBWC	0.00827	0.008311	0.002254	0.001542	0.004966	0.00827***	0.008675
	(0.007742)	(0.013798)	(0.007169)	(0.007631)	(0.007028)	(0.004766)	(0.008073)
SBWC	0.002756	-0.011516	-0.006424	-0.014624	-0.006683	0.002756**	0.002835
	(0.002108)	(0.011374)	(0.004911)	(0.010495)	(0.004807)	(0.001372)	(0.002325)
MCL	-0.000653	0.00694*	0.006215***	0.008092***	0.004781**	-0.000653	-0.000485
	(0.002181)	(0.003587)	(0.002091)	(0.002668)	(0.001983)	(0.001223)	(0.002076)
SCL	0.000406	0.008805	0.00404	0.007404	0.004032	0.000406	0.000429
	(0.001344)	(0.009315)	(0.002686)	(0.005491)	(0.002674)	(0.001212)	(0.002053)
FAM	-0.229179***	-0.02874	0.052556	-0.053358	-0.016351	-0.229179**	-0.233816
	(0.082923)	(0.137662)	(0.090757)	(0.085835)	(0.081791)	(0.109864)	(0.18628)
LNTGA	0.952316***	0.703664***	0.744408***	0.630679***	0.726646***	0.952316***	0.952893***
	(0.009657)	(0.06067)	(0.033024)	(0.063858)	(0.040325)	(0.005993)	(0.010158)
NAGE	0.015798***	0.034784***	0.266169	0.49583**	0.28133	0.015798***	0.015426***
	(0.002147)	(0.010733)	(0.193998)	(0.20507)	(0.204885)	(0.001739)	(0.002948)
R-Squared	0.84075	0.942195	0.949722	0.960012	0.950397	0.84075	0.840962
Number of Observations	2225	2022	2225	2022	2225	2225	2225

The dependent variable is sales. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.7: Panel Model Result for Model 2 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-3.602937***	-3.651269***	-6.647025	-7.217788	-8.127073*	-3.602937***	-3.600048***
	(0.185938)	(0.670277)	(4.498529)	(5.517113)	(4.566177)	(0.164313)	(0.210822)
MBWC	0.00577	0.005976	0.037956***	0.043012***	0.040129***	0.00577	0.006185
	(0.009367)	(0.018489)	(0.010784)	(0.014487)	(0.012018)	(0.007943)	(0.010114)
SBWC	-0.003645	-0.005548	-0.006908	-0.011648**	-0.006733	-0.003645	-0.003717
	(0.003795)	(0.004731)	(0.004558)	(0.005354)	(0.004881)	(0.002332)	(0.002968)
MCL	-0.004765***	-0.00155	-0.00999***	-0.012266***	-0.010439***	-0.004765**	-0.004405*
	(0.001301)	(0.003779)	(0.003244)	(0.004056)	(0.003734)	(0.002053)	(0.002623)
SCL	0.003653	0.005122	0.008048**	0.014203**	0.008376**	0.003653	0.003927
	(0.002607)	(0.005404)	(0.004084)	(0.006502)	(0.004091)	(0.002293)	(0.00292)
FAM	-0.203875	-0.355377	-0.659669**	-0.811219**	-0.709004***	-0.203875	-0.206089
	(0.176472)	(0.266983)	(0.258833)	(0.334469)	(0.262476)	(0.208673)	(0.26582)
LNTGA	1.051191***	1.035765***	0.741183***	0.652494***	0.73466***	1.051191***	1.051395***
	(0.012333)	(0.036073)	(0.046549)	(0.075424)	(0.068096)	(0.010163)	(0.01295)
NAGE	0.001798	0.012682*	0.376506*	0.464167**	0.448716**	0.001798	0.001483
	(0.002831)	(0.007406)	(0.211676)	(0.227443)	(0.210281)	(0.002903)	(0.003698)
R-Squared	0.824409	0.897112	0.904656	0.926521	0.90635	0.824409	0.8248
Number of Observations	1689	1366	1689	1366	1689	1689	1689

The dependent variable is profits. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.8: Panel Model Result for Model 3 with PLS, FEM & REM Estimations – All Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.264309***	-4.909889***	-4.91465**	-3.250321	-7.518102***	-4.264309***	-4.264309***
	(0.164518)	(0.558147)	(2.10848)	(2.876265)	(2.293212)	(0.160462)	(0.213023)
MBWC	0.005164	0.014337	0.033369**	0.039131**	0.032807**	0.005164	0.005164
	(0.017107)	(0.021075)	(0.013585)	(0.017164)	(0.014413)	(0.007757)	(0.010297)
SBWC	-0.008041**	-0.006141	-0.004797	-0.003612	-0.004183	-0.008041***	-0.008041***
	(0.004066)	(0.007059)	(0.005368)	(0.007179)	(0.00574)	(0.002277)	(0.003023)
MCL	-0.00571**	-0.008103*	-0.01385***	-0.018831***	-0.012635***	-0.00571***	-0.00571**
	(0.002611)	(0.004381)	(0.003591)	(0.00478)	(0.004095)	(0.002005)	(0.002662)
SCL	0.004274	0.003652	0.007065	0.010705	0.007142	0.004274*	0.004274
	(0.002896)	(0.006434)	(0.00442)	(0.006976)	(0.004449)	(0.002239)	(0.002972)
FAM	-0.168828	-0.304091	-0.725075***	-0.785481**	-0.73174**	-0.168828	-0.168828
	(0.218465)	(0.331289)	(0.273307)	(0.338395)	(0.286074)	(0.203781)	(0.270532)
LNTGA	0.092911***	0.116901***	-0.055803	0.055117	-0.017318	0.092911***	0.092911***
	(0.012329)	(0.035893)	(0.034808)	(0.05748)	(0.050031)	(0.009925)	(0.013176)
NAGE	-0.00029	0.007059	0.142902	-0.016663	0.231179***	-0.00029	-0.00029
	(0.002886)	(0.007938)	(0.090541)	(0.100806)	(0.088481)	(0.002835)	(0.003764)
R-Squared	0.035957	0.441998	0.515229	0.610631	0.520073	0.035957	0.035957
Number of Observations	1689	1366	1689	1366	1689	1689	1689

The dependent variable is profit margin. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.9: Panel Model Result for Model 1 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.464715***	4.719923***	-1.898843	-5.975824	-1.954363	0.464715***	0.464715**
	(0.099861)	(1.303403)	(4.642143)	(4.882102)	(4.844025)	(0.107363)	(0.18747)
MBWC	0.008061	0.017047	0.032068*	0.01616	0.036464**	0.008061	0.008061
	(0.006592)	(0.032414)	(0.016861)	(0.021163)	(0.016634)	(0.005629)	(0.00983)
SBWC	0.006076	-0.045069	-0.020287	-0.040209	-0.020876	0.006076**	0.006076
	(0.007606)	(0.031843)	(0.01562)	(0.024974)	(0.015667)	(0.002358)	(0.004117)
MCL	0.002413*	0.008922**	0.000508	0.007155**	-0.001073	0.002413*	0.002413
	(0.001325)	(0.004423)	(0.002931)	(0.003326)	(0.002829)	(0.001334)	(0.002329)
SCL	-0.003456	0.025589	0.016575**	0.021528	0.016587**	-0.003456*	-0.003456
	(0.003343)	(0.0197)	(0.007845)	(0.013525)	(0.00785)	(0.001864)	(0.003255)
FAM	-0.186102	-0.056653	-0.259307*	-0.306526**	-0.310952**	-0.186102	-0.186102
	(0.116507)	(0.123909)	(0.141891)	(0.155152)	(0.133066)	(0.114926)	(0.200676)
LNTGA	0.95227***	0.696688***	0.825128***	0.683238***	0.806374***	0.95227***	0.95227***
	(0.005731)	(0.073976)	(0.032959)	(0.067744)	(0.042792)	(0.006814)	(0.011897)
NAGE	0.011404***	0.019355**	0.216175	0.512468**	0.233406	0.011404***	0.011404***
	(0.001146)	(0.008869)	(0.225873)	(0.22479)	(0.231771)	(0.001685)	(0.002942)
R-Squared	0.831941	0.944381	0.94969	0.960725	0.950434	0.831941	0.831941
Number of Observations	1694	1545	1694	1545	1694	1694	1694

The dependent variable is sales. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.10: Panel Model Result for Model 2 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.285887***	-4.571207***	-7.110154	-9.267037	-9.872638*	-4.285887***	-4.31168***
	(0.292013)	(0.593789)	(5.153028)	(6.481526)	(5.167501)	(0.213917)	(0.273457)
MBWC	-0.0201	-0.028637	0.026373	-0.01535	0.026139	-0.0201*	-0.019702
	(0.015182)	(0.033562)	(0.02012)	(0.029606)	(0.021006)	(0.010524)	(0.013352)
SBWC	0.012473**	0.01133*	-0.000145	-0.008171	0.000573	0.012473***	0.011826**
	(0.005186)	(0.006324)	(0.008981)	(0.010501)	(0.009085)	(0.00452)	(0.005737)
MCL	-0.005113**	-0.001623	-0.012699***	-0.008935*	-0.012079***	-0.005113**	-0.004439
	(0.002373)	(0.006051)	(0.004196)	(0.004943)	(0.004661)	(0.002466)	(0.003141)
SCL	-0.010896**	-0.008567*	-0.009019**	-0.003775	-0.007716**	-0.010896**	-0.00946
	(0.004341)	(0.00516)	(0.004255)	(0.003951)	(0.003922)	(0.004649)	(0.005914)
FAM	-0.205143	-0.431522	-0.283197	-0.479547	-0.297003	-0.205143	-0.217825
	(0.266998)	(0.307886)	(0.270815)	(0.328652)	(0.271856)	(0.254899)	(0.32353)
LNTGA	1.091099***	1.086486***	0.813903***	0.776044***	0.831882***	1.091099***	1.092631***
	(0.018571)	(0.035822)	(0.040933)	(0.076087)	(0.063231)	(0.013036)	(0.016576)
NAGE	0.004425	0.018317**	0.331466	0.451639*	0.438143*	0.004425	0.004145
	(0.003236)	(0.007527)	(0.229954)	(0.259141)	(0.228261)	(0.003161)	(0.004011)
R-Squared	0.795608	0.879446	0.887421	0.908946	0.889169	0.795608	0.79618
Number of Observations	1329	1101	1329	1101	1329	1329	1329

The dependent variable is profits. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.11: Panel Model Result for Model 3 with PLS, FEM & REM Estimations – Manufacturing Firms

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-5.083152***	-6.063455***	-5.151793**	-4.066725	-9.376706***	-5.083152***	-5.10127***
	(0.303381)	(0.561093)	(2.088142)	(3.107125)	(1.838059)	(0.202598)	(0.262895)
MBWC	-0.024755	-0.034136	0.007912	-0.024989	0.004494	-0.024755**	-0.02454*
	(0.018037)	(0.02785)	(0.018715)	(0.027797)	(0.018455)	(0.009967)	(0.012857)
SBWC	0.0000503	-0.000519	-0.001938	-0.007213	-0.000488	0.0000503	-0.000409
	(0.004153)	(0.005928)	(0.007308)	(0.009323)	(0.007427)	(0.004281)	(0.005524)
MCL	-0.007865***	-0.006472	-0.011834***	-0.012602***	-0.009419**	-0.007865***	-0.007311**
	(0.002232)	(0.005039)	(0.003847)	(0.004569)	(0.004109)	(0.002335)	(0.003023)
SCL	-0.012417***	-0.011613***	-0.012331***	-0.006924*	-0.01037***	-0.012417***	-0.011331**
	(0.003886)	(0.004277)	(0.004038)	(0.003556)	(0.003746)	(0.004403)	(0.005693)
FAM	-0.049338	-0.275503	-0.231456	-0.428451	-0.238166	-0.049338	-0.050112
	(0.241943)	(0.379666)	(0.270521)	(0.278036)	(0.270486)	(0.241411)	(0.311509)
LNTGA	0.138812***	0.181235***	-0.014519	0.116309**	0.057749**	0.138812***	0.139787***
	(0.0175)	(0.033418)	(0.01828)	(0.046477)	(0.028038)	(0.012347)	(0.015955)
NAGE	0.002766	0.012281	0.117332	-0.021448	0.247096***	0.002766	0.002569
	(0.003533)	(0.009584)	(0.082727)	(0.110155)	(0.06848)	(0.002994)	(0.003862)
R-Squared	0.083537	0.455896	0.510878	0.600698	0.518797	0.083537	0.081738
Number of Observations	1329	1101	1329	1101	1329	1329	1329

The dependent variable is profit margin. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

6.3.3 Hausman Test

As mentioned in Chapter 5, the Hausman test was conducted to determine which model is preferred between the FEM and REM. The results in Table 6.12 show that for the cross-section random effects specifications, the null hypothesis of favoring REM can be rejected for both samples at the 1% significance level. On the contrary, we found otherwise in the period random effects specifications if we were to use the 1% significance level, as shown in Table 6.12. As discussed in Chapter 4, this clearly shows that there is a significant correlation between the individual effects in the cross-section effects specification and the regressors. However, there is no such correlation between the time effects in the period effects specification with the regressors. This may show that individual effects such as the inventor's capability to learn and invent, firm's managerial decision to patent, and an investment decision to patent more than in one territory, for example, are correlated with the regressors. Nevertheless, the time effect such as the financial and economic crisis or changes in the government policy, for example, are not correlated with the regressors.

Table 6.12: Hausman Test

Hausman Test	Null hypothesis: REM is favored			
Sample	All Firms		Manufacturing Firms	
Effects Specification	cross-section random	period random	cross-section random	period random
Model 1: Sales	Reject null at 1% significance level	Reject null at 10% significance level	Reject at 1% significance level	Do not reject null
Model 2: Profits	Reject null at 1% significance level	Do not reject null	Reject at 1% significance level	Reject null at 10% significance level
Model 3: Profit Margin	Reject null at 1% significance level	Do not reject null	Reject at 1% significance level	Reject null at 10% significance level

6.4 Dynamic Panel Model Results

The dynamic panel model was estimated with generalized method of moments (GMM) estimation, as discussed in Chapter 4. Similar to the panel model result, the specification were run with two separate samples which consisted of all firms and manufacturing firms which had been granted patents. The results are presented and discussed separately.

6.4.1 Generalized Method of Moments

Similar to Chapter 5, we ran the GMM estimation with two types of cross-section transformation, specifically first differences (Arellano & Bond, 1991) and orthogonal deviations (Arellano & Bover, 1995), with a one-step cross-section fixed effects and a two-step cross-section and period fixed effects. We also ran the Sargan test to ensure that the error terms are not serially correlated with the instruments, to determine if the instruments can be considered as healthy instruments. For the instrumental variable (IV) we used all available lagged values of the dependent variables plus the values of the regressors (Judson & Owen, 1999). The results show that all of the specifications in this study meet the Sargan test requirements. The results also show that the single lagged dependent variable had a positively statistically significant impact at the 1% level in all specifications.

6.4.1.1 All Firms

MCL gives a negatively statistically significant impact in both of the cross-section transformation at the 1% to 5% significance level in model 1. On the other hand, MBWC gives a negatively statistically significant result with the orthogonal deviations cross-section transformations at the 1% significance level. However, the magnitude of the impact in both variables is rather small with a unit increase in the claim in the Malaysian patent specification decreasing the firm's sales by 1% (see columns 3 and 4 of Table 6.13); while a unit increase in the backward citation in the Malaysian patent specification increases the firm's sales by 2% (see columns 1 to 4 of Table 6.13).

Model 2, on the other hand, shows that all of the explanatory variables have given a statistically significant impact on the firm's profits in at least one of the effects specification and cross-section transformation. However, only SBWC gives impact in all of the effects specification and cross-section transformation to the firm's profits, with a unit increase in the backward citation in the U.S. patent specification decreasing the firm's profits by 1% to 2% (see columns 1 to 4 of Table 6.14). Unlike model 1, MBWC in model 2 gives a positively significant impact at the 1% to 10% level to the firm's profits with a magnitude ranging across 4% to 5% (see columns 3 and 4 of Table 6.14). FAM also starts to give a negatively significant result in model 2 (unlike model 1), but the magnitude is very small, that is, having a family decreases the firm's profits by 0.2% to 0.5% (see columns 3 and 4 of Table 6.14).

Finally, in model 3, there are only three out of five explanatory variables that are statistically significant – MBWC, MCL and FAM. Nevertheless, with the orthogonal deviations cross-section transformation, only FAM has a negative significant impact in the cross-section fixed effects specifications (see Column 3 of Table 6.15). With the orthogonal deviations cross-section transformation, it shows that a unit increase in the backward citation in the Malaysian patent specification increases the profit margin by 2% to 3% (see columns 3 and 4 of Table 6.15). On the other hand, a unit increase in the claim in the Malaysian patent specification decreases the firm's profit margin by only 1% (see Table 6.15).

6.4.1.2 <u>Manufacturing Firms</u>

In the manufacturing firms sample, all of the explanatory variables are found to be statistically significant, except for MBWC in model 1. This situation also shows that there are more explanatory variables found to be statistically significant compared to the all firms sample. The claim in the patent specifications in both territories, Malaysia and the U.S., are found to have a positively statistically significant impact on the firm's sales ranging across the 1% to 5% level. Nevertheless, the magnitude is small – a unit increase in the claim in either territory increases the firm's sales by 1% to 2%. (see Table 6.16). On the other hand, SBWC and FAM both have a negatively statistically significant impact on the firm's sales with the backward citation in the U.S. patent specification of a higher magnitude compared to having a patent family. This shows that a unit increase in the backward citation in the U.S. patent specification decreases the firm's sales by 1% to 4% (see Table 6.16), while having a patent family decreases the firm's profits by 0.2% to 0.3% (see columns 2 to 4 of Table 6.16). Similar to the all firms sample, the manufacturing firms sample in model 2 also has all the explanatory variables with a statistically significant impact on the firm's profits. This time, however, all the variables are negatively related with MBWC having the highest impact, followed by SBWC, SCL, MCL and finally FAM (see Table 6.17). The same situation with all explanatory variables having a negative impact on the firm's profit margin also occurs in model 3 (see Table 6.18).

Table 6.13: Dynamic Panel Model Result for Model 1 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.154455***	0.22872***	0.092346***	0.163069***
	(0.022342)	(0.0208)	(0.022835)	(0.019667)
MBWC	0.006076	0.002022	0.004496	-0.000453
	(0.012167)	(0.011591)	(0.00732)	(0.006974)
SBWC	-0.016117***	-0.016545***	-0.007807***	-0.006833***
	(0.003966)	(0.003665)	(0.001762)	(0.002162)
MCL	0.003805	0.003038	0.004597**	0.00665***
	(0.002719)	(0.002819)	(0.002142)	(0.002217)
SCL	0.01369***	0.009908***	0.004426***	0.002665*
	(0.002619)	(0.003219)	(0.001647)	(0.001431)
FAM	0.10616	-0.03307	-0.012334	-0.027577
	(0.140283)	(0.107278)	(0.083955)	(0.075428)
LNTGA	0.493613***	0.436966***	0.657136***	0.615227***
	(0.031928)	(0.036232)	(0.027514)	(0.026733)
NAGE	0.443341***	0.583742***		
	(0.16834)	(0.190555)		
Number of Observations	1819	1819	1819	1819

The dependent variable is sales. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.14: Dynamic Panel Model Result for Model 2 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.18558***	0.414625***	0.253164***	0.440966***
	(0.028298)	(0.034802)	(0.02554)	(0.032817)
MBWC	0.010282	0.009215	0.045247***	0.038474***
	(0.011324)	(0.013077)	(0.008213)	(0.009056)
SBWC	-0.017497***	-0.012764**	-0.00688**	-0.006409*
	(0.006333)	(0.005809)	(0.003301)	(0.003465)
MCL	-0.001255	-0.003893	-0.01489***	-0.012562***
	(0.002721)	(0.003337)	(0.002468)	(0.002875)
SCL	0.008205**	0.004656	0.007044	0.008259*
	(0.003671)	(0.003863)	(0.004366)	(0.004332)
FAM	-0.223949*	-0.334808	-0.373171**	-0.467566***
	(0.131908)	(0.20709)	(0.163115)	(0.17001)
LNTGA	0.437884***	0.259661***	0.577777***	0.480938***
	(0.043857)	(0.057167)	(0.040983)	(0.048786)
NAGE	0.327114***	0.151857		
	(0.07719)	(0.110706)		
Number of Observations	1185	1185	1185	1185

The dependent variable is profits. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.15: Dynamic Panel Model Result for Model 3 with GMM Estimation – All Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.337233***	0.354437***	0.411544***	0.453145***
	(0.030011)	(0.022027)	(0.025591)	(0.018165)
MBWC	0.009711	0.011785	0.025098***	0.021792***
	(0.018999)	(0.020388)	(0.009293)	(0.008399)
SBWC	-0.006332	-0.00429	0.000688	0.000787
	(0.008331)	(0.008363)	(0.004291)	(0.004694)
MCL	-0.00643*	-0.007547*	-0.011372***	-0.009309***
	(0.003599)	(0.004244)	(0.002511)	(0.002495)
SCL	0.000121	0.001204	0.004273	0.003825
	(0.005751)	(0.004996)	(0.005311)	(0.005452)
FAM	-0.206312	-0.248737	-0.414396**	-0.295732
	(0.222529)	(0.246297)	(0.195782)	(0.202082)
LNTGA	0.050831	0.027761	0.030318	0.089657***
	(0.038023)	(0.049502)	(0.024094)	(0.033412)
NAGE	-0.116823***	0.000753		
	(0.029909)	(0.090838)		
Number of Observations	1185	1185	1185	1185

The dependent variable is profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.16: Dynamic Panel Model Result for Model 1 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.273622***	0.204997***	0.243617***	0.206817***
	(0.008169)	(0.010451)	(0.007321)	(0.012363)
MBWC	-0.008252	-0.003217	0.017224	0.005411
	(0.020515)	(0.018892)	(0.011054)	(0.009892)
SBWC	-0.034491***	-0.037356***	-0.012007***	-0.0159***
	(0.009623)	(0.009848)	(0.004237)	(0.004247)
MCL	0.008808***	0.007342**	0.000503	0.004731**
	(0.003346)	(0.003348)	(0.001695)	(0.001938)
SCL	0.013656***	0.014891***	0.01002***	0.01043***
	(0.004662)	(0.004217)	(0.002193)	(0.002554)
FAM	-0.035122	-0.237909***	-0.287385***	-0.311407***
	(0.090979)	(0.089458)	(0.054295)	(0.056689)
LNTGA	0.54188***	0.558204***	0.621591***	0.665737***
	(0.015477)	(0.031639)	(0.01473)	(0.023986)
NAGE	0.42018***	0.465356***		
	(0.104574)	(0.071022)		
Number of Observations	1396	1396	1396	1396

The dependent variable is sales. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.17: Dynamic Panel Model Result for Model 2 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.208725***	0.266268***	0.28673***	0.335183***
	(0.013408)	(0.014923)	(0.010629)	(0.014862)
MBWC	-0.058684***	-0.065551**	-0.010635	-0.016734*
	(0.021094)	(0.025709)	(0.010841)	(0.00927)
SBWC	-0.013588***	-0.011324*	-0.004592	-0.004446
	(0.00477)	(0.006774)	(0.003732)	(0.004527)
MCL	-0.0000724	-0.002661	-0.008571***	-0.006206***
	(0.00284)	(0.003372)	(0.002176)	(0.0024)
SCL	-0.014445***	-0.018963***	-0.007076**	-0.005095
	(0.003397)	(0.005681)	(0.003322)	(0.003322)
FAM	-0.274492***	-0.427674**	-0.171678*	-0.161786*
	(0.100586)	(0.168945)	(0.10325)	(0.088458)
LNTGA	0.539854***	0.459168***	0.608205***	0.670088***
	(0.029249)	(0.047041)	(0.027334)	(0.03427)
NAGE	0.201733	0.279613		
	(0.218833)	(0.26894)		
Number of Observations	967	967	967	967

The dependent variable is profits. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 6.18: Dynamic Panel Model Result for Model 3 with GMM Estimation – Manufacturing Firms

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.249632***	0.337764***	0.27928***	0.381933***
	(0.018044)	(0.017192)	(0.012598)	(0.013946)
MBWC	-0.066513**	-0.046599**	-0.019046**	-0.019331**
	(0.03001)	(0.023553)	(0.009613)	(0.008366)
SBWC	-0.018283***	-0.014791***	-0.005264*	-0.003366
	(0.003419)	(0.0033)	(0.002696)	(0.00242)
MCL	-0.00575*	-0.006543*	-0.0073***	-0.003661*
	(0.003347)	(0.003475)	(0.001877)	(0.002029)
SCL	-0.009554***	-0.00696**	-0.007761***	-0.005247**
	(0.002893)	(0.002844)	(0.002458)	(0.002252)
FAM	-0.506071*	-0.291507	-0.124972	-0.101093
	(0.263823)	(0.240131)	(0.101669)	(0.118422)
LNTGA	0.101022***	0.069486**	0.048469***	0.134676***
	(0.028649)	(0.029666)	(0.013859)	(0.016732)
NAGE	-0.076894	-0.005161		
	(0.047168)	(0.077923)		
Number of Observations	967	967	967	967

The dependent variable is profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

6.5 Summary of Findings

6.5.1 Summary of Findings Based on Estimation

Similar to Chapter 5, we summarize our findings based on estimations of the static panel model and dynamic panel model. Therefore, the estimation is divided into two main approaches: 1) PLS/FEM/REM, and 2) GMM. The selection of the PLS is based on the specification with an AR(1) correction, while between the FEM and REM, our selection is based on the Hausman test. In the summary, only two or more significant variables are taken into account. Table 6.19 shows the summary of findings based on the set of estimation results. Similar to Chapter 5, when comparing between the two approaches, GMM gives a higher number of significant variables compared to PLS/

FEM/ REM. The sign of the significant variables are very similar and the coefficients have only a slight difference between the static and dynamic specifications. Nevertheless, there is only one variable, the FAM in model 1, which gives contradicting signs between the FEM and REM in the manufacturing firms sample.

6.5.1.1 All Firms

Comparing between both types of estimations in model 1 in the all firms sample, the summary shows none of the variables are found to be a significant match for each other. With the PLS/FEM/REM estimations, the MCL and FAM are found to be positively statistically significant, while in the GMM estimation the SBWC are found to have a negatively significant impact but SCL a positively significant impact. All of the coefficients show a very low magnitude to the impact with 1% to 2%, except for FAM in which the highest impact climbs up to 4%, but this can still be considered relatively low. Moving onto model 2, the signs of the variables which are found to be significant match each other for both estimations. Only MBWC are found to be positively statistically significant in which the magnitudes for both estimations are quite similar, ranging from 0.038 to 0.045. MCL which is found to be statistically significant in both estimations had a much higher decrease in the GMM compared to the PLS/FEM/REM estimations, with magnitude ranging from -0.017 to -0.013 and -0.012 to -0.004, respectively. Interestingly, however, in model 2 having a patent family in the PLS/FEM/REM gives the highest magnitude of the negative impact to the firm's profits with ranges from -8.84 to -3.81; this only shows as -0.47 to -0.37 in the GMM estimation. Finally, in model 3, only MCL has both estimations with a negatively statistically significant impact with quite similar magnitudes ranging from -0.19 to -0.006.

6.5.1.2 Manufacturing Firms

As mentioned earlier, in the manufacturing firms sample, FAM had a contradicting sign between the FEM and REM estimations. In the Hausman test, we learned that we favor REM in the period random effects specification, and reject favoring REM in the cross-section random effects specifications. Thus, the period random effects gives a positively statistically significant impact with a magnitude of 0.28 (see Column 7 of Table 6.9), while the cross-section fixed effects specification has a magnitude of -6.28 (see Column 4 of Table 6.9). Thus, we referred to the RESET test to choose the signs to be included in the summary. In terms of Table 6.5, the FEM with cross-section and fixed effects specifications for model 1 are found not to be misspecified. We therefore chose the FEM estimation to be included in the summary of contradicting sign between the FEM and REM estimation for the FAM variable (see columns 4 to 7 of Table 6.9). When comparing with the GMM estimation, the sign is found to be negatively statistically significant with magnitude ranging from -0.31 to -0.24 (see Table 6.19). On the other hand, MCL gives a positively statistically significant impact in both types of estimations, and the magnitude is quite similar between the two, ranging from 0.005 to 0.009. Another explanatory variable which is also found to be positively statistically significant is the SCL with magnitude ranges from 0.011 to 0.006. In model 2, in the GMM estimation, all explanatory variables are found to be negatively statistically significant, compared to only 3 variables found to be significant in the PLS/FEM/REM estimations. Unlike other variables which have a quite similar magnitude, the FAM variable in the PLS/FEM/REM has a higher magnitude compared to the GMM, with -10.17 to -4.53 and -0.311 to -0.238, respectively. Finally, in model 3 and similar to model 2, all variables are found to be negatively statistically significant except for FAM in the GMM estimation, which has no significant impact.

6.5.1.3 Overall Summary

The results found in both estimations are similar to Chapter 5, where GMM shows a more significant impact compared to the PLS/FEM/REM estimation. We also believe that the results reported in the dynamic panel using the GMM estimator are better than the static panel model estimated using PLS/ FEM/ REM. This is due to firms making decisions based on historical values of sales, profits and profit margin to run their businesses. Furthermore, with the GMM estimation, almost all of our explanatory variables in the manufacturing firms sample have a statistically significant impact, compared to the all firms sample. Even though the impact on the financial performance is mostly less than 5% (whether positive or negative impact), we can now confirm that the patenting activity based on the patent quality measure undertaken by the Malaysian manufacturing firms give a statistically significant impact on their financial performance. In addition, running the analysis with the all firms sample and manufacturing firms sample of the Malaysian firms has also provided an additional contribution in empirical studies surrounding the patenting activity area, with the results generated by using the panel model and dynamic panel model.

Table 6.19: Summary of Findings Based on Estimations

Estimations	Explanatory Variables	All Firms			Manufacturing Firms		
		Model 1: Sales	Model 2: Profits	Model 3: Profit Margin	Model 1: Sales	Model 2: Profits	Model 3: Profit Margin
PLS/ FEM/ REM	MBWC		(+) 0.040~0.043				
	SBWC						
	MCL	(+) 0.005~0.008	(–) 0.012~0.004	(–) 0.019~0.006	(+) 0.007~0.009	(–) 0.012~0.009	(–) 0.013~0.007
	SCL					(–) 0.009~0.008	(–) 0.012~0.007
	FAM[a]	(+) 0.08~4.07	(–) 8.84~3.81	(–) 8.25~4.04	(–) 6.28~2.27	(–) 10.17~4.53	(–) 9.62~5.15
GMM	MBWC		(+) 0.038~0.045	(+) 0.022~0.025		(–) 0.066~0.017	(–) 0.067~0.019
	SBWC	(–) 0.017~0.007	(–) 0.017~0.006		(–) 0.037~0.012	(–) 0.014~0.011	(–) 0.018~0.005
	MCL		(–) 0.015~0.013	(–) 0.011~0.006	(+) 0.005~0.009	(–) 0.009~0.006	(–) 0.007~0.004
	SCL	(+) 0.003~0.014			(+) 0.010~0.015	(–) 0.019~0.007	(–) 0.010~0.005
	FAM[a]		(–) 0.47~0.37		(–) 0.311~0.238	(–) 0.428~0.162	

Only significant variables are reported; (+) means positive relationship between the dependent and explanatory variables; (–) means negative relationship between the dependent and explanatory variables; the values shown below the sign are the coefficient estimates from the lowest to the highest. [a]The coefficient reported for the FAM variable having a patent family.

6.5.2 Summary of Findings Based on Hypotheses Development

In this chapter, we answered Hypothesis 2 developed in Chapter 3 relating to the patent quality measures. While in the previous section the summary of findings was based only on statistically significant variables and the magnitude of the coefficients, in this section the findings focus on the expected sign in our hypotheses development. We summarize our findings based on the samples, which are shown in Table 6.20 for all firms and Table 6.21 for manufacturing firms.

6.5.2.1 All Firms

With the patent quality measure, all of the patenting activity variables matched our expected sign with a positive relationship with the firms' sales, except for backward citation in the U.S. patent specification (SBWC) in model 1. As discussed in earlier chapters, backward citation represents the previous inventions that have been applied to invent the current invention and, thus, citations from the previous patents to the new ones are required. Backward citation may also represent how knowledge travels from one setting to another. Referring to the negative sign of the SBWC, this may be due to the fact that the earlier invention which is quite similar to the patent may already has a place in the U.S. market. Therefore, the demand for the patented invention is low and leads to a negative sign of the relationship with the firms' sales.

Moving into model 2, more negative signs emerged from the results, with only MBWC having a significant positive sign with the firms' profits. Even though with the profit maximization model, ex-ante the firm should be receiving benefits in patenting activity with supernormal profits, empirically this is not the case in ex-post data. While MBWC has a positively statistically significant relationship with the firms' profits, SBWC has a statistically negative relationship. As mentioned in Chapter 3, this may due to the costs of paying the patent agent in the application process, which is much higher in the U.S. On the other hand, MCL has a negative sign that may due to the fact that the higher the claim in a patent specification, the higher the costs that need to be paid to the patent agent. Even though SCL has a positive sign, it is not statistically significant. In relation with the patent family which also gives a statistically significant negative sign, this may be due to higher costs in securing patents in more than one territory. On the other hand, model 3 with profit margin as the dependent variable has similar results to the sign with model 2, but with a less statistically significant relationship.

6.5.2.2 Manufacturing Firms

In terms of the patent renewal/ application measure outlined in Chapter 5, while the sample study of all firms and manufacturing firms had almost consistent results to the sign and significant relationship with the firms' financial performance, the results with the patent quality measure were inconsistent in almost all of the variables. All of the variables in models 2 and 3 were found to have a negative relationship with the firms' profits and profit margin.

In model 1, only MCL and SCL has a statistically positive relationship with the firms' sales. This shows the number of claims which also represent that the novelty of the invention has a place in both territories (Malaysia and the U.S.). However, similar to the all firms sample, the SBWC has a statistically negative significant impact on the firms' sales. On the other hand, the FAM variable in the all firms sample which gives a positive statistically significant impact, gives a negative statistically significant impact on the firms' sales in the manufacturing firms sample. That model 2 and 3 have all of the explanatory variables to have a negatively statistically significant impact with the firms' profits and profit margin may be explained by two reasons. Firstly, the broader the number of backward citations that represents the knowledge flows from advanced economies to the Malaysian manufacturing firms, the broader is the negative monetary benefits to them. Secondly, the broader the number of claims that may lead the manufacturing firms to incur higher costs, the broader the likelihood of a negatively statistically significant impact on the firms' profits and profit margin. The FAM variable on the other hand also gives a negative impact, and this may signal that patenting the same patent in more than one territory (as in this study with dual territories of Malaysia and the U.S.) is costly and leads to negative benefits. This is unexpected, as we learned in Chapter 2 that manufacturing firms also make up the exporting industries in Malaysia. We therefore assume that securing patent in both territories by these firms should result in a positive significant impact on the firms' financial performance.

6.5.2.3 Overall Summary

Thus, we have answered the second research question and second hypothesis statement in chapters 1 and 3, respectively. There is a significant relationship between the broader number of backward citations, claims and having a patent family in patents granted to Malaysian firms in both Malaysia and the U.S. and their financial performance. However, the reported sign of the explanatory variables are mixed. While in the all firms sample, there is still a positive relationship (as can be seen in model 1), that is, sales, a negative relationship is found in two of the models, that is, the profits and profit margin. Other than the argument above as to the negative impact, which is in contrast to our expectation, the result may be due the fact that the manufacturing firms are clustered in a more competitive condition compared to the all firms sample (see Section 4.1.2, Chapter 4).

Another possibility is that the negative impact may due to the measurement of variables discussed in Section 6.1.1. The calculation of the patent stocks is dissimilar to the renewal/ application measure, as the calculation of the patent stocks begins at the beginning the patent is applied for and continues to be calculated when it is being granted and until the end of the time series dimension. This is because the explanatory variables, that is, the backward citations and claims, are the proxy of knowledge which the firms have, as discussed in Chapter 3. What this means is that once the patent is applied for, the knowledge comes along with the invention and stays with the firm. Therefore, in the calculation, there is no concept of *obsolescence* as we calculated in Chapter 5.

Table 6.20: Summary of Findings based on Hypotheses Development – All Firms

Hypotheses Development	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between the broader number of backward citations in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MBWC (+)	MBWC (+)	MBWC (+)	**MBWC (+)**	MBWC (+)	**MBWC (+)**
There is a positive significant relationship between the broader number of backward citations in the U.S. patent specification granted to Malaysian firms and their financial performance.	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC (–)**	SBWC (+)	SBWC (–)
There is a positive significant relationship between the broader number of claims in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MCL (+)	**MCL (+)**	MCL (+)	**MCL (–)**	MCL (+)	**MCL (–)**
There is a positive significant relationship between the broader number of claims in the U.S. patent specification granted to Malaysian firms and their financial performance.	SCL (+)	**SCL (+)**	SCL (+)	SCL (+)	SCL (+)	SCL (+)
There is a significant relationship between having a patent family in Malaysia and the U.S. granted to Malaysian firms and their financial performance.	FAM (+)	**FAM (+)**	FAM (+)	**FAM (–)**	FAM (+)	FAM (–)

The boldface variables and signs are statistically significant based on Table 6.19. The statistically insignificant signs are based on the majority of cases. Please refer Table 6.6, 6.7, 6.8, 6.13, 6.14, and 6.15 for detail results.

Table 6.21: Summary of Findings based on Hypotheses Development – Manufacturing Firms

Hypotheses Development	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between the broader number of backward citations in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MBWC (+)	MBWC (+)	MBWC (+)	**MBWC (–)**	MBWC (+)	**MBWC (–)**
There is a positive significant relationship between the broader number of backward citations in the U.S. patent specification granted to Malaysian firms and their financial performance.	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC (–)**
There is a positive significant relationship between the broader number of claims in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MCL (+)	**MCL (+)**	MCL (+)	**MCL (–)**	MCL (+)	**MCL (–)**
There is a positive significant relationship between the broader number of claims in the U.S. patent specification granted to Malaysian firms and their financial performance.	SCL (+)	**SCL (+)**	SCL (+)	**SCL (–)**	SCL (+)	**SCL (–)**
There is a significant relationship between having a patent family in Malaysia and the U.S. granted to Malaysian firms and their financial performance.	FAM (+)	**FAM (–)**	FAM (+)	**FAM (–)**	FAM (+)	FAM (–)

The boldface variables and signs are statistically significant based on Table 6.19. The statistically insignificant signs are based on the majority of cases. Please refer Table 6.9, 6.10, 6.11, 6.16, 6.17, and 6.18 for detail results.

6.6 Chapter Summary

This chapter answered our second subsidiary research question of this study. Therefore, we have also successfully answered Hypothesis 2. The next chapter will answer the third subsidiary research question posited in Chapter 1 as to what extent the differences in the patent technology field impact on the financial performance at the Malaysian firm level for firms which have been granted patents in Malaysia and the U.S. The measurement in Chapter 7 is based on the patent renewal and application stocks in Chapter 5, and the patent quality of this chapter.

CHAPTER 7 PATENT TECHNOLOGY FIELD AND FINANCIAL PERFORMANCE

7.0 Introduction

This chapter answers the third research question in Chapter 1 as to the extent differences in the patent technology field impact on the financial performance of the firm at the Malaysian firm level. By segregating the patent technology field into two categories, 1) Human Necessities and Performing Operations, and 2) Mechanicals and Electronics, the measurement in Chapter 7 is based on the patent application and renewal stocks previously analyzed in Chapter 5 and patent quality previously analyzed in Chapter 6. Initially, Section 7.1 introduces the model specification and measurement of the variables. Section 7.2 then tests if we have violated the regression assumptions and measures taken to overcome the violations. This is to make sure that our results are robust, unbiased and consistent.

Since the measurement of patents follows chapters 5 and 6, we divide our results based on those measurements. Section 7.3 is based on the patent renewal/ application measures and Section 7.4 is based on the patent quality measures. The panel and dynamic panel model is described in sections 7.3.1, 7.3.2, 7.4.1 and 7.4.2, respectively. The panel model is estimated with panel least squares (PLS), fixed effects model (FEM) and random effects model (REM), while the dynamic panel is estimated with generalized method of moments (GMM). This is followed by a summary of the findings based on the estimation (sections 7.3.3 and 7.4.3) and hypotheses development (sections 7.4.3 and 7.4.4). The former focuses on the estimation with statistically significant variables and the magnitude of the variables in the two samples of our study, while the latter ties up the results focusing on the reported sign with the expected sign from the hypotheses development.

7.1 Model Specification and Measurement of Variables

The model specification and measurement of variables are similar to those in chapters 5 and 6. The only difference is that we have divided our sample into the patent technology field as discussed in Chapter 4. Therefore, the measurements are applied to two types of patent technology fields, that is, 1) Human Necessities and Performing Operations, and 2) Mechanicals and Electronics.

7.2 Relaxing the Assumptions

We tested for multicollinearity, autocorrelation, heteroskedasticity and misspecification to make sure that our results are robust, unbiased and consistent. As expected, we found no multicollinearity problem with the patent renewal/ application measures in either of our samples as shown in tables 7.1 and 7.2. Nevertheless, similar to Chapter 6, we found a potential multicollinearity problem with the patent quality measures with correlations of 0.60 to 0.90 between the backward citation and claim. As discussed in Chapter 6, the high correlation between the backward citation and claim is unsurprising as both variables may resemble the stock of knowledge which are the knowledge flows in backward citation and the new knowledge for claims. Thus, we calculate the variance inflation factor (VIF) to diagnose the seriousness of the multicollinearity. Since we have PLS, FEM and REM as our estimation methods, we tested the auxiliary regressions with all three specifications, which is shown in tables 7.5 and 7.6 for human necessities/ performing operations and mechanicals/ electronics technology field, respectively. In the human necessities/ performing operations technology field, the VIF for the PLS and REM were all below 2, while FEM has the highest value of only 7. This test confirms that all of our explanatory variables in the human necessities/ performing operations technology field sample do not suffer from a serious multicollinearity problem. On the other hand, in the mechanicals/ electronics technology field, the VIF for the PLS and REM are all below 5, while FEM has the highest value of 9. Nevertheless, we did not have to worry further as the figure is less than 10 (Marquardt, 1980). Furthermore, the F-test in the model specifications for the FEM estimation for the mechanicals/ electronics technology field sample shows a significant result. The F-test is to test the significance for the overall model specification. The t-statistics also shows that at least one of the explanatory variables has a significant impact on the dependent variable.

Table 7.1: Correlation Matrix Based on Patent Renewal/ Application Measures – Human Necessities and Performing Operations

	LNSALES	LNPROFITS	LNPM	APPM	GRANM	APPS	GRANS	LNTGA	NAGE
LNSALES	1								
LNPROFITS	0.881314	1							
LNPM	-0.00688	0.466454	1						
APPM	0.115663	0.110534	0.0174	1					
GRANM	0.094177	0.101364	0.038215	0.075	1				
APPS	0.067081	0.07986	0.04343	-0.00041	-0.0695	1			
GRANS	0.014987	0.020216	0.014726	-0.00897	-0.02395	0.236078	1		
LNTGA	0.898781	0.867824	0.154045	0.147512	0.145262	0.052749	-0.00701	1	
NAGE	0.263487	0.264847	0.067243	-0.01147	0.231225	-0.03744	-0.02828	0.341686	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; APPM, GRANM, APPS and GRANS are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age.

Table 7.2: Correlation Matrix Based on Patent Renewal/ Application Measures – Mechanicals and Electronics

	LNSALES	LNPROFITS	LNPM	APPM	GRANM	APPS	GRANS	LNTGA	NAGE
LNSALES	1								
LNPROFITS	0.913438	1							
LNPM	0.010685	0.416716	1						
APPM	0.310318	0.26238	-0.04847	1					
GRANM	0.102939	0.059695	-0.08326	0.473127	1				
APPS	0.267541	0.233795	-0.02315	0.181548	0.169877	1			
GRANS	0.311796	0.235522	-0.11776	0.101896	0.098631	0.319338	1		
LNTGA	0.957354	0.931984	0.151508	0.295359	0.093642	0.251546	0.310047	1	
NAGE	0.271809	0.257042	0.024431	0.006015	0.04672	0.133979	0.084867	0.230394	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; APPM, GRANM, APPS and GRANS are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age.

Table 7.3: Correlation Matrix Based on Patent Quality Measures – Human Necessities and Performing Operations

	LNSALES	LNPROFITS	LNPM	MBWC	SBWC	MCL	SCL	FAMILY	LNTGA	NAGE
LNSALES	1									
LNPROFITS	0.881314	1								
LNPM	-0.00688	0.466454	1							
MBWC	0.033592	0.036501	0.014361	1						
SBWC	-0.00746	0.033782	0.085452	0.033818	1					
MCL	0.097904	0.077569	-0.01912	0.643309	0.093738	1				
SCL	-0.04216	-0.02239	0.031522	0.024275	0.706822	0.150946	1			
FAM	0.01646	-0.0238	-0.08117	-0.00751	0.064469	0.0374	0.051632	1		
LNTGA	0.898781	0.867824	0.154045	0.064473	-0.02264	0.088989	-0.07217	0.029347	1	
NAGE	0.263487	0.264847	0.067243	0.054808	-0.04606	-0.10036	-0.03378	-0.01324	0.341686	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; MBWC, SBWC, MCL, SCL and FAM are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age.

Table 7.4: Correlation Matrix Based on Patent Quality Measures – Mechanicals and Electronics

	LNSALES	LNPROFITS	LNPM	MBWC	SBWC	MCL	SCL	FAMILY	LNTGA	NAGE
LNSALES	1									
LNPROFITS	0.913438	1								
LNPM	0.010685	0.416716	1							
MBWC	0.341141	0.296232	-0.03414	1						
SBWC	0.300933	0.226868	-0.11476	0.179555	1					
MCL	0.279198	0.226028	-0.06828	0.828194	0.235557	1				
SCL	0.328543	0.272616	-0.06403	0.154971	0.908692	0.200318	1			
FAM	0.244552	0.240432	0.044502	0.258423	0.124301	0.225537	0.367431	1		
LNTGA	0.957354	0.931984	0.151508	0.332651	0.277817	0.282019	0.322406	0.249125	1	
NAGE	0.271809	0.257042	0.024431	0.030597	0.142082	0.018844	0.191898	0.163813	0.230394	1

LNSALES, LNPROFITS and LNPM are the dependent variable of three different model specifications; MBWC, SBWC, MCL, SCL and FAM are the explanatory variables; LNTGA and NAGE are the control variables. LNSALES, LNPROFITS and LNPM are the sales, profits and profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age.

Table 7.5: Variance Inflation Factor (VIF) Based on Patent Quality Measures – Human Necessities and Performing Operations

Estimations	PLS		FEM		REM	
Explanatory Variables	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF
MBWC	0.404047	1.195106	0.929531	7.354449	0.676922	1.845779
SBWC	0.533333	1.397515	0.779999	2.553616	0.531294	1.393288
MCL	0.437642	1.236905	0.906640	5.617854	0.685753	1.887708
SCL	0.547122	1.427231	0.799367	2.769988	0.557915	1.451946
FAM	0.015908	1.000253	0.397085	1.187192	0.013223	1.000175

Table 7.6: Variance Inflation Factor (VIF) Based on Patent Quality Measures – Mechanicals and Electronics

Estimations	PLS		FEM		REM	
Explanatory Variables	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF	Auxiliary R_j^2	VIF
MBWC	0.657505	1.761534	0.914010	6.075861	0.696222	1.940712
SBWC	0.836135	3.323603	0.938295	8.361030	0.778698	2.540460
MCL	0.668913	1.809773	0.913267	6.026152	0.705604	1.991544
SCL	0.872051	4.174894	0.944279	9.230442	0.821204	3.071027
FAM	0.465884	1.277217	0.690073	1.909128	0.376564	1.165230

Relating to autocorrelation, we found serial correlation is present, and we therefore corrected the first-order serial correlation with autoregressive errors of order 1 or an AR(1) model. As for the dynamic panel, following the explanation in Chapter 5, the GMM estimation took care of the autocorrelation problem. We also took measures to correct for the heteroskedasticity problem. We chose the White Cross-Section coefficient covariance method to correct for heteroskedasticity in our panel model, and White Period method in our dynamic panel model. This is due to the fact that White's coefficient covariance method gave us the majority of statistically significant explanatory variables compared to seemingly unrelated regression (SUR) and panel corrected standard error (PCSE). Finally, we also tested for misspecification using the Ramsey (1969) Regressions Specification and Error Test (RESET) and normality of the residuals test of Jarque-Bera (1980).

Interestingly, even though the number of observations in the human necessities/ performing operations sample is slightly higher than the mechanicals/ electronics (see Chapter 4, tables 4.4 and 4.5), none of the model specifications are found not to be misspecified for both patent measures, that is, the patent renewal/ application measures, and patent quality measures. In the mechanicals/ electronics sample, all three models (models 1, 2 and 3) in this study had at least one effects specification which is not misspecified. All three models based on the patent renewal/ application and quality measures had the REM estimations with a cross-section random effects specification, not misspecified (see tables 7.7 and 7.8). This situation shows that the internal factors (μ_i unobservable individual effect) in the mechanicals and electronics sample are not correlated with the explanatory variables. Nevertheless, with the patent quality measures alone, more effects specifications are found not to be misspecified, which includes the period random effects specifications and PLS estimation for model 3 (see Table 7.8).

On the other hand, similar to our findings in chapters 5 and 6, we found the Jarque-Bera (1980) normality residual test is not met in all of our specifications. Nevertheless, since our observations are large, we followed the central limit theorem (CLT) assumptions.

Table 7.7: RESET Test – Based on Patent Application and Renewal Measures

RESET Test	Null Hypotheses: No Model Misspecification									
Sample	Human Necessities & Performing Operations					Mechanicals & Electronics				
Estimation	PLS	FEM	FEM	REM	REM	PLS	FEM	FEM	REM	REM
Effects Specification	-	cross-section fixed	cross-section & period fixed	cross-section random	period random	-	cross-section fixed	cross-section & period fixed	cross-section random	period random
Model 1: Sales	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null	Reject null	Do not reject null	Do not reject null
Model 2: Profits	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null
Model 3: Profit Margin	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null

Table 7.8: RESET Test – Based on Patent Quality Measures

RESET Test	Null Hypotheses: No Model Misspecification									
Sample	Human Necessities & Performing Operations					Mechanicals & Electronics				
Estimation	PLS	FEM	FEM	REM	REM	PLS	FEM	FEM	REM	REM
Effects Specification	-	cross-section fixed	cross-section & period fixed	cross-section random	period random	-	cross-section fixed	cross-section & period fixed	cross-section random	period random
Model 1: Sales	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null	Reject null	Do not reject null	Do not reject null
Model 2: Profits	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null
Model 3: Profit Margin	Reject null	Reject null	Reject null	Reject null	Reject null	Do not reject null	Reject null	Reject null	Do not reject null	Do not reject null

7.3 Results Based on Patent Renewal/ Application Measures

7.3.1 Panel Model Results

Our panel model is estimated using panel least squares (PLS), fixed effects model (FEM) and random effects model (REM). The model specifications were run with two separate samples which consisted of the human necessities/ performing operations technology field sample and the mechanicals/ electronics technology field sample. Both samples had similar R-squared in all model specifications to the samples discussed in Chapter 5, even though their number of observations is much lower by nearly 50% - for example 2225 for the all firms sample and 1178 for the human necessities/ performing operations sample. On the other hand, when comparing the manufacturing firms sample with the mechanicals/ electronics technology field sample, the number of observations is nearly 40% lower - 1694 for manufacturing firms sample and 1047 for the mechanicals and electronics sample. The control variables of LNTGA and NAGE are found to have a positively statistically significant impact on the dependent variable in almost all three model specifications (see tables 7.9 to 7.14). However, in Chapter 5 where we found a near singular matrix problem with the GMM estimation, we found a similar problem in the mechanicals/ electronics sample with the FEM estimation. Thus, similar action as in Chapter 5 was taken, that is, we omitted the NAGE variable from the FEM model in the mechanical/ electronics sample to obtain the parameter estimates (see columns 3 to 5 of tables 7.12 to 7.14).

7.3.1.1 <u>Human Necessities and Performing Operations Technology Fields</u>

Moving to specific explanatory variables in the specification of model 1, the APPM variable is found to have a positively statistically significant with the PLS with an AR(1) correction, as well as the FEM estimations. It shows that a unit increase in the pending patent application in the Malaysian territory increases the firm's sales by 3% to 4% (see columns 2 to 5 of Table 7.9). Unlike APPM, the GRANM variable is found to be negatively statistically significant with the firms' sales ranging across the 5% to 1% level with the REM estimations. The FEM estimations is only found to be negatively statistically significant with the cross section and period fixed effects specification (see Column 5 of Table 7.9). While GRANS has no statistically significant impact on the firm's sales, the APPS is found to be positively statistically significant with the PLS and REM with a cross section random effects specification (see columns 1 and 6 of Table 7.9).

In model 2, less statistically significant variables are found in almost all cases. With the GRANM variable, all estimations are found to have no statistically significant relationship with the firm's profits, while GRANS has a positively statistically significant impact at the 5% level with the PLS estimation with the AR(1) correction. Nevertheless, the other estimations consistently find GRANM has a positive impact but without being statistically significant. While APPM and APPS have a positive impact on the firm's profits, APPS has a more statistically significant impact in the types of estimations compared to APPM. Furthermore, APPS has a higher positive magnitude compared to APPM with a unit increase in the pending patent application in the U.S. territory increases the firm's profits by 12% to 14% (see columns 1 to 7 of Table 7.10), compared to APPM which only have a 4% increase onto the firm's profits. On the other hand, in model 3 with profit margin as the dependent variable, surprisingly only GRANM has a statistically significant impact with a positive sign in the FEM estimation. It shows that a unit increase in the active lifespan of granted patents in the Malaysian territory increases the firm's profit margin by 12% (see columns 3 and 5 of Table 7.11). Even though the other explanatory variables show a non-statistically significant impact, the signs on the variables are mostly positive (see Table 7.11).

7.3.1.2 Mechanicals and Electronics Technology Fields

Moving into the mechanicals/ electronics technology fields sample, the APPM variable in all three types of estimations, the PLS, FEM and REM is found to be positively statistically significant at the 5% and 1% level (see columns 1 to 7 of Table 7.12). However, their impact increases the firm's sales by only 1% to 2%. GRANM is only found to have a positively statistically significant relationship with the firm's sales in the FEM estimations. The impact shows that a unit increase in the active lifespan of the granted patent in the Malaysian territory increases the firm's sales by 4% to 5% (see columns 3 and 4 of Table 7.12). Comparing the APPS and GRANS variables, the GRANS has a positively statistically significant impact in all of the estimations except for REM with the period random effects specification. Furthermore, the positively statistically significant impact of GRANS on the firm's sales has the largest magnitude compared to other variables, which is from 4% to 12% (see columns 1 to 6 of Table 7.12).

Moving into model 2, the APPM and APPS have only one estimation each which gives a statistically significant impact on the firm's profits in the FEM with a cross-section fixed effects specification and PLS, respectively (see columns 4 and 1 of Table 7.13). Comparing the two samples, GRANS in model 2 in the mechanicals/ electronics sample not only has a statistically significant relationship with the firm's profits in all of the analysis except for PLS with an AR(1) correction, but also has a consistency in the signs which is negative, in contrast to the human necessities/ performing operations sample. The results show that a unit decrease in the active lifespan of the granted patent in the U.S. territory decreases the firm's profits by 16% to 25% (see columns 1 to 7 of Table 7.13). Nevertheless, when analyzing the GRANM, a surprising finding is that the GRANM has a statistically significant relationship but with a contradicting sign. While the FEM with a two-way fixed effects specification increases the firm's profits by 8%, the REM with period random effects specification decreases the firm's profits by 10% (see columns 4 and 7 of Table 7.13). This situation may be due to the gap in our unbalanced panel model, in that we cannot log transform the firm's negative profits (or loss) (see Chapter 4, Table 4.5). Further argument as to why this might happen in the mechanicals/ electronics sample but not in others may be due to the lower number of observations, in which the gap may give an inconsistent sign to the significance of the variables.

When compared to the human necessities/ performing operations sample in model 3, the mechanicals/ electronics sample has more statistically significant variables with APPM and GRANS having a negative impact. The results show that a unit increase in the pending patent application in the Malaysian territory decreases the firm's profit margin by 2% (see Column 1 to 7 of Table 7.10), while a unit increase in the active lifespan of the granted patent in the U.S. territory decreases the firm's profits by 30% (see columns 1 to 7 of Table 7.14).

Table 7.9: Panel Model Result for Model 1 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.320761*	5.380935***	-2.144443	-4.355525	-3.69591	0.320761**	0.32039
	(0.190116)	(1.308738)	(3.867302)	(4.086912)	(4.550238)	(0.148784)	(0.254738)
APPM	-0.000823	0.027015*	0.042356***	0.038476**	0.037124***	-0.000823	0.002084
	(0.014381)	(0.01575)	(0.009574)	(0.01596)	(0.008396)	(0.011128)	(0.019074)
GRANM	-0.118015***	0.033208	-0.03262	-0.00562	-0.13198***	-0.118015***	-0.11825**
	(0.03645)	(0.037025)	(0.039998)	(0.047017)	(0.048588)	(0.030714)	(0.05317)
APPS	0.10147***	0.07481	-0.016752	0.014308	-0.016816	0.10147***	0.108929
	(0.03053)	(0.057233)	(0.023884)	(0.029119)	(0.020388)	(0.039167)	(0.066845)
GRANS	0.058548	-0.016563	-0.027393	-0.031547	-0.063468	0.058548	0.059862
	(0.051178)	(0.097251)	(0.059673)	(0.079228)	(0.057887)	(0.037008)	(0.063346)
LNTGA	0.968115***	0.639172***	0.747681***	0.634226***	0.733988***	0.968115***	0.969077***
	(0.012863)	(0.086584)	(0.051769)	(0.078951)	(0.059125)	(0.010006)	(0.017063)
NAGE	0.006619	0.027193	0.298601	0.495044**	0.387236*	0.006619**	0.006109
	(0.00436)	(0.012897)	(0.197065)	(0.206992)	(0.223093)	(0.002603)	(0.004442)
R-Squared	0.774437	0.915117	0.929983	0.940893	0.93188	0.774437	0.775277
Number of Observations	1178	1066	1178	1066	1178	1178	1178

The dependent variable is sales. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.10: Panel Model Result for Model 2 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[a]	FEM	FEM[a]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-3.650614***	-3.108045***	-4.968208	-4.624205	-6.71898*	-3.650614***	-3.650614***
	(0.345586)	(0.89281)	(4.156469)	(4.943603)	(3.579345)	(0.259522)	(0.338929)
APPM	-0.023826	0.009206	0.040296**	0.040801	0.040784*	-0.023826	-0.023826
	(0.018504)	(0.026926)	(0.019747)	(0.031309)	(0.022227)	(0.016511)	(0.021563)
GRANM	-0.058705	-0.033069	0.07936	0.082286	-0.02229	-0.058705	-0.058705
	(0.056977)	(0.095442)	(0.072229)	(0.07635)	(0.07531)	(0.048922)	(0.063891)
APPS	0.118053	0.140019*	0.063203	0.08945	0.060465	0.118053**	0.118053**
	(0.056104)	(0.082786)	(0.051815)	(0.068914)	(0.057635)	(0.058341)	(0.076192)
GRANS	0.095949	0.168685**	0.10862	0.186192	0.09724	0.095949	0.095949
	(0.083215)	(0.07773)	(0.104843)	(0.183602)	(0.101912)	(0.067229)	(0.087799)
LNTGA	1.068035***	1.007785***	0.673611***	0.56421***	0.649133***	1.068035***	1.068035***
	(0.021903)	(0.055244)	(0.072097)	(0.095901)	(0.083663)	(0.016668)	(0.021768)
NAGE	-0.009354**	0.008368	0.348112*	0.412045**	0.449205**	-0.009354**	-0.009354**
	(0.004238)	(0.010104)	(0.194367)	(0.197725)	(0.181656)	(0.004087)	(0.005337)
R-Squared	0.756237	0.858793	0.874101	0.901642	0.877828	0.756237	0.756237
Number of Observations	893	721	893	721	893	893	893

The dependent variable is profits. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [a] The specification is run with AR(1) correction.

Table 7.11: Panel Model Result for Model 3 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.268543***	-5.301705***	-2.371781	-2.582953	-4.420208*	-4.268543***	-4.268543***
	(0.342554)	(0.867938)	(2.273648)	(3.181364)	(2.459335)	(0.245086)	(0.320774)
APPM	-0.003035	-0.00131	0.005989	0.002479	0.012418	-0.003035	-0.003035
	(0.012807)	(0.019541)	(0.016233)	(0.020048)	(0.018976)	(0.015592)	(0.020408)
GRANM	0.029192	0.027014	0.123288***	0.04863	0.116725*	0.029192	0.029192
	(0.042626)	(0.067346)	(0.0471)	(0.058263)	(0.062722)	(0.046201)	(0.060469)
APPS	0.074561	0.10671	0.086471	0.095933	0.09194	0.074561	0.074561
	(0.051071)	(0.07944)	(0.065132)	(0.076597)	(0.0685)	(0.055096)	(0.07211)
GRANS	0.01974	0.054234	0.050489	0.033578	0.072619	0.01974	0.01974
	(0.077904)	(0.094949)	(0.107391)	(0.199106)	(0.104242)	(0.063489)	(0.083096)
LNTGA	0.083128***	0.124954**	-0.121562***	0.048829	-0.080797*	0.083128***	0.083128***
	(0.022111)	(0.051612)	(0.037526)	(0.06663)	(0.04674)	(0.01574)	(0.020602)
NAGE	0.002125	0.01344	0.069134	-0.048805	0.132062	0.002125	0.002125
	(0.005343)	(0.010878)	(0.101837)	(0.108953)	(0.102327)	(0.003859)	(0.005051)
R-Squared	0.025627	0.426405	0.497163	0.592546	0.506541	0.025627	0.025627
Number of Observations	893	721	893	721	721	721	721

The dependent variable is profit margin. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.12: Panel Model Result for Model 1 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[a]	FEM	FEM[a]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	0.162634	1.95716***	3.844391***	5.427892***	4.325021***	1.779494***	0.162634
	(0.14044)	(0.619938)	(0.867848)	(1.621691)	(1.070468)	(0.430577)	(0.192207)
APPM	0.023367***	0.0205***	0.007788	0.00627	0.008811**	0.007764	0.023367**
	(0.005104)	(0.007886)	(0.004796)	(0.006333)	(0.003845)	(0.007378)	(0.009251)
GRANM	0.02458	0.025599	0.049446***	0.04126**	0.031811	0.038888	0.02458
	(0.020906)	(0.017473)	(0.01525)	(0.018772)	(0.020609)	(0.025815)	(0.037334)
APPS	-0.033032***	0.020059	0.005334	-0.007503	0.002903	0.00377	-0.033032
	(0.00971)	(0.020915)	(0.022443)	(0.025538)	(0.021373)	(0.02355)	(0.027343)
GRANS	0.035759**	0.086447***	0.125329***	0.099514***	0.115099***	0.122153***	0.035759
	(0.01766)	(0.025109)	(0.021119)	(0.029352)	(0.023516)	(0.027623)	(0.039013)
LNTGA	0.942718***	0.824395***	0.757674***	0.66741***	0.729623***	0.821316***	0.942718***
	(0.010259)	(0.04414)	(0.052169)	(0.096257)	(0.063988)	(0.024385)	(0.012102)
NAGE	0.028129***	0.037292***				0.045648***	0.028129***
	(0.003064)	(0.012823)				(0.012592)	(0.003856)
R-Squared	0.892186	0.961329	0.96432	0.973019	0.964678	0.59085	0.892186
Number of Observations	1047	956	1047	956	1047	1047	1047

The dependent variable is sales. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [a] The specification is run with AR(1) correction.

Table 7.13: Panel Model Result for Model 2 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[a]	FEM	FEM[a]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-3.896801***	-4.424141***	0.997305	1.884711	0.212789	-2.786286***	-3.885831***
	(0.176507)	(0.710276)	(1.374049)	(2.060409)	(2.236957)	(0.620448)	(0.270922)
APPM	0.000907	-0.011711	-0.002369	-0.01192*	0.003955	-0.003404	0.002571
	(0.005644)	(0.008212)	(0.005312)	(0.007183)	(0.006715)	(0.01234)	(0.011289)
GRANM	-0.088994	0.046969	0.029238	0.077321**	0.002782	-0.00218	-0.096288**
	(0.060322)	(0.057492)	(0.03633)	(0.036676)	(0.028941)	(0.04456)	(0.047746)
APPS	0.066228*	-0.061194	-0.026928	-0.087842	-0.022026	-0.024318	0.069595
	(0.037159)	(0.073311)	(0.043364)	(0.062955)	(0.044175)	(0.056847)	(0.057494)
GRANS	-0.254154***	-0.164104	-0.208049**	-0.240723*	-0.209232**	-0.23845***	-0.253379***
	(0.046996)	(0.120565)	(0.081376)	(0.13002)	(0.085727)	(0.06061)	(0.056888)
LNTGA	1.050285***	1.068679***	0.786027***	0.740954***	0.831766***	0.960258***	1.050304***
	(0.011507)	(0.033316)	(0.079254)	(0.116184)	(0.130203)	(0.037925)	(0.015994)
NAGE	0.017801***	0.023289***				0.034232**	0.017494***
	(0.003447)	(0.00664)				(0.014296)	(0.005146)
R-Squared	0.874543	0.921384	0.92431	0.942207	0.926208	0.50365	0.875163
Number of Observations	796	645	796	645	796	796	796

The dependent variable is profits. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [a] The specification is run with AR(1) correction.

Table 7.14: Panel Model Result for Model 3 with PLS, FEM & REM Estimations (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[a]	FEM	FEM[a]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
Explanatory Variables							
C	-4.367013***	-4.960039***	-2.207597*	-2.659236	-3.391773*	-3.692485***	-4.367013***
	(0.156928)	(0.984108)	(1.142117)	(1.841746)	(1.871437)	(0.573087)	(0.301286)
APPM	-0.023094**	-0.02939***	-0.009435	-0.018155**	-0.003091	-0.01119	-0.023094*
	(0.009555)	(0.010612)	(0.007074)	(0.007392)	(0.007565)	(0.012359)	(0.012578)
GRANM	-0.067548	0.057477	-0.01302	0.052911	-0.033464	-0.025494	-0.067548
	(0.052598)	(0.060301)	(0.04574)	(0.037779)	(0.041301)	(0.044756)	(0.052226)
APPS	-0.003836	-0.091129	-0.007814	-0.073945	-0.001245	-0.014898	-0.003836
	(0.038693)	(0.064034)	(0.036495)	(0.049968)	(0.03904)	(0.057046)	(0.064239)
GRANS	-0.295252***	-0.197426	-0.281012***	-0.28227**	-0.277328***	-0.301479***	-0.295252***
	(0.050559)	(0.129068)	(0.081192)	(0.126812)	(0.085707)	(0.060541)	(0.063042)
LNTGA	0.107774***	0.128895***	-0.023271	0.00297	0.045518	0.058609*	0.107774***
	(0.011123)	(0.047063)	(0.066438)	(0.104606)	(0.109388)	(0.035248)	(0.017875)
NAGE	-0.001922	0.001847				0.004946	-0.001922
	(0.004372)	(0.010491)				(0.012792)	(0.005748)
R-Squared	0.064369	0.459446	0.534289	0.627632	0.541946	0.036084	0.064369
Number of Observations	796	645	796	645	796	796	796

The dependent variable is profit margin. C is the constant; APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [a] The specification is run with AR(1) correction.

7.3.1.3 Hausman Test

In the panel model estimation, in addition to the PLS we also conducted the FEM and REM estimations. To determine which model was preferred between the FEM and REM, we conducted a Hausman test. The results in Table 7.15 show that for the cross-section random effects specifications, the null hypothesis of favoring REM can be rejected for the human necessities/ performing operations sample at the 1% significance level. In the mechanicals/ electronics sample, however, we failed to reject favoring the REM in model 3 for the cross-section random effects specifications, and we also failed to reject favoring REM in model 2 if we were to use the 1% significance level. Further, for the period random effects specifications, we failed to reject favoring the REM in both samples. The result is quite similar when comparing with the all firms sample and manufacturing firms sample (see Chapter 5, Table 5.10). In addition, when comparing with the RESET test, the REM in both the cross-section and period random effects specifications are shown not to be misspecified in one of the model specifications (model 1, 2 or 3), in the mechanicals/ electronics sample, but not in the human necessities/ performing operations sample (see Table 7.7).

This shows that the mechanicals/ electronics technology field sample are not correlated with the regressors. This may signal that the regressors are not being affected by the individual effects such as the firm's managerial decision to patent, investment decision of paying the renewal fee, advertising promotions on the patented products or processes, and the time effect such as the financial and economic crisis or changes in the government policy for example. This situation may also show that the patented products in the mechanicals/ electronics sample are meant for sales in order to maximize profits, as model 3 with profit margin as the dependent variable cannot be rejected as being misspecified. On the other hand, even though the human necessities/ performing operations sample cannot be rejected as being misspecified in the RESET test, the Hausman test gave us the opportunity to choose between the FEM and REM.

Table 7.15: Hausman Test – Based on Patent Renewal and Application Measures

Hausman Test	Null hypothesis: REM is favored			
Sample	Human Necessities and Performing Operations		Mechanicals and Electronics	
Effects Specification	cross-section random	period random	cross-section random	period random
Model 1: Sales	Reject null at 1% significance level	Reject null at 5% significance level	Reject at 1% significance level	Reject null at 10% significance level
Model 2: Profits	Reject null at 1% significance level	Do not reject null	Reject at 5% significance level	Do not reject null
Model 3: Profit Margin	Reject null at 1% significance level	Do not reject null	Do not reject null	Do not reject null

7.3.2 Dynamic Panel Model Results

Our dynamic panel model was estimated using Generalized Method of Moments (GMM) with two types of cross-section transformation, specifically, first differences (Arellano & Bond, 1991) and orthogonal deviations (Arellano & Bover, 1995). In addition, the specifications were run with a one-step cross-section fixed effects and a two-step cross-section and period fixed effects. We used the Sargan test to ensure that the error terms are not serially correlated with the instruments, and the results show that all of the specifications in this study met the Sargan test requirements. The results also show that the single lagged dependent variable has a positively statistically significant impact at the 1% level in all specifications (see tables 7.16 to 7.21). Similar to the static panel model, the model specifications were run with two separate samples which consisted of the human necessities/ performing operations technology field sample and the mechanicals/ electronics technology field sample. However, with those samples, we found some statistically significant variables which have contradicting signs. This may be due to the large gaps in the unbalanced panel dataset, whereby we have negative profits which could not be log transformed (see Chapter 4, Table 4.1). However, we did not experience this situation in Chapter 5, as the larger number of continuous observations may well have overcome this problem compared to the smaller number of continuous observations in the analysis in this chapter.

7.3.2.1 Human Necessities and Performing Operations Technology Fields

Model 1 gives a positively statistically significant result at the 1% level for APPM, with orthogonal deviations having a slightly higher impact of 4% on the firm's sales compared to first difference cross-section transformation with 1% to 2% impact (see Table 7.16). As mentioned in the preceding section, the contradicting sign can already be found with the GRANM in model 1. While the orthogonal deviations and two-step cross-section and period fixed in the first differences cross-section transformation gives a negatively statistically significant result (see columns 3 to 5 of Table 7.16), the one-step cross-section fixed effects specification in the first differences transformation gives a negative sign (see Column 1 of Table 7.16). APPS has only one specification which is positively statistically significant at the 1% level, that is, in the first differences transformation with cross-section fixed effects specifications (see Column 1 of Table 7.16). As for the GRANM, both the first difference and orthogonal deviations transformation with a cross-section and period fixed effects specification give a negatively statistically significant impact on the firm's sales ranging across 3% to 9% (see columns 2 and 4 of Table 7.16).

In model 2, APPM and GRANM have a statistically significant result but with different signs of the coefficient. While the first differences give a negative impact, the orthogonal deviations gives a positive impact (see Table 7.17). Interestingly, the difference between the negative and positive signs is nearly double, with -3.5% in the first difference transformation and 3.5% in the orthogonal deviations transformation with the APPM (see columns 1 and 3 of Table 7.17). With the statistically significant results for APPS and GRANS, both are found to have a positive impact on the firm's profits with GRANS having a higher impact than APPS. A unit increase in the patent active lifespan in the U.S. territory increases the firm's profits by 10% to 40% (see columns 1 to 3 of Table 7.17); while a unit increase in the pending patent application in the U.S. territory increases the firm's profits by only 4% to 8% (see columns 1 and 3 of Table 7.17).

Unlike model 1 and 2, model 3 has fewer explanatory variables that have a statistically significant impact. APPM and GRANM have at least two specifications that are statistically significant with negative and positive impact, which range from -0.05 to -0.03 and 0.03 to 0.07, respectively (see columns 1 to 3 of Table 7.18). APPS and GRANS are found to have a positive and negative statistically significant impact respectively, with the orthogonal deviations transformation in the one-step cross section fixed effects specifications on the firm's profit margin (see Column 3 of Table 7.18).

7.3.2.2 Mechanicals and Electronics Technology Fields

APPM, APPS and GRANS are found to have consistency in having a positively statistically significant impact on the firm's sales. APPM and GRANM have an impact of less than 10%, but the impact of GRANS is slightly higher at 9% to 13% (see Table 7.19). APPS also has a positive impact, but only in the first differences transformation, with a unit increase in the pending patent application in the U.S. territory increasing the firm's sales by 4% (see columns 1 and 2 of Table 7.19). However, the negative impact in the orthogonal deviations transformation is quite small, accounting for only a 1% decrease in the firm's sales (see columns 3 and 4 of Table 7.19).

While most explanatory variables have a positively statistically significant impact on the firm's sales in model 1, model 2 has APPS and GRANS negatively statistically significant with the firm's profits, with GRANS having a higher negative impact. A unit increase in the pending patent application in the U.S. territory decreases the firm's profits by 6% to 17% (see columns 1 to 3 of Table 7.20). On the other hand, a unit increase in the active lifespan of the granted patent in the U.S. territory decreases the firm's profits by 20% to 33% (see columns 1 and 2 of Table 7.20). While GRANS is negatively related, GRANM is found to be positively related with the firm's profits, ranging from 6% to 15% (see columns 1, 3 and 4 of Table 7.20). Nevertheless, there is another contradicting sign given between the first differences and orthogonal deviations transformation, that is, for the APPM, with a positive and negative impact on the firm's profits respectively.

On the other hand, model 3 shows only GRANM having a positively statistically significant impact with the firm's profit margin but a negatively statistically significant with the other explanatory variables. It shows that a unit increase in the active lifespan of granted patents in the Malaysian territory increases the firm's profit margin by 4% to 9% (see columns 1 and 3 of Table 7.21). Comparing the magnitude of the negative impact of APPM, APPS and GRANS, GRANS has the highest negative impact on the firm's profit margin, that is, 20%, with the others at less than 10% (see Table 7.21).

Table 7.16: Dynamic Panel Model Result for Model 1 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.152311***	0.27009***	0.163565***	0.179925***
	(0.003945)	(0.005505)	(0.003698)	(0.004944)
APPM	0.019672***	0.01122***	0.037168***	0.039618***
	(0.001658)	(0.0028)	(0.005993)	(0.00538)
GRANM	0.025983***	-0.083576***	-0.040037***	-0.087337***
	(0.004994)	(0.014046)	(0.00718)	(0.014358)
APPS	0.019796***	0.002765	0.01133	-0.002959
	(0.007654)	(0.011122)	(0.01318)	(0.006814)
GRANS	-0.012445	-0.08821***	-0.012674	-0.034347***
	(0.011091)	(0.01665)	(0.018594)	(0.013416)
LNTGA	0.478303***	0.482077***	0.62271***	0.635619***
	(0.005816)	(0.009876)	(0.007803)	(0.010656)
NAGE	0.504833***	0.668662***		
	(0.036951)	(0.018897)		
Number of Observations	954	954	954	954

The dependent variable is sales. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.17: Dynamic Panel Model Result for Model 2 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.164441***	0.269021***	0.24304***	0.383771***
	(0.0046)	(0.02855)	(0.005296)	(0.022884)
APPM	-0.034396***	-0.027269	0.035986***	0.010959
	(0.003019)	(0.026304)	(0.004776)	(0.020968)
GRANM	-0.062436***	-0.25483***	0.070746***	0.017218
	(0.003915)	(0.093416)	(0.007277)	(0.036182)
APPS	0.042616**	-0.106913	0.077132***	0.076114
	(0.016859)	(0.105767)	(0.019466)	(0.065005)
GRANS	0.39063***	0.32958*	0.102025***	0.041774
	(0.035635)	(0.194875)	(0.039177)	(0.169865)
LNTGA	0.379712***	0.275721***	0.462435***	0.43263***
	(0.010003)	(0.100356)	(0.013292)	(0.070919)
NAGE	0.172445	0.921983	0.434623	-0.50991
	(0.199902)	(1.122759)	(0.341724)	(1.238148)
Number of Observations	623	623	623	623

The dependent variable is profits. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.18: Dynamic Panel Model Result for Model 3 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.140255***	0.273055***	0.188243***	0.364418***
	(0.006511)	(0.019608)	(0.003686)	(0.020089)
APPM	-0.033581***	-0.04634*	0.00118	-0.03941
	(0.003355)	(0.023918)	(0.00334)	(0.047666)
GRANM	0.034639**	-0.059029	0.073164***	0.062434
	(0.014344)	(0.091204)	(0.00678)	(0.111371)
APPS	0.009728	-0.101102	0.097843***	0.0461
	(0.019745)	(0.086273)	(0.006835)	(0.069816)
GRANS	0.003386	0.07146	-0.070056***	0.041639
	(0.072021)	(0.141048)	(0.018135)	(0.204495)
LNTGA	0.10114***	-0.068515	0.013752	-0.014961
	(0.032452)	(0.113929)	(0.013536)	(0.103473)
NAGE	-0.480195	-0.430258	-0.560083	-0.020301
	(0.572834)	(1.111102)	(0.633982)	(0.665106)
Number of Observations	623	623	623	623

The dependent variable is profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.19: Dynamic Panel Model Result for Model 1 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.012647***	-0.042842***	-0.089731***	0.08506***
	(0.002167)	(0.013587)	(0.004044)	(0.015534)
APPM	-0.000078	-0.011251	0.007377***	0.002835
	(0.000732)	(0.007125)	(0.000946)	(0.004835)
GRANM	0.017436***	-0.005075	0.052864***	0.063157***
	(0.001136)	(0.012559)	(0.003091)	(0.019505)
APPS	0.044938***	0.043863***	-0.010692***	-0.010741
	(0.001806)	(0.004783)	(0.001438)	(0.011433)
GRANS	0.11546***	0.085868***	0.134187***	0.115661***
	(0.002117)	(0.010948)	(0.001505)	(0.012924)
LNTGA	0.610206***	0.568866***	0.810348***	0.68461***
	(0.003091)	(0.033881)	(0.002396)	(0.03126)
Number of Observations	865	865	865	865

The dependent variable is sales. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.20: Dynamic Panel Model Result for Model 2 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.103354***	0.348226***	0.327259***	0.37768***
	(0.021475)	(0.042953)	(0.011518)	(0.0358)
APPM	0.021638***	0.009125	-0.010092***	-0.003373
	(0.004913)	(0.011265)	(0.001127)	(0.006962)
GRANM	0.154937***	0.111518	0.055026***	0.062558**
	(0.016295)	(0.068001)	(0.003009)	(0.024283)
APPS	-0.168625***	-0.128183*	-0.061339***	-0.055052
	(0.019675)	(0.067833)	(0.009461)	(0.037665)
GRANS	-0.330371***	-0.224067***	-0.200574***	-0.228805***
	(0.020834)	(0.069911)	(0.008457)	(0.045571)
LNTGA	0.50038***	0.365576***	0.510444***	0.573875***
	(0.018736)	(0.078749)	(0.010069)	(0.079415)
Number of Observations	562	562	562	562

The dependent variable is profits. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.21: Dynamic Panel Model Result for Model 3 with GMM Estimation (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.29575***	0.290744***	0.402187***	0.36515
	(0.007132)	(0.020268)	(0.001797)	(0.031336)
APPM	-0.007102*	0.012576	-0.013075***	0.018912
	(0.003633)	(0.025756)	(0.001001)	(0.021998)
GRANM	0.079404***	-0.005011	0.044938***	0.001519
	(0.010634)	(0.09476)	(0.001679)	(0.038713)
APPS	-0.085102***	-0.016406	-0.031077***	0.010339
	(0.025264)	(0.083055)	(0.009586)	(0.076865)
GRANS	-0.160665***	-0.179273*	-0.196073***	-0.191836
	(0.029505)	(0.099809)	(0.018023)	(0.15328)
LNTGA	-0.047268***	-0.192478**	-0.018981***	-0.151888
	(0.013257)	(0.091393)	(0.005937)	(0.102696)
Number of Observations	562	562	562	562

The dependent variable is profit margin. APPM and APPS are the patents applied for in Malaysia and the U.S. respectively; GRANM and GRANS are the patents granted to in Malaysia and the U.S. respectively; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

7.3.3 Summary of Findings Based on Estimation

Since we have several types of estimations, the selection of the estimation to be included in the summary is similar to that in chapters 5 and 6. Hence, the selection of PLS in this summary is based on the PLS estimation with the AR(1) correction, due to the higher value of the R-squared. In deciding between the FEM and REM, we based our selection on the Hausman test. In the summary, only two or more significance variables are taken into account. Thus, in the GMM estimation, if only two significance variables were found from the orthogonal deviations transformation but none in the first difference transformation, we would consider the variables to be included in this summary.

From the analysis and selection of variables to be included in the summary, we encountered contradicting signs in the statistically significant impact of the variables on the firm's financial performance, compared to no contradicting sign in Chapter 5, and only one variable having the problem in Chapter 6. Therefore, we did the following if we encountered such a problem. In the static panel model, we referred to the RESET test as to which model would best fit into our summary findings. In the dynamic panel model on the other hand, if we encountered such a problem, we chose the orthogonal deviation transformations instead of the first differences transformation. In a simulation study, Hayakawa (2009), found that the GMM estimator in a dynamic panel model transformed by forward orthogonal deviation tends to work better than that transformed by the first difference.

Similar with Chapter 5 and 6, when comparing between the two approaches, GMM has given a higher number of significant variables compared to PLS/ FEM/ REM in both the human necessities/ performing operations and mechanical/ electronics technology field samples. The sign of the significance variables are very similar and the coefficients have only a slight difference between the static and dynamic specifications. Table 7.22 shows the summary of findings based on the set of estimation results.

7.3.3.1 Human Necessities and Performing Operations Technology Fields

All the estimations (PLS/FEM/REM/GMM) in model 1, APPM, have a positively statistically significant relationship with the firm's sales, and in which the coefficients are quite similar which ranges from 0.01 to 0.04. GRANM has a negatively statistically significant relationship with the firm's sales in all estimations, while GRANS only exhibits in the significance GMM estimation. In model 2, there are more variables (APPM, GRANM and GRANS) having a positively statistically significant relationship with the firm's profits in the GMM estimation compared to only one variable, that is, APPS in the PLS/FEM/REM estimations. The coefficients are largest in GRANS in the GMM estimation, ranging from 0.10 to 0.39. For model 3, on the other hand, only GMM estimation has given a statistically significant relationship with the firm's profit margin, with APPM having a negative sign and GRANM having a positive sign and with no significant impact in the PLS/FEM/REM estimations.

7.3.3.2 Mechanicals and Electronics Technology Fields

There are more statistically significant variables in the mechanicals/ electronics technology fields sample compared to the human necessities/ performing operations fields sample, and more statistically significant variables in the GMM estimation compared to the PLS/FEM/REM estimations. In model 1, only two variables (APPM and GRANS) are found to have a positively statistically significant relationship with the firm's sales in the PLS/FEM/REM estimations, but three variables (GRANM, APPS and GRANS) are found in the GMM estimation. However, GRANS in all estimators has a similar coefficient that ranges from 0.09 to 0.12. Model 2, on the other hand, has all negative sign to the significance impact on the firm's profits, except for GRANM in the GMM estimation. Nevertheless, when comparing the PLS/FEM/REM estimation with the GMM estimation, the GRANM gives a negative sign with 0.10 coefficient and positive sign with coefficient ranges from 0.06 to 0.15, respectively. This is the only variable which gives a contradicting sign between the PLS/FEM/REM and GMM estimation. The highest coefficient in model 2 is GRANS, with a negative impact that ranges from -0.33 to -0.20. Finally, model 3 has similar results as model 2 in terms of the statistically significant variables and signs, as well as the magnitude of the coefficients.

7.3.3.3 Overall Summary

Comparing all the estimators, the GMM estimation shows a more statistically significant impact on the firm's financial performance. Comparing between the technology fields, the human necessities/ performing operations technology fields sample has all variables showing a positively statistically significant impact on the firm's profits. In contrast, the mechanical/ electronics technology fields sample has three variables with positively statistically significant impact on the firm's sales, while there are only two variables in the human necessities/ performing operations technology fields. The magnitude of the coefficients in both samples is quite similar in both samples with the only difference being that they give a contradicting sign. Thus, in Chapter 3, our expectation that the magnitude of the coefficients would vary significantly is not met. In spite of this result, there is only one variable which has a positively statistically significant relationship with the firm's profits in both technology fields, that is, the GRANM. However, it also has a similar magnitude to the coefficients, ranging from 0.06 to 0.15.

Overall, when comparing between the technology fields, firms that have patents in the mechanical/ electronics technology field have more statistically significant variables in model 2 and 3, compared to the human necessities/ performing operations technology field. If we refer to the RESET test in Table 7.7, the mechanicals/ electronics technology field has model 2 and 3 not to be misspecified compared to all models in the human necessities/ performing operations technology field that are found to be misspecified. Even though the RESET test does not tell us how to correct the misspecification, the results we have favor the mechanicals/ electronics technology field. That the result demonstrate more statistically significant variables in the mechanicals/ electronics technology field is unsurprising because, as discussed in Chapter 3, Malaysia's largest export in the manufacturing industries is the mechanicals/ electronics technology field. Furthermore, in Chapter 5 we also found that manufacturing firms have more statistically significant variables.

Table 7.22: Summary of Findings Based on Estimations – Patent Renewal/ Application Measures

Estimations	Explanatory Variables	Human Necessities & Performing Operations			Mechanicals & Electronics		
		Model 1: Sales	Model 2: Profits	Model 3: Profit Margin	Model 1: Sales	Model 2: Profits	Model 3: Profit Margin
PLS/ FEM/ REM	APPM	(+) 0.03~0.04			(+) 0.01~0.02		(–) 0.03~0.02
	GRANM	(–) 0.13~0.12				(–) 0.10	
	APPS		(+) 0.12~0.14				
	GRANS				(+) 0.09~0.12	(–) 0.25~0.21	(–) 0.30
GMM	APPM	(+) 0.01~0.04	(+) 0.04	(–) 0.05~0.03		(–) 0.01	(–) 0.01
	GRANM	(–) 0.09~0.04	(+) 0.07	(+) 0.03~0.07	(+) 0.02~0.06	(+) 0.06~0.15	(+) 0.04~0.08
	APPS				(+) 0.04	(–) 0.17~0.06	(–) 0.09~0.03
	GRANS	(–) 0.09~0.03	(+) 0.10~0.39		(+) 0.09~0.13	(–) 0.33~0.20	(–) 0.20~0.16

Only significant variables are reported; (+) means positive relationship between the dependent and explanatory variables; (–) means negative relationship between the dependent and explanatory variables; the values shown below the sign are the coefficient estimates from the lowest to the highest.

7.3.4 Summary of Findings Based on Hypotheses Development

Similar to Chapter 5, this section will answer subsidiary research question 1 and Hypothesis 1 developed in chapters 1 and 3, respectively. The only difference is that the sample study has been arranged according to patent technology fields that we have divided into two as discussed in Chapter 4. With the patent renewal/ application measure, we hypothesized that there is a positive significant relationship between patents applied for and granted to Malaysian firms and their financial performance in both Malaysia and the U.S. We found, however, mixed results to the reported sign and significance of the variables. We summarize our findings based on the samples, which is shown in Table 7.23 for firms that have patents in the human necessities/ performing operations technology field, and Table 7.24 for firms that have patents in the mechanicals/ electronics technology field.

7.3.4.1 Human Necessities and Performing Operations Technology Fields

In the human necessities/ performing operations technology field, both APPM and APPS have a positive sign to the impact on the firm's sales, but only APPM is statistically significant. On the other hand, GRANM and GRANS both have a negatively statistically significant impact on the firm's sales. The positive impact of patents applied for may signal that the market demand and supply of the patented technology does last from when the patent is applied for until the time the patent is granted. However, the measurement of the granted patents that is based on the renewal behavior may reveal that the granted patents in the territories of both Malaysia and the U.S. are not well being demanded and supplied in the long run, which in turn leads to negative sales.

Surprisingly, however, the negative impact does not continue when we move into model 2. All of our explanatory variables have a positive significant impact on the firm's profits. This may be due to the fact that the firms that patent in the human necessities/ performing operations technology fields patented the products or processes to be used in the firm to reduce the business costs. This contrasts with the argument in the preceding paragraph, as the patented product or process in this technology field may not be meant for sale directly to the consumers, but to be applied to their own firms. Moving into model 3 with profit margin as the dependent variable, only two variables are significantly reported with APPM having a negative impact and GRANM having a positive impact. The negative impact of APPM may be interesting, as earlier APPM gave a positive impact on both the firm's sales and profits. This may due to the lagged effects which result in a negative impact of APPM on the ratio of the firm's profits to its sales (profit margin).

7.3.4.2 Mechanicals and Electronics Technology Fields

When comparing the result of the hypotheses development for mechanical/ electronics technology field sample in Table 7.24, with the manufacturing firms sample in Table 5.19 of Chapter 5, they are quite similar. The only difference involves one variable, that is, GRANM on the firm's sales with a positive impact in the mechanical/ electronics technology field sample, and a negative impact in the manufacturing firms sample. The significance of all variables in the two samples is also nearly the same. This is unsurprising, as we pointed out in earlier chapters that Malaysia has moved into an industrialized nation, with manufacturing industries and mechanicals/ electronics sectors providing the largest portion of manufactured products, as well as those that are exported to other parts of the world. The positive impact of GRANM on the firm's sales also shows that the firms with the patented invention in the mechanicals/ electronics technology field have a place in Malaysia until the patent is granted, and continues giving positive impact as the measurement involves the patent renewal behavior.

7.3.4.3 Overall Summary

Rearranging our sample data by classifying firms into two broad patent technology fields, we finally have answered the first subsidiary research question in Chapter 1, that there is a statistically significant relationship between the patents applied for and granted to Malaysian firms in both Malaysia and the U.S. and their financial performance. However, the signs to the results are found to be mixed, depending on the model estimations. Earlier in Chapter 3, we also anticipated that there would be no significance difference between these two fields in terms of the impact of the firms' patenting activity on their financial performance relating to the sign and significance, as both could be categorized as fast moving technology. Our expectation was not met. Furthermore, in terms of the analysis of competitive condition in these two fields of technology, the firms could be categorized as facing competitive condition, especially in the human necessities/ performing operations technology field (see Chapter 4).

Table 7.23: Summary of Findings Based on Hypotheses Development – Human Necessities and Performing Operations

Hypotheses Statements	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between Malaysian patent applied for by Malaysian firms and their financial performance.	APPM (+)	**APPM (+)**	APPM (+)	**APPM (+)**	APPM (+)	**APPM (–)**
There is a positive significant relationship between Malaysian patent granted to Malaysian firms and their financial performance.	GRANM (+)	**GRANM (–)**	GRANM (+)	**GRANM (+)**	GRANM (+)	**GRANM (+)**
There is a positive significant relationship between U.S. patent applied for by Malaysian firms and their financial performance.	APPS (+)	APPS (+)	APPS (+)	**APPS (+)**	APPS (+)	APPS (+)
There is a positive significant relationship between U.S. patent granted to Malaysian firms and their financial performance.	GRANS (+)	**GRANS (–)**	GRANS (+)	**GRANS (+)**	GRANS (+)	GRANS (+)

The boldface variables and signs are statistically significant based on Table 7.22. The statistically insignificant signs are based on the majority of cases.

Table 7.24: Summary of Findings Based on Hypotheses Development – Mechanicals and Electronics

Hypotheses Statements	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between Malaysian patent applied for by Malaysian firms and their financial performance.	APPM (+)	**APPM (+)**	APPM (+)	**APPM (–)**	APPM (+)	**APPM (–)**
There is a positive significant relationship between Malaysian patent granted to Malaysian firms and their financial performance.	GRANM (+)	**GRANM (+)**	GRANM (+)	**GRANM (+)**	GRANM (+)	**GRANM (+)**
There is a positive significant relationship between U.S. patent applied for by Malaysian firms and their financial performance.	APPS (+)	**APPS (+)**	APPS (+)	**APPS (–)**	APPS (+)	**APPS (–)**
There is a positive significant relationship between U.S. patent granted to Malaysian firms and their financial performance.	GRANS (+)	**GRANS (+)**	GRANS (+)	**GRANS (–)**	GRANS (+)	**GRANS (–)**

The boldface variables and signs are statistically significant based on Table 7.22. The statistically insignificant signs are based on the majority of cases.

7.4 Results Based on Patent Quality Measures

7.4.1 Panel Model Results

Both samples had similar R-squared in all model specifications with the samples discussed in Chapter 6, even though their number of observations is much lower, as discussed earlier with regard to patent renewal/ application measures. With the patent quality measures, we also have to omit the NAGE variable from the FEM model in the mechanical/ electronics sample to obtain the parameter estimates (see columns 3 to 5 of tables 7.28 to 7.30).

7.4.1.1 Human Necessities and Performing Operations Technology Fields

The SBWC in model 1 is found to have a negatively statistically significant impact at the 5% level in all types of effects specification in the FEM and cross-section random effects specifications in the REM (see columns 3 to 6 of Table 7.25). MBWC and MCL are also found to be statistically significant ranging across the 10% to 1% level, but only with the REM and PLS estimations, with a negative and positive impact, respectively. Model 1 also shows that a unit increase in claims in U.S. patent specification decreases the firm's profits by only 1%. FAM is a dummy variable, the size of the coefficients relative to the constant showing that having a patent family in both territories decreases the firm's sales by 0.2% (see Column 3 of Table 7.25) with the FEM. Interestingly, however, in the PLS it shows that the sign and magnitudes of the coefficient changes, with a patent family in both territories increasing the firm's sales by 6.3% (see Column 2 of Table 7.25)

Moving to model 2, SBWC and SCL have a positively statistically significant impact ranging across the 5% and 10% level. SBWC has a positive impact on profits in the PLS and REM estimation (see columns 1, 6 and 7 of Table 7.26), while the positive impact of SCL on profits is seen in the FEM estimation (see columns 3 to 5 of Table 7.26). In contrast with the positive impact of SBWC and SCL on the firm's profits, having a patent family in both territories decreases the firm's profits by 6% to 8% (see Table 7.26). Model 3, on the other hand, shows that only two explanatory variables have the most estimations with a statistically significant impact on the firm's profit margin that is, the SBWC and FAM, with a positive and negative impact respectively (see Table 7.27).

7.4.1.2 Mechanicals and Electronics Technology Fields

While we saw only one contradicting sign in the human necessities/ performing operations sample in model 1, we now have two in the mechanicals/ electronics sample. For MCL and SCL, the FEM with a one-way model (cross-section fixed) and two-way model (cross-section and period fixed), has given a positively statistically significant impact ranging across 5% and 10% level (see columns 4 and 5 of Table 7.28), while the REM with period random effects specification has a negatively statistically significant impact at the 1% and 5% level (see Column 7 of Table 7.28). In addition, the REM with period random effects also gives a positively statistically significant impact on the firm's sales for the MBWC and SBWC, with 0.02 and 0.01 coefficients, respectively (see Column 7 of Table 7.28). In the human necessities/ performing operations sample we saw a contradicting sign to the FAM variable, while in the mechanicals/ electronics sample, having a patent family in both territories increases the firm's profits by 2% to 5% (see Table 7.28).

Only MBWC is found to have a positively statistically significant impact ranging across the 1% to 10% levels on the firm's profits, while MCL and FAM are found to have a negatively statistically significant impact at the 1% level. FAM has the highest magnitude of the impact with ranges from -4.41 to -2.93, while MCL only has an impact of -0.01 (see Table 7.29). Moving to model 3, MBWC is found to have positively statistically significant impact on the firm's profit margin ranging across the 10% to 1% level with the FEM and REM (see Column 3 to 6 of Table 7.30), while SCL is also found to have a positively statistically significant impact, but only with the PLS (see Column 1 of Table 7.30). In contrast to the positive sign found in MBWC and SCL, the SBWC, MCL and FAM variables have negative signs, with FAM having the highest magnitude (-4.8 to -3.3) followed by MCL and SBWC (-0.01 to -0.02).

Table 7.25: Panel Model Result for Model 1 with PLS, FEM & REM (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	0.311259	6.022598***	-1.414483	-3.814277	-0.749562	0.311259**	0.299688
	(0.192543)	(1.470533)	(3.800049)	(3.817065)	(4.206975)	(0.147166)	(0.255858)
MBWC	-0.033168***	-0.025231	0.022543	0.025446	0.019731	-0.033168***	-0.031261*
	(0.00817)	(0.048217)	(0.023001)	(0.036237)	(0.022646)	(0.009364)	(0.016207)
SBWC	-0.005908	-0.039481	-0.023453**	-0.034409**	-0.023958**	-0.005908**	-0.005507
	(0.006816)	(0.028472)	(0.009678)	(0.017282)	(0.009954)	(0.002693)	(0.00466)
MCL	0.008242***	0.010644	0.001727	0.00363	-0.000235	0.008242***	0.008613**
	(0.002357)	(0.00818)	(0.004478)	(0.007683)	(0.004563)	(0.002105)	(0.003647)
SCL	0.005408**	0.013605	0.007806*	0.012608	0.00802**	0.005408***	0.005439*
	(0.002498)	(0.014392)	(0.004019)	(0.008036)	(0.004076)	(0.001611)	(0.002784)
FAM	-0.077548	0.297989**	-0.073458	0.066761	-0.208127*	-0.077548	-0.07087
	(0.122001)	(0.146413)	(0.132814)	(0.147004)	(0.125439)	(0.22709)	(0.39313)
LNTGA	0.967792***	0.611007***	0.738024***	0.608257***	0.71879***	0.967792***	0.969313***
	(0.012368)	(0.093268)	(0.055285)	(0.080421)	(0.061547)	(0.009902)	(0.017128)
NAGE	0.006255*	0.026256**	0.270123	0.488824**	0.254027	0.006255**	0.00566
	(0.003744)	(0.012911)	(0.19885)	(0.200571)	(0.21441)	(0.002574)	(0.004454)
R-Squared	0.774825	0.918327	0.932131	0.943895	0.933564	0.774825	0.775782
Number of Observations	1178	1066	1178	1066	1178	1178	1178

The dependent variable is sales. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.26: Panel Model Result for Model 2 with PLS, FEM & REM (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	-3.661092***	-3.256678***	-6.552591	-6.436264	-5.616106	-3.661092***	-3.661092***
	(0.332662)	(0.861599)	(4.276944)	(4.931515)	(3.776227)	(0.25907)	(0.336286)
MBWC	-0.023632	-0.032876	0.022914	0.032034	0.038011	-0.023632	-0.023632
	(0.01988)	(0.043931)	(0.061189)	(0.071293)	(0.060444)	(0.014817)	(0.019234)
SBWC	0.011855***	0.005241	-0.003317	-0.006886	-0.002487	0.011855***	0.011855**
	(0.001988)	(0.006985)	(0.003156)	(0.006192)	(0.003499)	(0.004124)	(0.005353)
MCL	0.001748	0.007108	-0.005102	-0.003894	-0.008895	0.001748	0.001748
	(0.00309)	(0.006099)	(0.009583)	(0.010592)	(0.010176)	(0.003222)	(0.004182)
SCL	0.00085	0.006043	0.008506**	0.016137**	0.008763**	0.00085	0.00085
	(0.002096)	(0.004499)	(0.004228)	(0.007526)	(0.004244)	(0.002748)	(0.003567)
FAM	-2.067105***	-3.810374***	-1.177185*	-1.684846*	-1.166907*	-2.067105***	-2.067105***
	(0.449913)	(0.427058)	(0.671219)	(1.012835)	(0.700976)	(0.484656)	(0.629109)
LNTGA	1.068777***	1.017826***	0.711527***	0.595478***	0.656486***	1.068777***	1.068777***
	(0.0209)	(0.052894)	(0.071343)	(0.082093)	(0.087417)	(0.016614)	(0.021566)
NAGE	-0.009617**	0.008394	0.394874*	0.471393**	0.39353**	-0.009617**	-0.009617*
	(0.004685)	(0.010314)	(0.210709)	(0.21216)	(0.194307)	(0.004088)	(0.005306)
R-Squared	0.760352	0.859959	0.874726	0.90257	0.878758	0.760352	0.760352
Number of Observations	893	721	893	721	893	893	893

The dependent variable is profits. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.27: Panel Model Result for Model 3 with PLS, FEM & REM (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	-4.355154***	-5.479322***	-4.921258**	-3.825248	-6.365457**	-4.355154***	-4.355154***
	(0.335064)	(0.859429)	(2.168607)	(2.785191)	(2.548381)	(0.244034)	(0.318122)
MBWC	0.01606	0.011199	0.002377	0.03192	0.013565	0.01606	0.01606
	(0.022201)	(0.042932)	(0.067682)	(0.081373)	(0.067644)	(0.013957)	(0.018195)
SBWC	0.012956***	0.010974***	0.006252*	0.00506	0.007968**	0.012956***	0.012956**
	(0.001712)	(0.002222)	(0.003399)	(0.004478)	(0.003792)	(0.003884)	(0.005064)
MCL	-0.005338*	-0.003248	-0.006303	-0.013194	-0.006926	-0.005338*	-0.005338
	(0.002853)	(0.005646)	(0.009872)	(0.009451)	(0.010561)	(0.003035)	(0.003956)
SCL	-0.002039	0.002753	0.005789	0.012564*	0.005592	-0.002039	-0.002039
	(0.002423)	(0.004028)	(0.004251)	(0.007136)	(0.00429)	(0.002588)	(0.003374)
FAM	-1.606447***	-3.762873***	-0.847263	-1.703279*	-0.80359	-1.606447***	-1.606447***
	(0.401344)	(0.432996)	(0.590901)	(0.911545)	(0.594773)	(0.456528)	(0.595129)
LNTGA	0.089942***	0.137162***	-0.075292*	0.074787	-0.059222	0.089942***	0.089942***
	(0.01993)	(0.049547)	(0.040197)	(0.057929)	(0.046985)	(0.01565)	(0.020401)
NAGE	0.001206	0.012422	0.154972	-0.010953	0.208112**	0.001206	0.001206
	(0.00486)	(0.010617)	(0.102665)	(0.099752)	(0.105697)	(0.003851)	(0.00502)
R-Squared	0.043115	0.434008	0.502209	0.601901	0.512669	0.043115	0.043115
Number of Observations	893	721	893	721	893	893	893

The dependent variable is profit margin. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.28: Panel Model Result for Model 1 with PLS, FEM & REM (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	0.18161	2.051675***	3.85753***	5.538799***	4.364438***	1.797447***	0.18161
	(0.16069)	(0.631144)	(0.889389)	(1.676044)	(1.107573)	(0.437623)	(0.193634)
MBWC	0.024332	0.011207	-0.004912	-0.005109	-0.003362	-0.001202	0.024332***
	(0.011296)	(0.010891)	(0.008759)	(0.006617)	(0.008431)	(0.0105)	(0.009063)
SBWC	0.011877	0.001318	0.0000851	0.000544	-0.0000454	0.000298	0.011877***
	(0.001892)	(0.001547)	(0.001545)	(0.002628)	(0.001513)	(0.003144)	(0.003276)
MCL	-0.00513	0.004808	0.006877**	0.00764**	0.005967**	0.004842*	-0.00513**
	(0.002839)	(0.003033)	(0.003018)	(0.003428)	(0.002805)	(0.002718)	(0.00239)
SCL	-0.009337	0.00273	0.00331*	0.003041*	0.003072*	0.003384	-0.009337***
	(0.00204)	(0.001805)	(0.001838)	(0.001694)	(0.001693)	(0.003235)	(0.003602)
FAM	0.147677	-0.181804	0.10641	-0.035318	0.06748	0.066006	0.147677
	(0.137863)	(0.146892)	(0.111505)	(0.140376)	(0.108426)	(0.183932)	(0.23349)
LNTGA	0.94452	0.816543***	0.754836***	0.657464***	0.725341***	0.819332***	0.94452***
	(0.012455)	(0.042683)	(0.053686)	(0.100458)	(0.066285)	(0.024987)	(0.012079)
NAGE	0.026462	0.03691***				0.045062***	0.026462***
	(0.003127)	(0.012991)				(0.012703)	(0.00383)
R-Squared	0.893768	0.961428	0.964026	0.972945	0.964525	0.586282	0.893768
Number of Observations	1047	956	1047	956	1047	1047	1047

The dependent variable is sales. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.29: Panel Model Result for Model 2 with PLS, FEM & REM (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[(a)]	FEM	FEM[(a)]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	-3.818009***	-4.266698***	1.024131	1.616124	0.319037	-2.685608***	-3.814406***
	(0.211716)	(0.740442)	(1.404362)	(2.00562)	(2.240389)	(0.617675)	(0.273173)
MBWC	0.023131***	0.020926	0.041887***	0.042703***	0.039996***	0.036976**	0.02313*
	(0.008067)	(0.017144)	(0.0104)	(0.012602)	(0.010645)	(0.01759)	(0.012095)
SBWC	0.000893	-0.006628	-0.002124	-0.016371	-0.002657	-0.002596	0.000754
	(0.003671)	(0.006517)	(0.004404)	(0.010744)	(0.004525)	(0.006035)	(0.005076)
MCL	-0.010452***	-0.006813	-0.012879***	-0.014762***	-0.011108***	-0.013162***	-0.010238***
	(0.002169)	(0.005363)	(0.003634)	(0.0039)	(0.003788)	(0.004886)	(0.0033)
SCL	-0.006566	-0.000126	-0.001122	0.004636	-0.00039	-0.001972	-0.006316
	(0.004405)	(0.005461)	(0.00319)	(0.004836)	(0.00312)	(0.006782)	(0.006051)
FAM	0.398999	-0.147643	-0.278194	-0.415791	-0.337043	-0.245895	0.39332
	(0.313525)	(0.29816)	(0.228174)	(0.305546)	(0.21993)	(0.344986)	(0.340558)
LNTGA	1.044809***	1.058989***	0.784602***	0.760495***	0.824737***	0.953569***	1.044872***
	(0.013016)	(0.036766)	(0.081895)	(0.11368)	(0.130598)	(0.037924)	(0.016009)
NAGE	0.018099***	0.024327***				0.035028**	0.017861***
	(0.003637)	(0.005869)				(0.014078)	(0.005206)
R-Squared	0.873748	0.921494	0.924001	0.942016	0.925818	0.508958	0.874061
Number of Observations	796	645	796	645	796	796	796

The dependent variable is profits. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [(a)] The specification is run with AR(1) correction.

Table 7.30: Panel Model Result for Model 3 with PLS, FEM & REM (Based on Patent Renewal/ Application Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation	PLS	PLS[a]	FEM	FEM[a]	FEM	REM	REM
Effects Specification	-	-	cross-section fixed	cross-section fixed	cross-section & period fixed	cross-section random	period random
C	-4.207633***	-4.700371***	-2.220089**	-3.047728*	-3.300377*	-3.568277***	-4.207633***
	(0.228379)	(1.050579)	(1.048602)	(1.757789)	(1.848704)	(0.583005)	(0.303841)
MBWC	-0.000543	0.021009	0.044201***	0.036274**	0.041756**	0.028868*	-0.000543
	(0.018774)	(0.026832)	(0.015875)	(0.01645)	(0.016392)	(0.017402)	(0.013492)
SBWC	-0.01592***	-0.012711*	-0.003426	-0.012969	-0.003498	-0.006304	-0.01592***
	(0.002988)	(0.006845)	(0.0045)	(0.012399)	(0.00465)	(0.006021)	(0.005663)
MCL	-0.005082	-0.010678	-0.017797***	-0.018652***	-0.015572***	-0.013035***	-0.005082
	(0.004007)	(0.007098)	(0.00523)	(0.005928)	(0.005627)	(0.004829)	(0.003675)
SCL	0.009418***	0.003325	-0.001639	-0.000325	-0.001378	-0.000521	0.009418
	(0.003284)	(0.005895)	(0.003601)	(0.004009)	(0.003374)	(0.0068)	(0.006748)
FAM	-0.051538	-0.103432	-0.434249**	-0.256407	-0.443585**	-0.386594	-0.051538
	(0.160222)	(0.250719)	(0.217015)	(0.22834)	(0.225093)	(0.3466)	(0.379826)
LNTGA	0.096445***	0.116069**	-0.020728	0.032365	0.040945	0.049026	0.096445***
	(0.013937)	(0.052885)	(0.061387)	(0.101757)	(0.107537)	(0.035942)	(0.017857)
NAGE	-0.001568	0.002363				0.007429	-0.001568
	(0.004303)	(0.009511)				(0.01297)	(0.005803)
R-Squared	0.060974	0.461875	0.532258	0.627437	0.538732	0.025504	0.060974
Number of Observations	796	645	796	645	796	796	796

The dependent variable is profit margin. C is the constant; MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. [a] The specification is run with AR(1) correction.

7.4.1.3 Hausman Test

The result of the Hausman test in this chapter (see Table 7.31) is very similar to that of the Hausman test conducted in Chapter 6 for the all firms sample (see Table 6.12), whereby in the period random effects specification, we fail to reject the null hypothesis of favoring REM in both samples under study. This may show that the time effect such as financial and economic crisis or changes in the government policy, for example, are not correlated with the regressors. In addition, referring to the RESET test (see Table 7.8), almost all model specifications in the REM estimations in the mechanicals/ electronics sample are found not to be misspecified (except for model 2 in the period random effects specifications). On the other hand, for the cross-section random effects specifications, the null hypothesis of favoring REM can be rejected for both samples at the 1% significance level, except for model 3 in the mechanicals/ electronics technology field sample. This may show that the individual effects such as the inventor's capability to learn and invent, firm's managerial decision to patent, investment decision to patent in more than one territory for example are correlated with the regressors. Similar with the results found in the patent renewal/ application measures, even though the human necessities/ performing operations sample cannot be rejected as being misspecified in the RESET test, the Hausman test has given us the opportunity to choose the between FEM or REM.

Table 7.31: Hausman Test – Based on Patent Quality Measures

Hausman Test	Null hypothesis: REM is favored			
Sample	Human Necessities & Performing Operations		Mechanicals & Electronics	
Effects Specification	cross-section random	period random	cross-section random	period random
Model 1: Sales	Reject null at 1% significance level	Reject null at 10% significance level	Reject null at 1% significance level	Do not reject null
Model 2: Profits	Reject null at 1% significance level	Do not reject null	Reject null at 5% significance level	Do not reject null
Model 3: Profit Margin	Reject null at 1% significance level	Do not reject null	Do not reject null	Do not reject null

7.4.2 Dynamic Panel Model Results

In this patent quality measures, the results also show that all of the specifications meet the Sargan test requirements, similar to the patent renewal/ application measures. The results also show that the single lagged dependent variable has a positively statistically significant impact at the 1% level in all specifications. Similar to the static panel model, the model specifications was run with two separate samples which consisted of a human necessities/ performing operations technology field sample and a mechanicals/ electronics technology field sample. However, as mentioned earlier in the patent renewal/ application measure, we found contradicting signs in some statistically significant variables in the model specifications.

7.4.2.1 Human Necessities and Performing Operations Technology Fields

We found SBWC and SCL have a statistically significant impact at the 1% level, with a negative and positive sign, respectively. SBWC has a higher negative impact with a coefficient ranging across -0.04 to -0.02; while MCL has a coefficient range from 0.01 to 0.02 (see Table 7.32). As mentioned earlier relating to the contradicting sign, MBWC and FAM have a contradicting sign between the first difference and orthogonal deviations transformation. While MBWC has a negatively statistically significant impact at the 1% level with the first difference transformation, the orthogonal deviations transformation has a positive impact. Otherwise, we found that FAM is positively related with the first difference transformation, but negatively related with the orthogonal deviations transformation.

In model 2 with profits as the dependent variable, SCL is once again found to be positively statistically significant similar to model 1. MBWC, on the other hand, still has a positively statistically significant impact, but only with the orthogonal deviations transformation in the cross-section fixed effects specifications (see Column 3 of Table 7.33). Otherwise, with the first difference transformation MBWC has a negative impact on the firm's profits (see columns 1 and 2 of Table 7.33). SBWC is found to have a negatively statistically significant impact at the 10% level (see columns 2 and 3 of Table 7.33). Another variable which also has a contradicting sign is the MCL, with the first difference having a positive impact and orthogonal deviations having a negative impact (see columns 1 and 3 of Table 7.33). FAM is found to have a negatively statistically significant impact with the highest magnitude ranging from -145 to -1.62 (see columns 1 to 3 of Table 7.33).

The MBWC and MCL are again found to have a contradicting sign similar to model 2. However, their impact (either positive or negative) on profit margin is less than 10% (see columns 1 and 3 of Table 7.34). SCL and FAM also have the same sign as in model 2, with a positive and negative impact respectively. Interestingly, however, while SBWC is found to be negatively related in model 2, it is found otherwise in model 3. Nevertheless, the positive impact is rather small at less than 0.5% with both types of cross-section transformations (see columns 1 and 3 of Table 7.34). Even though in model 1 the FAM variable has a contradicting sign, in model 3 all specifications have a negatively statistically significant impact on the firm's profit margin (see columns 1, 2 and 4 of Table 7.34), except for cross-section and period fixed effects specification in the first difference transformation which is found not to be statistically significant (see Column 3 of Table 7.34).

7.4.2.2 Mechanicals and Electronics Technology Fields

The MBWC and SBWC are found to have contradicting signs between the first differences and orthogonal deviations. In the first differences transformation, a unit increase in the backward citation in the Malaysian patent specification increases the firm's sales by 1% (see Column 1 of Table 7.35), while the orthogonal deviations transformation decreases the firm's sales by 1% (see columns 3 and 4 of Table 7.35). In the first differences transformation, a unit increase in the backward citation in the U.S. patent specification decreases the firm's sales by 1% (see columns 1 and 2 of Table 7.35), while in the orthogonal deviations transformation it increases the firm's sales by 0.1% (see Column 3 of Table 7.35). MCL is found to have a positively statistically significant impact at the 1% level in the orthogonal deviation transformation (see columns 3 and 4 of Table 7.35), while SCL is also found to have a positively statistically significant impact in both types of transformations and in the all effects specifications (see Table 7.35). FAM, on the other hand, has a positively statistically significant impact in the first differences transformation with cross-section effects specifications with a 0.35 coefficient (see Column 1 of Table 7.35).

While there are many variables that are found to be statistically significant in model 1, less variables are found to be statistically significant in model 2. MBWC is found to have a positively statistically significant impact on the firm's profits in contrast to SBWC in both types of transformations (see Table 7.36). On the other hand, MCL and SCL is found to have a negative and positive impact on the firm's profits, respectively, but in only one effects specification each (see columns 1 and 3 of Table 7.36). Finally, in model 3, only SBWC has a negatively statistically significant impact ranging across 1% to 10% levels in both types of transformations. MCWC and MCL are also found to have a statistically significant impact, with positive and negative signs respectively, but in only the orthogonal deviations with cross-section fixed effects specifications (see Column 3 of Table 7.37).

Table 7.32: Dynamic Panel Model Result for Model 1 with GMM Estimation (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.204823***	0.269633***	0.171678***	0.190918***
	(0.003032)	(0.008811)	(0.004348)	(0.004806)
MBWC	-0.062273***	-0.042026**	0.020118***	0.011802**
	(0.014193)	(0.020403)	(0.006073)	(0.005469)
SBWC	-0.039388***	-0.043853***	-0.021505***	-0.026247***
	(0.0048)	(0.006511)	(0.003336)	(0.003062)
MCL	0.014835***	0.005474	0.000697	0.00256*
	(0.002699)	(0.003356)	(0.001631)	(0.001458)
SCL	0.012993***	0.017558***	0.00713***	0.009255***
	(0.003341)	(0.004693)	(0.001349)	(0.001175)
FAM	0.635714***	0.244255***	-0.05081***	-0.092167***
	(0.010132)	(0.06595)	(0.018692)	(0.019496)
LNTGA	0.493625***	0.435768***	0.6066***	0.604667***
	(0.005228)	(0.016236)	(0.009932)	(0.011591)
NAGE	0.495639***	0.26197**		
	(0.014504)	(0.110541)		
Number of Observations	954	954	954	954

The dependent variable is sales. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.33: Dynamic Panel Model Result for Model 2 with GMM Estimation (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.160863***	0.251438***	0.29717***	0.400247***
	(0.008525)	(0.024807)	(0.005577)	(0.024598)
MBWC	-0.131831***	-0.11176**	0.048027**	0.050047
	(0.018892)	(0.04494)	(0.02264)	(0.034351)
SBWC	-0.005749	-0.011039*	-0.004698*	-0.000166
	(0.006858)	(0.006668)	(0.002525)	(0.004691)
MCL	0.010418***	0.005829	-0.010507***	-0.009461
	(0.002489)	(0.010215)	(0.003286)	(0.006181)
SCL	0.007071	0.011215***	0.011997***	0.01474**
	(0.005987)	(0.004131)	(0.00307)	(0.006597)
FAM	-1.615887**	-1.515537**	-1.445418***	-1.079377
	(0.689359)	(0.754516)	(0.415085)	(0.76562)
LNTGA	0.4296***	0.21529**	0.464918***	0.46109***
	(0.0133)	(0.09605)	(0.013368)	(0.052448)
NAGE	0.433921	-0.16178	0.282777	-0.568549
	(0.424066)	(1.003074)	(0.306916)	(1.003884)
Number of Observations	623	623	623	623

The dependent variable is profits. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.34: Dynamic Panel Model Result for Model 3 with GMM Estimation (Based on Patent Quality Measures) – Human Necessities & Performing Operations

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.135024***	0.273941***	0.199598***	0.352459***
	(0.003469)	(0.025145)	(0.001868)	(0.013768)
MBWC	-0.062078***	-0.029702	0.034687***	0.0487
	(0.013497)	(0.050258)	(0.010121)	(0.03326)
SBWC	0.004939*	0.009228	0.003478**	0.005076
	(0.002549)	(0.010661)	(0.001623)	(0.004012)
MCL	0.006044**	-0.00521	-0.011012***	-0.013507
	(0.003006)	(0.011629)	(0.001645)	(0.008589)
SCL	0.002415	-0.003201	0.011139***	0.010335***
	(0.001614)	(0.009688)	(0.002383)	(0.002572)
FAM	-1.624626***	-0.644199	-1.392027***	-1.124793***
	(0.251113)	(0.846192)	(0.218689)	(0.426469)
LNTGA	0.116286***	-0.219316*	0.036385***	0.033361
	(0.004195)	(0.12929)	(0.001816)	(0.060628)
NAGE	-0.126171	-0.11523	-0.398521	0.350924
	(0.510591)	(1.62981)	(0.484401)	(0.950153)
Number of Observations	623	623	623	623

The dependent variable is profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.35: Dynamic Panel Model Result for Model 1 with GMM Estimation (Based on Patent Quality Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNSALES(-1)	0.004247	-0.03924**	-0.033805***	0.056719***
	(0.003452)	(0.015305)	(0.003909)	(0.013835)
MBWC	0.013749***	-0.002092	-0.010416*	-0.010823**
	(0.005267)	(0.013603)	(0.006317)	(0.005185)
SBWC	-0.007933***	-0.005663***	0.000671**	0.00114
	(0.000479)	(0.001407)	(0.000318)	(0.000882)
MCL	0.000529	-0.001167	0.007655***	0.006986***
	(0.000578)	(0.002813)	(0.000651)	(0.001415)
SCL	0.011931***	0.008701***	0.003183***	0.002349***
	(0.000551)	(0.001786)	(0.000212)	(0.000747)
FAM	0.347336***	0.309718	0.160302	0.118875
	(0.130685)	(0.247073)	(0.150922)	(0.101409)
LNTGA	0.597297***	0.581721***	0.767468***	0.701117***
	(0.003317)	(0.039627)	(0.003775)	(0.035431)
Number of Observations	865	865	865	865

The dependent variable is sales. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.36: Dynamic Panel Model Result for Model 2 with GMM Estimation (Based on Patent Quality Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPROFITS(-1)	0.229086***	0.327424***	0.354976***	0.423273***
	(0.015543)	(0.046488)	(0.010647)	(0.05039)
MBWC	0.036285***	0.04848*	0.027327***	0.039228
	(0.006559)	(0.029265)	(0.00725)	(0.025995)
SBWC	-0.023963***	-0.02493	-0.012868***	-0.018264***
	(0.006125)	(0.015706)	(0.003005)	(0.006889)
MCL	0.001257	-0.007663	-0.010078***	-0.0108
	(0.002818)	(0.005739)	(0.001945)	(0.007619)
SCL	0.003098*	0.006864	0.001363	0.005705
	(0.001626)	(0.010234)	(0.001299)	(0.005177)
FAM	-0.181343	-0.447257	-0.125503	-0.36506
	(0.23108)	(0.76719)	(0.15399)	(0.445103)
LNTGA	0.435192***	0.300915***	0.504047***	0.614496***
	(0.01006)	(0.097197)	(0.009242)	(0.104462)
Number of Observations	562	562	562	562

The dependent variable is profits. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

Table 7.37: Dynamic Panel Model Result for Model 3 with GMM Estimation (Based on Patent Quality Measures) – Mechanicals & Electronics

Column	(1)	(2)	(3)	(4)
Effects Specification	Cross-section fixed	Cross-section & period fixed	Cross-section fixed	Cross-section & period fixed
Cross-section Transformation	First differences	First differences	Orthogonal deviations	Orthogonal deviations
Explanatory Variables				
LNPM(-1)	0.318452***	0.314882***	0.473333***	0.449191***
	(0.015485)	(0.035857)	(0.009852)	(0.026858)
MBWC	0.013156	0.013527	0.026371***	0.020808
	(0.009894)	(0.017954)	(0.009262)	(0.020435)
SBWC	-0.02257***	-0.019341*	-0.007089*	-0.006392
	(0.003318)	(0.01158)	(0.004096)	(0.009851)
MCL	-0.001653	-0.002218	-0.01072***	-0.00873
	(0.003055)	(0.003978)	(0.002426)	(0.006148)
SCL	0.003863	0.01233	-0.000845	0.002697
	(0.004455)	(0.017247)	(0.006878)	(0.011796)
FAM	-0.177195	-0.510344	0.049609	0.047676
	(0.265365)	(0.947454)	(0.258203)	(0.572601)
LNTGA	-0.004985	-0.183954**	-0.011125	-0.019173
	(0.018918)	(0.079235)	(0.024993)	(0.086238)
Number of Observations	562	562	562	562

The dependent variable is profit margin. MBWC and SBWC are the backward citations in Malaysian and the U.S. patent specification, respectively; MCL and SCL are the patent claims in Malaysian and the U.S. patent specification, respectively; FAM is the patent family; LNTGA is the tangible assets; NAGE is the age. Values shown are the coefficient estimates. Values below the coefficient estimates in the parentheses are the robust standard error. ***, **, and * indicate the significance level at 1%, 5%, and 10% respectively.

7.4.3 Summary of Findings Based on Estimation

The selection of the estimation to be included in the summary is similar to the patent renewal/ application measures, as discussed in Section 7.3.3. Since we also experienced contradicting signs during the selection, we again referred to the RESET test for the static panel and favored orthogonal deviation transformation for the dynamic panel to select which model to be included in the summary table. When comparing between the two approaches, GMM gave a higher number of significant variables compared to PLS/ FEM/ REM in both human necessities/ performing operations and mechanical/ electronics technology field samples. The sign of the significant variables are very similar, and the coefficients have only a slight difference between the static and dynamic specifications. Table 7.38 shows the summary of findings based on the set of estimation results.

7.4.3.1 Human Necessities and Performing Operations Technology Fields

While in the dynamic panel model with the GMM estimation all of the explanatory variables are found to have a statistically significant relationship with the firm's financial performance in all three models, the static panel model with PLS/FEM/REM estimations has only some variables which are statistically significant. In the PLS/FEM/REM estimation, there are only three, one and two variables found to be statistically significant in models 1, 2 and 3 respectively. Among all of the estimations, the magnitude to the coefficients is quite small, that is, less than 10%. The highest magnitude of the coefficients among all of the explanatory variables is the FAM that ranges from -0.96, -8.12 to -5.73 and -9.24 to -5.53 for models 1, 2 and 3 respectively in the PLS/FEM/REM estimations. In addition, the FAM variable also has the highest magnitude of the coefficients reported in the GMM estimation with -0.09 to 0.05, -1.62 to -1.45, and -1.62 to -1.12 for models 1, 2 and 3 respectively.

7.4.3.2 Mechanicals and Electronics Technology Fields

Compared to the human necessities/ performing operations technology field, the mechanicals/ electronics technology field had fewer variables to be statistically significant with the firm's financial performance variables. Interestingly, the FAM variable in the GMM estimation is found not to be statistically significant in all three models, but statistically significant in the PLS/FEM/REM estimations, with a positive sign in model 1 and a negative sign in the other two models. This situation is in contrast to the SBWC variable, where no statistically significant impact is found in all three models with the PLS/FEM/REM estimation, but is positively related in model 1 and negatively related in the other two models with the GMM estimation. However, the magnitude of the coefficients in all variables that are found to be statistically significant is rather small at less than 15%.

7.4.3.3 Overall Summary

Unlike the renewal/ application measures that have more statistically significant variables in the mechanical/ electronics technology field, the patent quality measures in the human necessities/ performing operations technology field are found to have all variables statistically significant, especially the GMM estimation. This is quite surprising, since we experienced the same trend with the manufacturing firms sample in both types of measures – patent renewal/ application and quality (see chapters 5 and 6), but not with the technology fields sample. Two of the patent variables in the patent quality measures, which are the backward citation and claim as discussed in earlier chapters, may represent the knowledge flows, and therefore in this analysis are found to have more statistically significant impacts on the firm's financial performance in the human necessities/ performing operations technology field. On the other hand, the magnitude of the coefficients to the statistically significant variables between these two fields does not vary by a large margin, which means they are quite similar, most of them with less than 10% impact on the firm's financial performance. Therefore, our expectation in Chapter 3 that the magnitude of the coefficients between these two fields will vary significantly is not met.

Table 7.38: Summary of Findings Based on Estimations – Patent Quality Measures

Estimations	Explanatory Variables	Human Necessities & Performing Operations			Mechanicals & Electronics		
		Model 1: Sales	Model 2: Profits	Model 3: Profit Margin	Model 1: Sales	Model 2: Profits	Model 3: Profit Margin
PLS/ FEM/ REM	MBWC					(+) 0.02~0.04	
	SBWC	(–) 0.03~0.02		(+) 0.008~0.013			
	MCL				(–) 0.005	(–) 0.014~0.010	
	SCL	(+) 0.005~0.008			(–) 0.009		
	FAM[(a)]	(–) 0.96	(–) 8.12~5.73	(–) 9.24~5.53	(+) 1.87~5.50	(–) 4.41~3.42	(–) 4.80~3.95
GMM	MBWC	(+) 0.01~0.02	(+) 0.05	(+) 0.03	(–) 0.01	(+) 0.03~0.05	
	SBWC	(–) 0.04~0.02	(–) 0.011~0.005	(+) 0.003~0.005	(+) 0.001	(–) 0.02~0.01	(–) 0.023~0.007
	MCL	(+) 0.003~0.015	(–) 0.01	(–) 0.01	(+) 0.007~0.008		
	SCL	(+) 0.007~0.018	(+) 0.011~0.015	(+) 0.010~0.011	(+) 0.002~0.012		
	FAM[(a)]	(–) 0.09~0.05	(–) 1.62~1.45	(–) 1.62~1.12			

Only significant variables are reported; (+) means positive relationship between the dependent and explanatory variables; (–) means negative relationship between the dependent and explanatory variables; the values shown below the sign are the coefficient estimates from the lowest to the highest. [(a)]The coefficient reported for the FAM variable having a patent family.

7.4.4 Summary of Findings Based on Hypotheses Development

In this section, we answer Hypothesis 2 developed in Chapter 3 relating to the patent quality measures. The results reported will also focus on the expected sign in our hypotheses development, unlike in the previous section where results focused on statistically significant variables and the magnitude of the coefficients. We summarize our findings based on the samples, which are shown in Table 7.39 for the human necessities/ performing operations technology field and Table 7.40 for the mechanicals/ electronics technology field sample.

7.4.4.1 Human Necessities and Performing Operations Technology Fields

In model 1, all of the explanatory variables have a statistically significant relationship with the firm's sales. However, only SBWC and FAM variables are found to have a negatively statistically significant impact, which contradicts our expected sign while developing the hypotheses. In a similar argument to that within Chapter 6, the negative sign of the backward citation in the U.S. patent specification may signal that a similar invention to the patent already has a place in the U.S. market, since backward citation is citing an existing invention to the current invention. In another setting, it may also relate to other existing patented inventions in the U.S. market that are able to compete by lowering the price, which results in higher demand for the existing invention, and in turn leads to a negative sign of the relationship with the Malaysian firms' sales. The negative sign continues in model 2 with profits as the dependent variable. Besides the negative impact on sales which could also lead to a negative impact on profits, this situation may also be caused by higher costs in securing the patent in the U.S. Interestingly, however, SBWC in model 3 with profit margin as the dependent variable shows a positive sign. In another setting, profit margin may signal the firm's growth, as empirically analyzed by Geroski, Machin, and Walters (1997). Thus, the knowledge that travels from the backward citation in the advanced economies to the Malaysian firms, lead to the firm's growth in the human necessities/ performing operations technology field. FAM, however, which initially had a negative impact on model 1, continues to give a negative impact on models 2 and 3. This situation may signal that the intention to patent in more than one territory is a long term investment, rather than a short term one.

While MBWC and SCL matched our expected sign in Chapter 3 with having positive impact on all three models (sales, profits and profit margin), MCL had a positive sign with sales, but a negative sign with the other two models (profits and profit margin). This is quite interesting, if we were to argue in terms of costing the patent claims that even though more costly in the U.S., (SCL) give a positive impact throughout all three models, while being negatively related in Malaysia (MCL) where the costs should be much lower. This situation needs a more rigorous explanation as to why this might happen. We learned in the earlier chapters that claim points out the inventor's right to exclude others from the invention. We also learned that claims can also be associated with patent litigations and, therefore, it needs tighter intellectual property rights (IPR) in a particular territory. We also learned that the U.S. has more structured and tighter IPRs than in Malaysia, and therefore, a positive sign of patent claim in the U.S. compared to negative sign in Malaysia may be the case to answer as to the impact of the claim on the profits and profit margin.

7.4.4.2 Mechanicals and Electronics Technology Fields

As mentioned in the preceding section, there are fewer statistically significant variables found in the mechanicals/ electronics technology field compared to the human necessities/ performing operations technology field with the patent quality measure. This is quite interesting when comparing this with the patent renewal/ application measure, as the results found otherwise. In model 1, only MBWC has a negatively statistically significant impact on sales; while the others have a positively statistically significant impact except for FAM which is not statistically significant, but has a positive sign. This may show that even though the broader citation is made in the Malaysian patent specification, the stock of knowledge from the patent citation is negatively related to the firm's sales. In a positive view, this may show that the more unique the patented invention from the Malaysian firms in the mechanicals/ electronics technology field, in which less citation is made to other inventions, the higher demand from the market for sales of the product. However, when moving to model 2, MBWC gives a positively statistically significant impact on the firm's profits. This would be a little puzzling if we were to conjecture based on previous argument in sales. We now suspect, however, that the patented invention and the stock of knowledge learned from the advanced economies are meant to be used in the firms to reduce business costs, which in turn leads to a positive impact on profits.

On the other hand, there is only one variable that gave a statistically significant impact on all of the financial performance adopted in this study (sales, profits and profit margin),that is, the SBWC. However, the statistically significant impact has a positive sign only on sales, with a negative sign to the other two dependent variables (profits and profit margin). This may show that the stock of knowledge that are learned from the backward citation in the U.S. created high demand for the products and, in turn, led to positive sales. However, the costs relating to the patent agent that also deals with the patent citation may lead to negative profits and profit margin. Similar to the human necessities/ performing operations technology field, the FAM variable is found to have a negatively statistically significant impact on the firm's profits and profit margin. While the claim variable in the human necessities/ performing operations technology field seems to be consistent in all three models of financial performance, it is inconsistent in the mechanicals/ electronics field. Both MCL and SCL had a positive significant impact on sales, but start to give a negative impact on profits. Nevertheless, the statistically significant impact takes place only with the claim in the Malaysian patent specification (MCL), not with the claim in the U.S. patent specification (SCL).

*7.4.4.3 **Overall Summary***

We finally have answered the second research question and second hypothesis statement by dividing the sample firms into the patent technology fields. Our expectation that both fields would have no significant difference relating to the sign and significance of the impact of their patenting activity on the firms' financial performance are not met. Even though in the patent renewal/ application measure the mechanicals/ electronics technology field has almost all variables as statistically significant, it is not so with the patent quality measures. This is quite interesting, because if we refer to the RESET test reported in Section 7.2, both measures had the mechanicals/ electronics technology with more model specifications that were not to be misspecified in the REM estimations in almost all of the financial performance models. However, when it comes to the significance of variables, the patent quality measure in the mechanicals/ electronics technology fields have a fewer number of statistically significance variables. This may signal that the patent family (FAM) and stock of knowledge (backward citation and claim) which is the essence in the patent quality measures, may not be as imperative as the patent renewal/ application measure in measuring the impact of patenting activity on the Malaysian firm's financial performance.

Table 7.39: Summary of Findings based on Hypotheses Development – Human Necessities and Performing Operations

Hypotheses Development	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between the broader number of backward citations in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MBWC (+)	**MBWC (+)**	MBWC (+)	**MBWC (+)**	MBWC (+)	**SBWC** (+)
There is a positive significant relationship between the broader number of backward citations in the U.S. patent specification granted to Malaysian firms and their financial performance.	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC** (+)
There is a positive significant relationship between the broader number of claims in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MCL (+)	**MCL (+)**	MCL (+)	**MCL (–)**	MCL (+)	**MCL (–)**
There is a positive significant relationship between the broader number of claims in the U.S. patent specification granted to Malaysian firms and their financial performance.	SCL (+)	**SCL (+)**	SCL (+)	**SCL (+)**	SCL (+)	**SCL (+)**
There is a positive significant relationship between having a patent family in Malaysia and the U.S. granted to Malaysian firms and their financial performance.	FAM (+)	**FAM (–)**	FAM (+)	**FAM (–)**	FAM (+)	**FAM (–)**

The boldface variables and signs are statistically significant based on Table 7.38. The statistically insignificant signs are based on the majority of cases.

Table 7.40: Summary of Findings based on Hypotheses Development – Mechanicals and Electronics

Hypotheses Development	Model 1: Sales		Model 2: Profits		Model 3: Profit Margin	
	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)	Variables (Expected sign)	Variables (Reported sign)
There is a positive significant relationship between the broader number of backward citations in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MBWC (+)	**MBWC (–)**	MBWC (+)	**MBWC (+)**	MBWC (+)	MBWC (+)
There is a positive significant relationship between the broader number of backward citations in the U.S. patent specification granted to Malaysian firms and their financial performance.	SBWC (+)	**SBWC (+)**	SBWC (+)	**SBWC (–)**	SBWC (+)	**SBWC (–)**
There is a positive significant relationship between the broader number of claims in the Malaysian patent specification granted to Malaysian firms and their financial performance.	MCL (+)	**MCL (+)**	MCL (+)	**MCL (–)**	MCL (+)	MCL (–)
There is a positive significant relationship between the broader number of claims in the U.S. patent specification granted to Malaysian firms and their financial performance.	SCL (+)	**SCL (+)**	SCL (+)	SCL (–)	SCL (+)	SCL (+)
There is a positive significant relationship between having a patent family in Malaysia and the U.S. granted to Malaysian firms and their financial performance.	FAM (+)	FAM (+)	FAM (+)	**FAM (–)**	FAM (+)	**FAM (–)**

The boldface variables and signs are statistically significant based on Table 7.38. The statistically insignificant signs are based on the majority of cases.

7.5 Chapter Summary

This chapter answered the third subsidiary research question in Chapter 1. Using the same measurements as in chapters 5 and 6, that is, the patent renewal/ application and quality measures, the sample study has been rearranged following the firms' technology fields. The technology fields were divided into two broad patent technology fields, that is, the human necessities/ performing operations and mechanicals/ electronics technology fields. This is the final chapter of the empirical analysis of results, with the next chapter concluding this study.

CHAPTER 8 CONCLUSION

8.0 Introduction

This study started with a broad observation of patenting activity in Malaysia with macro level data. The current situation does not favor Malaysian residents to undertake patenting activity, and this deepened our curiosity over whether this activity actually benefits them. Focusing on micro level data of Malaysian firms which aimed to maximize profits, we explored whether the patenting activity undertaken by them may result in a positive significant impact on their financial performance. Theoretically, receiving monetary benefits by securing patents in a firm should be the case; empirically however, this had not yet been proved in the case of Malaysian firms.

This study differs from other studies on several grounds. We studied one of the emerging economies, Malaysia, and refined the sample study further to include only Malaysian firms. Conducting an empirical study in an emerging economy brought with it challenges with data. While other studies (mostly of advanced economies) have used market-based financial performance, we on the other hand used accounting-based financial performance. The measures of the patenting activity that are based within the patent system in this study were also modified to cater to the availability of data. Nevertheless, we took it as a challenge to proceed with this topic, even though we were aware that the results may not be promising. As Griliches (1990, p. 1688) points out:

…while the estimated variance components are rather small, they should not be interpreted as implying that the returns to inventive activity are small or that the topic we have been pursuing is not interesting, only that we have been looking for our particular needle in a very large haystack.

This chapter concludes our study. By briefly revisiting the main research question formulated in Chapter 1, we present our key findings in Section 8.1. Section 8.2 discusses the implications of the findings and Section 8.3 presents the research limitations and further extensions to this study.

8.1 Key Finding

In Chapter 1 we formulated the fundamental research question for this study:

What is the relationship between patenting activity and financial performance at the Malaysian firm level for firms which have been granted patents in Malaysia and the United States of America (U.S.)?

In chapters 1 to 3 we learned that patents have their own system and, therefore, the measurement of patenting activity in this study was generated from within the patent system. We also established that the financial performance in this study would be measured following accounting-based measures instead of market-based measures, due to the fact that 97% of our sample was drawn from privately limited firms instead of publicly listed firms. Therefore, we adopted the profit maximization model instead of the market valuation model as the theoretical underpinning of this research.

The key finding of this research is that there is a significant relationship between patenting activity and financial performance at the Malaysian firm level for firms which have been granted patents in Malaysia and the U.S. In chapters 1 to 3 we argued that monopoly power from the patenting activity may have a significant positive impact on the firm's financial performance. In addition, studying firms with a goal to maximize profits strengthened our premise of a positive sign. Empirically, however, the statistically significant impact is found to be rather small and the results are mixed.

The fairly small impact and mixed signs have been discussed comprehensively in chapters 5 to 7, but concluding broadly ex-ante with the profit maximization model, we expect the results may be due to the market structure that the firms faced. Even though the analysis of competitive condition was not central in our analysis, the results of this analysis added value to our study, as we needed to understand the situation better and support the empirical results of our hypotheses statements. As empirically shown in Chapter 4, all of our sample firms (see Table 4.6) can be considered to face a competitive condition. What this means in theory is that the firms may have supernormal profits in the short run, but normal (zero economic profits) or less than normal economic profits in the long run. In relation to the competitive condition that the firms faced (as discussed in Chapter 1), the mixed signs may also result in a firm securing patents as part of a long term strategy to develop a strong market position, enter new markets, and access other technology through cross-licensing or even for defensive purposes. Thus, the mixed signs of negative (loss) or positive profits in our empirical results, even though calculated using accounting profits as explained in Chapter 4 (see Section 4.1.2), actually match the competitive condition theorized in the profit maximization model. By applying the panel data model in our econometric analysis, we conclude our key findings based on the model estimation, measurement, and sample study.

8.1.1 Based on Model Estimation

Even though we analyzed our data based on the static and dynamic panel model with various model estimations, almost all of the patenting activity variables which are found to be statistically significant have fairly consistent magnitudes of the coefficients. Nevertheless, the magnitudes of the patenting activity variables were rather small compared to the control variables, that is, the firm's size and age. Even though our focus was not on the firm's size and age, the inclusion of these variables in the model specification was crucial, as specified by other empirical studies discussed in Chapter 3. This has not made our models overspecified, however, as some of them are found not to be misspecified when analyzed in the RESET test. On the other hand, the three different model specifications based on the accounting-based measures following the profit maximization model have shed some light on the empirical study of emerging economies, specifically Malaysia. Even though the signs are mixed, it shows that there is demand for the patented inventions of Malaysian firms, as well as the ability of such firms to supply these technologies in Malaysia and the U.S. The results also show the firms' capability to accrue appropriate returns from the activity.

8.1.2 Based on Measurement and Sample Study

As discussed in Chapter 3, the empirical literature also shows mixed results based on the model estimations, measurements and sample study. The variables that are found to be statistically significant mostly have consistent magnitudes and signs between the static and dynamic panel model, but the results actually differ based on the measurements and sample of the study. We learned that the patenting activity is measured from within the patent system, while the financial performance is measured based on the accounting information. The patent renewal/ application measure has given us more consistent statistically significant variables and signs in the all firms and manufacturing firms sample study when compared to the patent quality measure. In terms of the sample firms, this is unsurprising because the manufacturing firms sample accounts for 73% of the all firms sample. Relating to the patent measures, this may show that the theory behind patenting which involves monopoly power may result in a positive sign; however, as time passes the monopoly power can come to an end as other firms may create a better product and there is market demand which results in a negative sign. Furthermore, with the patent renewal/ application measure, firms that patent in the mechanical/ electronics technology field are also seen to have quite similar statistically significant variables and signs. This situation may not be surprising since we highlight in Chapter 3 that Malaysian manufacturing industries are the largest exporting industries of that country and, further, the U.S. is Malaysia's largest trading partner with these technology fields commonly residing in the aforementioned sectors.

Moving to the patent quality measure, the results are surprisingly different in terms of signs of the statistically significant variables among the sample firms in this study. We note in chapters 3 and 4 that the chosen patenting variables in the patent quality measure were modified due to the unavailability of forward citation data that are widely used in empirical research; instead we used the backward citation data. Furthermore, relating these data to the accounting-based measure is quite novel in this study compared to other empirical research. In the manufacturing firms, even though all of the variables seem not to favor our positive sign following the hypothesis, the all firms sample shows some statistically positive signs. This may show that the non-manufacturing firms in the all firms sample may learn from the advanced economies (backward citations) and successfully create an invention that deters others from legally imitating the claim, thus leading to positive monetary returns. The patent family has also given a positive sign to the sales in the all firms sample. The statistically significant results continue to be quite similar in firms that have patents in the mechanicals/ electronics technology field, but when compared with the manufacturing firms sample, the statistically significant impacts are fewer. On the other hand, the human necessities/ performing operations technology field have quite similar signs with a positive impact on the financial performance in the all firms sample, the only difference being that the statistically significant impacts are much higher. This situation shows that the stock of knowledge from the patenting activity has a significant impact on the Malaysian firms' financial performance, even if segregated by different types of firms and technology fields.

8.2 Research Findings Implications

The key findings shed some light on the fact that, when empirically analyzed with ex-post data, there is a significant relationship between patenting activity and financial performance at the Malaysian firm level for firms that have been granted patents in Malaysia and the U.S. Therefore, the Ministry of Science Technology and Innovation (MOSTI) may choose to re-evaluate its decision on grants given to private parties, with the money granted providing valuable returns to the firm and country. As mentioned in Chapter 1, many earlier grants on innovation were given by MOSTI to public organizations such as universities or research institutions which had not been commercialized or, if they were, the commercialization rate from the invented products was very small accounting for only about 5% (Malaysia, 2001). This is unsurprising as a public institution has no goal to maximize profits as does a firm.

While the Intellectual Property Corporation of Malaysia (MyIPO) has done much to promote the securing of intellectual property (IP) to the Malaysian public, this public awareness has mostly been concentrated on trademarks, another form of IP. This is because a trademark is a simpler form of IP to create. In addition, there are fewer difficulties involved in applications and maintenance with the duration of protection set at ten years, renewable every ten years thereafter. Nevertheless, this situation is also unsurprising, as Malaysia is still learning about protecting its IP, and the simplicity of trademark compared to patent would be a good form to start with in protecting IP. This study has also highlighted that having a monopoly position with patents and contending in a competitive market help firms to grow in a healthy environment. A focus of this study, then, is that the patent system protects firms so that their inventions cannot be imitated by others. If other firms are interested, the system allows legal avenues to use the inventions through licensing. As such, the patent system actually benefits both parties in a beneficial manner. Nevertheless, the patent system mostly benefits the patent holder and works well in a country that practices tight intellectual property rights (Teece, 2005). Hence, this study may also alert MyIPO and the Malaysian government to the benefits of having a good infrastructure in place in relation to the patent system in that country, as the patent system in Malaysia is still at its embryonic stage (Hamsawi, 2007).

On the other hand, those Malaysian firms that wish to innovate may use this study as a benchmark to learn more about patenting activity and thus patent their inventions. Many firms in Malaysia are found to have carried out some innovative activity via research and development (R&D) (Lee, 2004; Malaysia, 2000); however, this study demonstrates that few have gone further to actually patent the products or processes. This study highlights that one of the most important initial steps in the patent process is that firms learn to do a patent search. This is to ensure that the innovation is novel in a legal sense, so that the resources used to invent the products or processes are not wasted by failure to be granted patents. To conclude the implication of the findings of this study to managers and innovators within firms, is to stress is that through understanding patent activity they will better appreciate that it involves not only innovation per se, but also the patent system. Clearly, this system has many rules and regulations that must be adhered to in order to maximize profits in their firms.

8.3 Research Limitations and Extensions

There are some limitations to this study. As emphasized earlier, the key limitation is relating to the patent data in emerging economies. Further in Chapter 4, we can see how much data has been lost throughout the matching of the data at MyIPO and CCM, and further lost when cleaning of data is undertaken. Nevertheless, our sample data is actually a population as we select all Malaysian firms that have been granted patents in Malaysia and the U.S. Thus having the sample data of more than 60% from the total population can be considered a success. Furthermore, regardless of the limitations, we have successfully analyzed all available data in a competent way. As an extension to the key limitation, we plan to analyze the existing data with no match and cleaned through qualitative analysis using interviews in subsequent research.

There are also other limitations involved. The first relates to the selection of the variables. We learned in Chapter 2 that patents are a form of IP, but there are other forms of IP that the firms in our sample study may have secured. As discussed earlier, MyIPO has been actively promoting trademark activity to the Malaysian public and, further, MyIPO statistics show that Malaysia has had the highest number of applicants and successfully been granted trademarks, followed by other advanced countries such as the U.S., Japan, United Kingdom (U.K.), and Germany (MyIPO, 2011). Hence, the firms in our sample study may also have undertaken trademark activity. An interesting extension would be to examine the impact of trademark activity on the firms' financial performance. The second limitation relates to the desirability of adding more variables to the model specifications. We would like to add other territories to the patent family in future research, with possible other territories being Japan and the European Union (specifically the United Kingdom (U.K) and Germany) as these countries represent some of Malaysia's largest trading partners (Malaysia, 2006, 2001, 1996). Furthermore, these countries are advanced economies that have purchasing power and tight intellectual property rights. Thus, we anticipate that Malaysian firms that patent in these territories may well expect to gain benefits beyond the costs of patenting.

The third limitation relates to the model estimation in the dynamic panel model. In this study we apply only two approaches in the generalized method of moments (GMM) estimation. These are the first difference transformation by Arellano and Bond (1991) and orthogonal deviation transformation by Arellano and Bover (1995). In the future, we would like to apply the System GMM introduced by Blundell and Bond (1998). Since our panel is an unbalanced panel, some firms in our time series dimension have quite small T, that is, as small as 3. With this estimator, the T can be as small as 3 and still provide reasonable and precise estimates of the coefficients (Blundell & Bond, 2000). The fourth limitation is also related to the econometrics issue, in that our model that needs to be re-specified as the RESET test shows some misspecification. Nevertheless, the disadvantage of the RESET test is that it does not provide us with alternative models which are correct (Asteriou & Hall, 2007). The model that we have used in this study is a linear model and we conjecture that it may contain some form of non-linearity. Therefore, more work needs to be done in the future in terms of the econometric issues so that our findings are more robust, unbiased and consistent.

The final limitation, relates to the geographical condition of Malaysia that is located in Asia. In 1997 the Asian financial crisis has hit Asia. As many were struggling with the economy, those firms with granted patents may have experienced the heat that impacted the firms' financial performance. Therefore, as an extension to this study, we plan to analyze the existing data and examine the impact on the firms' financial performance due to the Asian Financial Crisis in subsequent research.

References

Alcacer, J., & Gittelman, M. (2006). Patent Citations as A Measure of Knowledge Flows: The Influence of Examiner Citations. *The Review of Economics and Statistics, 88*(4), 774-779.

Amemiya, T. (1971). The Estimation of the Variances in a Variance-Components Model. *International Economic Review, 12*(1), 1-13.

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies, 58*(2), 277-297.

Arellano, M., & Bover, O. (1995). Another Look at the Instrumental Variable Estimation of Error-Components Models. *Journal of Econometrics, 68*(1), 29-51.

Asteriou, D., & Hall, S. G. (2007). *Applied Econometrics - A Modern Approach* (Revised ed.). New York: Palgrave Macmillan.

Bacchiocchi, E., & Montobbio, F. (2009). Knowledge Diffusion From University and Public Research. A Comparison Between US, Japan and Europe Using Patent Citations. *Journal of Technology Transfer, 34*, 169-181.

Bacchiocchi, E., & Montobbio, F. (2010). International Knowledge Diffusion and Home-bias Effect: Do USPTO and EPO Patent Citations Tell the Same Story? *Scandinavian Journal of Economics, 112*(3), 441-470.

Bagheri, S. K., Moradpour, H. A., & Rezapour, M. (2009). The Iranian Patent Reform. *World Patent Information, 31*(1), 32-35.

Baltagi, B. H. (2008). *Econometric Analysis of Panel Data* (Fourth ed.). Sussex: John Wiley & Sons Ltd.

Barnes, P. (1986). Thin Trading and Stock Market Efficiency: The Case of the Kuala Lumpur Stock Exchange. *Journal of Business Finance & Accounting, 13*(4), 609-617.

Bauman, W. S. (1989). Investment Research Analysis in an Emerging Market: Singapore and Malaysia. *Financial Analysts Journal, 45*(6), 60-67.

Baumol, W. J. (1962). On the Theory of Expansion of the Firm. *The American Economic Review, 52*(5), 1078-1087.

Bessen, J. (2005). Patents and the Diffusion of Technical Information. *Economics Letters, 86*, 121-128.

Blundell, R., & Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics, 87*(1), 115-143.

Blundell, R., & Bond, S. (2000). GMM Estimation with Persistent Panel Data: An Application to Production Functions. *Econometric Reviews, 19*(3), 321-340.

Blundell, R., Griffith, R., & John, V. R. (1999). Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms. *The Review of Economic Studies, 66*, 529-554.

Bosworth, D. L., & Rogers, M. (2001). Market Value, R&D and Intellectual Property: An Empirical Analysis of Large Australian Firms. *Economic Record, 77*(239), 323-337.

Bound, J., Cummins, C., Griliches, Z., Hall, B. H., & Jaffe, A. (1982). Who Does R&D and Who Patents. *NBER Working Paper Series, 908*, 1-57.

Brue, S. L., & Grant, R. R. (2007). The Classical School - Forerunners *The History of Economic Thought* (Seventh ed., pp. 45-60). Mason, Ohio: Thomson South-Western.

Bursa Malaysia. (2010). List of Companies. Retrieved 10 October, 2010, from http://www.klse.com.my/website/bm/listed_companies/list_of_companies/

Chandran, V. G. R., Ghapar, F. A., & Veera, P. K. S. (2009). The Role of Collaboration, Market and Intellectual Property Rights Awareness in University Technology Commercialization. *International Journal of Innovation and Technology Management, 6*(4), 363-378.

Charest, G. (1978). Split Information, Stock Returns and Market Efficiency-I. *Journal of Financial Economics, 6*(2-3), 265-296.

Cheeptham, N., & Chantawannakul, P. (2001). Intellectual Pproperty Management and Awareness at the University Level in the Biotechnology Era: A Thai Perspective. *World Patent Information, 23*, 373-378.

Choi, S. B., Lee, S. H., & Williams, C. (2011). Ownership and Firm Innovation in a Transition Economy: Evidence from China. *Research Policy, 40*(3), 441-452.

Cockburn, I., & Griliches, Z. (1988). Industry Effects and Appropriability Measures in the Stock Market's Valuation of R&D and Patents. *The American Economic Review, 78*(2), 419-423.

Connolly, R. A., & Hirschey, M. (1988). Market Value and Patents. *Economics Letters, 27*, 83-87.

Connolly, R. A., & Hirschey, M. (1990). Firm Size and R&D Effectiveness: A Value-Based Test. *Economics Letters, 32*(3), 277-281.

Coombs, J. E., & Bierly, P. E. (2006). Measuring Technological Capability and Performance. *R&D Management, 36*(4), 421-438.

Curwen, P. J. (1976). *The Theory of the Firm*. London: The Macmillan Press Ltd.

Dereli, T., & Durmusoglu, A. (2009). Patenting Activities in Turkey: The Case of the Textile Industry. *World Patent Information, 31*(2), 123-130.

Edwards, C. (1999). Skilled and Unskilled Foreign Labour in Malaysian Development - A Strategic Shift? In K. S. Jomo & G. Felker (Eds.), *Technology, Competitiveness and the State: Malaysia's Industrial Technology Policies*. London: Routledge.

Eng, L. L., Nabar, S., & Chng, C. K. (2005). The Predictive Value of Earnings, Cash flows and Accruals in the Period Surrounding the Asian Financial Crisis: Evidence from Hong Kong, Malaysia, Singapore and Thailand. *Journal of International Financial Management and Accounting, 16*(3), 165-193.

Ernst, H. (2001). Patent Applications and Subsequent Changes of Performance: Evidence from Time-Series Cross-Section Analyses on the Firm Level. *Research Policy, 30*(1), 143-157.

Faber, J., & Hesen, A. B. (2004). Innovation Capabilities of European Nations: Cross-National Analyses of Patents and Sales of Product Innovations. *Research Policy, 33*(2), 193-207.

Fai, F. (2005). Using Intellectual Property Data to Analyse China's Growing Technological Capabilities. *World Patent Information, 27*, 49-61.

Fai, F., & Tunzelmann, N. V. (2001). Industry-specific competencies and converging technological systems: evidence from patents. *Structural Change and Economic Dynamics, 12*(2), 141-170.

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance, 25*(2), 383-417.

Federico, P. J. (1958). Renewal Fees and Other Foreign Fees in Foreign Countries *Study of the Subcommittee of Patents, Trademarks, and Copyrights of the Committee of the Judiciary, United States Senate*. Washington: U.S. Governement Printing Office.

Geroski, P. A., Machin, S., & Van Reenen, J. (1993). The Profitability of Innovating Firms. *The Rand Journal of Economics, 24*(2), 198-211.

Geroski, P. A., Machin, S. J., & Walters, C. F. (1997). Corporate Growth and Profitability. *The Journal of Industrial Economics, 45*(2), 171-189.

Ghapar, F. A. (2009). The Future of Innovation is Inspired by the Intellectual Property System. In B. V. Stamm & A. Trifilova (Eds.), *The Future of Innovation* (pp. 454-455). Surrey: Gower Publishing.

Glen, J., Lee, K., & Singh, A. (2001). Persistence of profitability and competition in emerging markets. *Economics Letters, 72*(2), 247-253.

Goon, D. (2003). Malaysia. In C. Heath (Ed.), *Intellectual Property in Asia* (pp. 307-336). London: Kluwer Law International.

Grandstrand, O. (2006). The Nature of the Patent System - Patents and Intellectual Property: A General Framework. In J. Cantwell (Ed.), *The Economics of Patents* (Vol. I, pp. 3-59). Cheltenham: Edward Elgar Publishing Limited.

Greenhalgh, C., & Rogers, M. (2006). The Value of Innovation: The Interaction of Competition, R&D and IP. *Research Policy, 35*, 562-580.

Griffith, W., Jensen, P. H., & Webster, E. (2005). The Effect on Firm Profits of the Stock of Intellectual Property Rights. *Melbourne Institute Working Paper Series, 4/05*, 1-21.

Griliches, Z. (1981). Market Value, R&D, and Patents. *Economics Letters, 7*, 183-187.

Griliches, Z. (1990). Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature, 28*(4), 1661-1707.

Gujarati, D. N. (2003). *Basic Econometrics* (Fourth ed.). New York: McGraw-Hill.

Hall, B. H. (1993). The Stock Market's Valuation of R&D Investment During the 1980's. *The American Economic Review, 83*(2), 259-264.

Hall, B. H. (2005). Exploring the Patent Explosion. *Journal of Technology Transfer, 30*(1-2), 35.

Hall, B. H., & Ziedonis, R. H. (2001). The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995. *The Rand Journal of Economics, 32*(1), 101-128.

Hall, B. H., & Oriani, R. (2006). Does the Market Value R&D Investment by European Firms? Evidence from a Panel of Manufacturing Firms in France, Germany, and Italy. *International Journal of Industrial Organization, 24*, 971-993.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market Value and Patent Citations. *The Rand Journal of Economics, 36*(1), 16-38.

Hall, B. H., Thoma, G., & Torrisi, S. (2007). The Market Value of Patents and R&D: Evidence from European Firms. *NBER Working Paper Series, 13426*, 1-54.

Hall, B. H., Thoma, G., & Torrisi, S. (2009). Financial Patenting in Europe. *European Management Review, 6*(1), 45.

Hallenborg, L., Ceccagnoli, M., Clendenin, M., Gary, D. L., & Marie, C. T. (2008). Intellectual Property Protection in the Global Economy *Advances in the Study of Entrepreneurship, Innovation, & Economic Growth* (Vol. Volume 18, pp. 63-116). Amsterdam: Elsevier Ltd.

Hamsawi, R. (2007, 31 October). Intellectual Property Court Helps Boost Economic Growth. *The New Straits Times*.

Harhoff, D., Scherer, F. M., & Vopel, K. (2003). Citations, Family Size, Opposition and the Value of Patent Rights. *Research Policy, 32*(8), 1343-1363.

Harris, C. P. (1992). *Market Analysis and the Theory of the Firm* (3rd ed.). Townsville: James Cook University of North Queensland.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica, 46*(6), 1251-1271.

Hayakawa, K. (2009). First Difference or Forward Orthogonal Deviation - Which Transformation Should be Used in Dynamic Panel Data Models?: A Simulation Study. *Economics Bulletin, 29*(3), 2008-2017.

Hornickel, J. H. (2002). *Patenting Strategies and Patent Cooperation Treaty.* Paper presented at the International Workshop on Management and Commercialization of Inventions and Technology, Mexico.

Hu, A. G. Z., & Jaffe, A. B. (2003). Patent Citations and International Knowledge Flow: The Cases of Korea and Taiwan. *International Journal of Industrial Organization, 21*(6), 849-880.

Hunt, R. M. (2004). Patentability, Industry Structure, and Innovation. *The Journal of Industrial Economics, 52*(3), 401-425.

Idris, K. (2002). *Intellectual Property: A Power Tool for Economic Growth*. Geneva: WIPO.

Jaffe, A. B., & Trajtenberg, M. (1999). International Knowledge Flows: Evidence from Patent Citations. *Economics of Innovation & New Technology, 8*(1/2), 105-136.

Jaffe, A. B., Fogarty, M. S., & Banks, B. A. (1998). Evidence from Patents and Patent Citations on the Impact of NASA and other Federal Labs on Commercial Innovation. *The Journal of Industrial Economics, 46*(2), 183-205.

Jarque, C. M., & Bera, A. K. (1980). Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals. *Economics Letters, 6*(3), 255-259.

Jensen, P. H., & Webster, E. (2006). Firm Size and the Use of IP Rights. *Economic Record, 82*(256), 44-55.

Jensen, P. H., Webster, E., & Buddelmeyer, H. (2006). Innovation, Technological Conditions and New Firm Survival. *Melbourne Institute Working Paper Series, 26/06*, 1-24.

Jensen, P. H., Palangkaraya, A., & Webster, E. (2008). Application Pendency Times and Outcomes Across Four Patent Office. *Intellectual Property Research Institute of Australia Working Paper, 01/08*, 1-25.

Jomo, K. S., & Felker, G. (1999). *Technology, Competitiveness and the State: Malaysia's Industrial Technology Policies*. London: Routledge.

Judson, R. A., & Owen, A. L. (1999). Estimating Dynamic Panel Data Models: A Guide for Macroeconomists. *Economics Letters, 65*(1), 9-15.

Kondo, M. (1999). Improving Malaysian Industrial Technology Policies and Institutions. In K. S. Jomo & G. Felker (Eds.), *Technology, Competitiveness and the State: Malaysia's Industrial Technology Policies* (pp. 199-217). London: Routledge.

Kortum, S. (1997). Research, Patenting and Technological Change. *Econometrica, 65*(6), 1389-1419.

Kranakis, E. (2007). Patents and Power: European Patent-System Integration in the Context of Globalization. *Technology and Culture, 48*(4), 689.

Kwa, S. H. (2004). *Commercialization of Research & Development in Universities & Public Research Organizations: The Singapore Experience.* Paper presented at the Commercialization of Research & Development in Universities & Public Research Organizations, Kuala Lumpur.

Lall, S. (1999). Technology Policy and Competitiveness in Malaysia. In K. S. Jomo & G. Felker (Eds.), *Technology, Competitiveness and the State: Malaysia's Industrial Technology Policies*. London: Routledge.

Lamoreaux, N. R., & Sokoloff, K. L. (2001). Market Trade in Patents and the Rise of a Class of Specialized Inventors in the 19th-Century United States. *The American Economic Review, 91*(2), 39-44.

Lanjouw, J. O. (1998). Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value. *The Review of Economic Studies, 65*(4), 671-710.

Lanjouw, J. O., & Schankerman, M. (2001). Characteristics of Patent Litigation: A Window on Competition. *The Rand Journal of Economics, 32*(1), 129-151.

Lanjouw, J. O., & Schankerman, M. (2004). Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators. *The Economic Journal, 114*(April), 441-465.

Lanjouw, J. O., Pakes, A., & Putnam, J. (1998). How to Count Patents and Value Intellectual Property:The Uses of Patent Renewal and Application Data. *The Journal of Industrial Economics, 46*(4), 405-432.

Lee, C. (2004). The Determinants of Innovation in the Malaysian Manufacturing Sector: An Econometric Analysis at the Firm Level. *ASEAN Economic Bulletin, 21*(3), 319.

Lerner, J. (1994). The Importance of Patent Scope: An Empirical Analysis. *The Rand Journal of Economics, 25*(2), 319-333.

Lerner, J. (2002). 150 Years of Patent Protection. *The American Economic Review, 92*(2), 221-225.

Lim, K.-P. (2008). Sectoral Efficiency of the Malaysian Stock Market and the Impact of the Asian Financial Crisis. *Studies in Economics and Finance, 25*(3), 196.

Lindenberg, E. B., & Ross, S. A. (1981). Tobin's q Ratio and Industrial Organization. *The Journal of Business, 54*(1), 1-32.

MABIC. (2011). National Biotechnology Policy. Retrieved 9 April, 2011, from http://bic.org.my/?action=localscenario&do=policy

Macdonald, S. (2004). When Means Become Ends: Considering the Impact of Patent Strategy on Innovation. *Information Economics and Policy, 16*, 135-158.

MacGarvie, M. (2005). The Determinants of International Knowledge Diffusion as Measured by Patent Citations. *Economics Letters, 87*, 121-126.

Macleod, C. (1986). The 1690s Patents Boom: Invention or Stock-Jobbing? *The Economic History Review, 39*(4), 549-571.

Malaysia. (1996). *Seventh Malaysia Plan (1996-2000)*. Kuala Lumpur: Government Printers.

Malaysia. (2000). *National R&D Survey*. Kuala Lumpur: Government Printers.

Malaysia. (2001). *Eighth Malaysia Plan (2001-2005)*. Kuala Lumpur: Government Printers.

Malaysia. (2006). *Ninth Malaysia Plan (2006-2010)*. Kuala Lumpur: Government Printers.

Mansfield, E. (1997). The Firm and Its Technology *Applied Microeconomics* (Second ed., pp. 187-221). New York: W.W. Norton & Company.

Marquardt, D. W. (1980). A Critique of Some Ridge Regression Methods: Comment. *Journal of the American Statistical Association, 75*(369), 87-91.

Matthews, D. (2002). *Globalising Intellectual Property Rights*. London: Routledge.

Matthews, D., Pickering, J., & Kirkland, J. (2003). A Startegic Approach to Managing Intellectual Property. In R. A. Blackburn (Ed.), *Intellectual Property and Innovation Management in Small Firms* (pp. 35-44). London: Routledge.

Michael, T. (2005). Slow-Going at the Patent Office. *Innovation: America's Journal of Technology Commercialization* (February / March), 5-6.

Mueller, D. C. (1990). *The Dynamics of Company Profits: An International Comparison*. Cambridge: Cambridge University Press.

Mueller, J. M. (2006). *An Introduction to Patent Law*. New York: Aspen Publishers, Inc.

MyIPO. (2008). *IP Commercialization, Franchise & License*. Paper presented at the Hari Harta Intelek Negara 2008.

MyIPO. (2010a). Patent Forms & Related Fees. Retrieved 25 September, 2010, from http://www.myipo.gov.my/en/patent/form-a-related-fees.html

MyIPO. (2010b). Patent Statistics. Retrieved 25 September, 2010, from http://www.myipo.gov.my/en/ip-statistics/160.html

MyIPO. (2011). Top Ten Countries for Trade Mark Applications and Registrations. Retrieved 23 August, 2011, from http://www.myipo.gov.my/index.php?option=com_content&view=article&id=478

Nicholas, T. (2010). The Role of Independent Invention in U.S. Technological Development, 1880-1930. *The Journal of Economic History, 70*(1), 57.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica, 49*(6), 1417-1426.

OECD. (2004). *Compendium of Patent Statistics*. Europe: World Intellectual Property Organization.

Ornaghi, C. (2006). Spillovers in Product and Process Innovation: Evidence from Manufacturing Firms. *International Journal of Industrial Organization, 24*, 349-380.

Pakes, A. (1985). On Patents, R&D, and the Stock Market Rate of Return. , 93,90-409. *Journal of Political Economy, 93*, 904-909.

Pakes, A. (1986). Patents as Options: Some Estimates of the Value of Holding European Patent Stocks. *Econometrica, 54*(4), 755-784.

Pakes, A., & Schankerman, M. (1979). The Rate of Obsolescene of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources. *NBER Working Paper Series, 346*, 1-27.

Pakes, A., & Griliches, Z. (1980). Patents and R&D at the Firm Level: A First Look. *NBER Working Paper Series, 561*.

Park, H. M. (2008). *Linear Regression Models for Panel Data Using SAS, Stata, LIMDEP, and SPSS*. The University Information Technology Services (UITS) Center for Statistical and Mathematical Computing, Indiana University.

Pavitt, K. (1984). Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory. *Research Policy, 13*(6), 343-373.

PHIM. (2004). *General Information on Patents*. Kuala Lumpur: Intellectual Property Corporation of Malaysia.

Polanyi, M. (1966). *The Tacit Dimension*. London: Routledge & Kegan Paul Ltd.

Posner, R. A. (2005). Intellectual Property: The Law and Economics Approach. *The Journal of Economic Perspectives, 19*(2), 57-73.

Putnam, J. (1996). The Value of International Patent Rights. Unpublished Ph.D. Dissertation. Department of Economics, Yale University.

Ramsey, J. B. (1969). Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis. *Journal of the Royal Statistical Society. Series B (Methodological), 31*(2), 350-371.

Rasiah, R. (1999). Malaysia's National Innovation System. In K. S. Jomo & G. Felker (Eds.), *Technology, Competitiveness and the State: Malaysia's Industrial Technology Policies*. London: Routledge.

Rezapour, M., Bagheri, S. K., Rashtchi, M., & Bakhtiari, M. R. (2007). The Iranian Patenting System: An Introduction. *World Patent Information, 29*, 250-254.

Rimmer, M. (2004). The Race to Patent the SARS Virus: The TRIPS Agreement and Access to Essential Medicines. *Melbourne Journal of International Law, 5*(2), 335-374.

Rogers, M. (2002). Firm Performance and Investment in R&D and Intellectual Property. *Melbourne Institute Working Paper Series, 15/02*, 1-24.

Rottner, R. (2004). Intellectual Proprety Management. In K. Tang, A. Vohora & R. Freeman (Eds.), *Taking Research to Market: How to Build and Invest in Successful University Spinouts* (pp. 67-86). London: Euromoney Institutional Investor Plc.

Sanders, B. S. (1962). Speedy Entry of Patented Inventions into Commercial Use. *Patent, Trademark and Copyright Journal, 6*(1), 87-116.

Sanders, B. S. (1963). The Upgrading of Patented Inventions and Their Use Here and Abroad. *Patent, Trademark and Copyright Journal, 7*(2), 185-228.

Sapsalis, E., & Potterie, B. V. P. D. L. (2007). The Institutional Sources of Knowledge and the Value of Academic Patents. *Economics of Innovation & New Technology, 16*(2), 139-157.

Sarkissian, A. (2008). Intellectual Property Rights for Developing Countries: Lessons from Iran. *Technovation, 28*(11), 786-798.

Saudagaran, S. M., & Diga, J. G. (2000). The Institutional Environment of Financial Reporting Regulation in ASEAN. *The International Journal of Accounting, 35*(1), 1-26.

Schankerman, M. (1998). How Valuable is Patent Protection? Estimates by Technology Field. *The Rand Journal of Economics, 29*(1), 77-107.

Schankerman, M., & Pakes, A. (1986). Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period. *The Economic Journal, 96*(384), 1052-1076.

Scherer, F. M. (1965). Corporate Inventive Output, Profits, and Growth. *The Journal of Political Economy, 73*(3), 290-297.

Scherer, F. M., & Harhoff, D. (2000). Technology Policy for a World of Skew-Distributed Outcomes. *Research Policy, 29*(4-5), 559-566.

Schmookler, J. (1951). Invention and Economic Development. Unpublished Ph.D. Dissertation. University of Pennsylvania.

Schmookler, J. (1966). *Invention and Economic Growth*. Cambridge: Harvard University Press.

Schumpeter, J. A. (1942). *Capitalism, Socialism and Democracy*. New York: Harper & Row.

Sirilli, G. (1987). Patents and Inventors: An Empirical Study. *Research Policy, 16*(2-4), 157-174.

Sokoloff, K. L., & Khan, B. Z. (1990). The Democratization of Invention During Early Industrialization: Evidence from the United States, 1790-1846. *The Journal of Economic History, 50*(2), 363-378.

SSM. (2010). Statistics: Total Number of Companies and Business Registered. Retrieved 10 October, 2010, from http://www.ssm.com.my/en/statistics.php

Stoddard, S. L., & Danielsen, A. J. (2008). What Makes an Idea or Discovery Marketable - and Approaches to Maximize Success. *Surgery, 143*(2), 161-164.

Sullivan, R. J. (1989). England's "Age of Invention": The Acceleration of Patents and Patentable Invention During the Industrial Revolution. *Explorations in Economic History, 26*(4), 424-452.

Teece, D. J. (2005). Technology and Technology Transfer: Mansfieldian Inspirations and Subsequent Developments. *Journal of Technology Transfer, 30*(1-2), 17.

Terziovski, M., & Lai, A. (2007). Developing Innovation Capability Through Intellectual Property Strategy in the Australian Biotechnology Industry: Starpharma. In M. Terziovski (Ed.), *Building Innovation Capability in Organizations: An International Cross-Case Perspective* (pp. 157-175). London: Imperial College Press.

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and Organizational Change* (Third ed.). West Sussex: John Wiley & Sons Ltd.

Tobin, J. (1969). A General Equilibrium Approach To Monetary Theory. *Journal of Money, Credit and Banking, 1*(1), 15-29.

Trajtenberg, M. (1987). Patents, Citations and Innovations: Tracing the Links. *NBER Working Paper Series, 2457*, 1-56.

Trajtenberg, M. (1990). A Penny for Your Quotes: Patent Citations and the Value of Innovations. *The Rand Journal of Economics, 21*(1), 172.

Trajtenberg, M. (1999). Innovation in Israel 1968-97: A Comparative Analysis Using Patent Data. *NBER Working Paper Series, 7022*, 1-28.

Trajtenberg, M. (2001). Innovation in Israel 1968-1997: A Comparative Analysis Using Patent Data. *Research Policy, 30*(3), 363-389.

Tuck, C. E. (2005). A Quality Award and Stock Market Reaction: Evidence from Malaysia. *Total Quality Management, 16*(6), 681-691.

Tulloch, D. (2007). Global Patents Update for Australian IP Managers. *Australasian Biotechnology, 17*(1), 22-23.

United Nations. (2007). *The Least Developed Countries Report 2007*. Geneva: United Nations Conference on Trade and Development (UNCTAD).

USPTO. (2010a). Process for Obtaining a Utility Patent. Retrieved 30 June, 2010, from http://www.uspto.gov/patents/process/index.jsp

USPTO. (2010b). United States Patent and Trademark Office Fee Schedule. Retrieved 15 June, 2010, from http://www.uspto.gov/web/offices/ac/qs/ope/fee2009september15.htm

USPTO. (2010c). Patents. Retrieved 7 July, 2010, from http://www.uspto.gov/patents/index.jsp

USPTO. (2010d). The Difference Between Design and Utility Patents. Retrieved 17 June, 2010, from http://www.uspto.gov/patents/resources/types/index.jsp

USPTO. (2010e). USPTO Patents Full-Text and Image Database. Retrieved 7 August, 2010, from http://patft.uspto.gov/netahtml/PTO/search-adv.htm

Van Triest, S., & Vis, W. (2007). Valuing Patents on Cost-Reducing Technology: A Case Study. *International Journal of Production Economics, 105*(1), 282-292.

Wansbeek, T., & Kapteyn, A. (1989). Estimation of the Error-Components Model with Incomplete Panels. *Journal of Econometrics, 41*(3), 341-361.

Waring, G. F. (1996). Industry Differences in the Persistence of Firm-Specific Returns. *The American Economic Review 86*(5), 1253-1265.

Webster, E., & Jensen, P. H. (2006). Investment in Intangible Capital: An Enterprise Perspective. *Economic Record, 82*(256), 82-96.

WIPO. (2003). *WIPO Survey of Intellectual Property Services of European Technology Incubators*. Geneva: Mimeo.

WIPO. (2004a). International Treaties and Conventions of Intellectual Property *WIPO Intellectual Property Handbook: Policy, Law and Use* (pp. 240-364). Geneva: Mimeo.

WIPO. (2004b). *WIPO Intellectual Property Handbook: Policy, Law and Use*. Geneva: Mimeo.

WIPO. (2006a). An Introduction to Patents for Small and Medium-Sized Enterprises *Inventing the Future* (Vol. 3). Switzerland: World Intellectual Property Organization.

WIPO. (2006b). *What is Intellectual Property*. Geneva: World Intellectual Property Organization.

WIPO. (2007a). *PCT - The International Patent System Yearly Review*: World Intellectual Property Organization.

WIPO. (2007b). *Recent Developments in the PCT System*. Paper presented at the WIPO National Workshop on Patent Cooperation Treaty (PCT).

WIPO. (2007c). *WIPO Patent Report - Statistics on Worldwide Patent Activities* (2007 ed.): World Intellectual Property Organization.

WIPO. (2008). *WIPO Patent Report - A Statistical Review* (2008 ed.): World Intellectual Property Organization.

WIPO. (2009). *World Intellectual Property Indicators 2009* (2007 ed.). Geneva: World Intellectual Property Organization.

WIPO. (2010a). Patent Cooperation Treaty Contracting Parties. Retrieved 17 June, 2010, from http://www.wipo.int/treaties/en/Remarks.jsp?cnty_id=1932C

WIPO. (2010b). Intellectual Property Statistics. Retrieved 1 October, 2010, from http://www.wipo.int/ipstats/en/

WIPO. (2010c). Paris Convention Contracting Parties. Retrieved 17 June, 2010, from http://www.wipo.int/treaties/en/Remarks.jsp?cnty_id=270C

Woolridge, J. M. (2006). *Introductory Econometrics - A Modern Approach* (Vol. Third Edition). Ohio: Thomson South-Western.

Zainol, A., Nair, M., & Kasipillai, J. (2008). R&D Reporting Practice: Case of a Developing Economy. *Journal of Intellectual Capital, 9*(1), 122-132.

Zuallcobley, R. W. (2007). *The Malaysian National Phase and Reinstatement*. Paper presented at the Hari Harta Intelek Negara 2007.