R&D Investment and Capital Markets: Evidence from Emerging Markets

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Abstract

This thesis deals with the firm-, macro-and institutional-level determinants of research and development (R&D) investment, assessing the impact of R&D spending on firm performance and the financing of R&D investment in emerging markets. The recent financial crisis has had adverse effects worldwide. This study finds that the financial crisis had a significant negative impact on firms' R&D investment in emerging markets. It also finds that the R&D investments of both local firms and multinational enterprises (MNEs) were affected, and that the latter was affected 1.63 times more than the former.

However, when the firms were split between innovative and non-innovative, it was observed that innovative firms continued to invest in R&D during the recession, while non-innovative firms cut down their R&D investment. In addition, it is found that, during a financial crisis, the firm-level determinants of R&D are firm age, firm size, export orientation, debt ratio and foreign ownership. This implies that the assumptions of the resource based view (RBV) hold true, even during a financial crisis. The results suggest that affected and less-/unaffected countries' R&D determinants behave differently during a financial crisis. They also show that the probability of a decrease in R&D investment in affected countries is 60 percent higher than in less-/unaffected countries. Similarly to firm-level factors, macroeconomic factors also influence R&D expenditure. GDP growth, exports, trade openness, patents and financial crisis are the main macroeconomic determinants of a country's R&D expenditure. Moreover, analysis suggests that macroeconomic determinants of R&D investment behave differently in advanced and emerging countries, owing to their different nature and purpose, and the countries' levels of economic development.

In addition to firm and macroeconomic factors, the institutional environment plays an important role in R&D investment in emerging countries. The results show that government effectiveness and rule of law have significant positive impacts, while corruption and political instability have significant negative impacts on R&D investment in emerging countries. However, opponents of country-level factors have claimed that these factors influence the innovative activities and firm performance of emerging countries indirectly. This study finds that investor protection (safeguards) tends to have a greater moderating effect on the relationship between R&D and firm performance than country-level governance (systems). The results indicate that safeguards promote firm-level innovation in emerging markets, while systems are substituted by firm-level corporate governance in emerging countries. Moreover, in the case of risky and uncertain investments such as R&D, investors seek protection from possible losses. It is also observed that R&D financing behaves differently according to different levels of multi-nationality and financial systems. Local firms do not use external funding, while MNEs use both internal and external funding for R&D investments due to the availability of organisational slack. A country's financial systems may restrict firms from choosing particular sources of finance. Firms within bank-based systems tend to rely on external funding and firms within market-based systems depend more on internal funding for R&D investment. The results indicate that market-based firms follow pecking order theory.

Secondary data for the analysis were collected from various sources, including DataStream, annual financial reports, LexisNexis, the World Bank's Development Indicators, Worldwide Governance Indicators and Protecting Minority Shareholder data, and the International Country Risk Guide database. Both static and dynamic panel data techniques, including generalised methods of moment (GMM) estimation, were used for the analysis. Dynamic GMM panel estimation was used to control for endogeneity and unobserved heterogeneity, and to provide efficient and consistent estimation even in the presence of heteroscedasticity. The study also adopted an instrumental variable (IV) approach with OLS and Granger causality tests for the analysis. This study will be helpful to various stakeholders, including investors and managers, lenders and policy makers in emerging markets.

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Author's Declaration

The candidate confirms that the work submitted is his own. Moreover, the work has not been submitted for any other qualification at this or any other institution. The candidate would like to give credit to those whose references have been used in this work. The following chapters of this thesis have been submitted to peer-reviewed journals and presented to conferences or seminars.

Chapter 5 was used in Alam, M. A. (2015), "Financial Crisis and R&D Investment in the Emerging Markets", *CEGBI/ CSWL Summer Conference 2015*.

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Chapter 1: Introduction

1.1 Background of the study

An increasingly competitive market may boost firm innovation. In such an environment, firms are obliged to develop and produce new products more rapidly, more effectively and more efficiently, resulting in greater investment in research and development (R&D) (Ebrahim et al., 2009). In addition to competitive pressure, export orientation and vertical integration influence a firm's inclination to undertake R&D (Kumar and Saqib, 1996). Cohen and Levinthal (1990) suggested that firms invest in R&D for two reasons: to generate new knowledge and to develop absorptive capacity. These represent an ability to recognise, assimilate and exploit knowledge embedded within a firm's business processes and routines. Similarly, Garcia-Manjon and Romero-Merino (2012) have stated that R&D investment aims to generate knowledge to fuel the growth of business and the economic system as a whole. Thus, Evension and Kislev (1973) found that firms with higher investment in their own R&D are better able to exploit externally-generated knowledge than firms with lower R&D expenditure.

Although it is assumed that firms invest in R&D primarily to generate new knowledge (Cohen and Levinthal 1990; Garcia-Manjon and Romero-Merino, 2012), the globalisation of trade, far reaching deregulation and technological changes force firms to depend on R&D for survival and growth (Lev, 2001). The assumption is that R&D spending differentiates firms and ensures sustainable development and a better future (UNESCO, 2014). Moreover, both large and small firms may benefit from R&D investment (Rothwell and Dodgson, 1994). Smaller firms may handle R&D activities more efficiently and effectively as their environment has fewer bureaucratic constraints (Scherer, 1988). On the other hand, larger firms have more resources and tend to be more diversified, more technologically complex and better aware of technological opportunities (Lall, 1983); therefore, they have the ability to benefit from returns on their innovative activities. Thus,

a firm may gain benefits from R&D investment, irrespective of size. As a result, R&D expenditure is considered as a core part of business strategy (Ito and Pucik, 1993) and a driving force for firm-level growth.

In addition to firm-level growth, R&D activity is a key driver of the economic growth of a country (Rosenberg, 2004). Endogenous growth theory holds that investments in innovation, knowledge and human capital are significant contributors to economic growth. Investment in R&D ensures technological innovation and increased productivity (Griffith and Simpson, 1998), resulting in economic development. Ulku (2004) has found that higher R&D ensures higher per capita GDP for both OECD and non-OECD countries. Similarly, Westmore (2013) has found that growth in countries such as the USA, Canada, Belgium and Ireland has decreased since 2000 due to lower investment in R&D. Hence, an inefficient national R&D strategy may cause low economic growth, low wages, high unemployment rates, and even trade deficits (Perez-Sebastian, 2015). Moreover, a country's standard of living depends on its investment in R&D (Bernstein, 1996). Reasons for this are that R&D investment results in the development of high-quality products (Saperstein and Rouach, 2002) and provides higher rates of return than other investments such as on structure, machinery and equipment (Coe et al., 1997), while the social rate of return is seven times higher than on fixed investments (Lichtenberg, 1992). Moreover, R&D investment is important in responding to global challenges such as financial crises, climate change and sustainable development (OECD, 2007a, 2007b, 2009).

Given the importance of R&D investment at the firm level as well as the country level, researchers have been interested in examining the determinants of R&D. Exploring these determinants may help managers to decide the optimal level of R&D expenditure. The existing literature has shown that the firm-level determinants of R&D expenditure are a firm's size (Schumpeter, 1942; Lall, 1983), age (Kumar and Saqib, 1996), profitability (Becker and Pain, 2008), diversification, sales, government subsidies, ownership control

(Link, 2003), R&D intensity, cash flows (Simanjuntak and Tjandrawinata, 2011), cash reserves and net income (Harmantzis and Tanguturi, 2005). Due to the adverse effect of the recent recession, the nature of relationships between R&D determinants may have changed. Thus, this thesis aims to relate R&D investment to the financial crisis. In Chapter 5, common R&D determinants during a financial crisis will be examined.

Although most of the existing literature has examined firm-level determinants (Lall, 1983, Kumar and Saqib, 1996; Galende and Suarez, 1999; Galende and Fuente, 2003; Lai et al., 2015), few have examined the macroeconomic determinants of R&D expenditure (Becker and Pain, 2008; Wang, 2010; Sameti et al., 2010; Guloglu et al., 2012). Macroeconomic conditions facilitate countries' innovative activities (OECD, 2007a). For example, patent protection motivates entrepreneurs to invest more in innovative activities. However, these determinants may vary between emerging and developed countries due to factors such as their financial systems, growth, skills and culture. Therefore, in Chapter 6, behavioural differences between emerging and developed countries are observed in terms of R&D investment. Similarly to macroeconomic determinants, the institutional settings of a country, such as government effectiveness, regulatory quality, rule of law, control of corruption and political stability, may also create a favourable environment for R&D investment (OECD, 2007a). In this regard, Barge-Gil and Lopez (2014) have identified the omission of this important R&D determinant from the literature. Peng (2008) has also emphasised the importance of institutional determinants. Therefore, the institutional determinants of R&D are examined in Chapter 7.

In order to analyse the impact of R&D activity, it is equally important to establish its determinants. Analysis of outcomes is important with regard to stakeholders, as it relates to their financial and emotional expectations. For instance, analysis of the impact of R&D may help investors to assess the importance of innovation for firm growth and performance. Thus, researchers have established that R&D has a significant impact on firm

performance (Graboski, 1968; Guellec and Potterie, 2001; Yeh et al., 2010). However, Rafiq et al. (2016) have recently observed that R&D is not the only factor that has an impact on performance, but that the external environment and firm age also play important roles. In this regard, Srholec (2011) has suggested that not only firm characteristics, but also the institutional setting of the country within which the firm operates are important. This implies that the relationship between R&D and firm performance may be strengthened or weakened by the institutional setting of a country. Therefore, in Chapter 8 the moderating effects of country-level factors on the relationship between R&D and firm performance are examined.

In addition to examining the determinants and impact of R&D, the financing behaviour of R&D investment has been of interest in the R&D literature. Studying financing helps establish how funds can be raised for and allocated to R&D. Moreover, it helps firms to decide the optimal level of R&D investment. The financing behaviour of R&D may vary according to the prevalence of multinationals and the systems of a country. For example, firms in a market-based economy prefer to use internal funds as sources of finance (Bougheas, 2004), while a bank-based economy uses debt. In addition, financing decisions also depend on firm size, profitability, form of ownership, locality, nature, and the extent to which firms are prepared to "experiment with new strategy, new products, new markets, and so forth" (Chen and Humbrick, 1995; Bhat, 2008; Kim et al., 2008; Hambrick and Snow, 1977). For instance, multinational firms (MNEs) have greater access to funding than local firms, and may devote greater funding to innovative activities. Considering these issues, in Chapter 9 the role of a firm's level of multi-nationality (local versus MNEs) and the financial system (market-based versus bank-based system) are examined in terms of financing R&D investment.

Emerging markets have been considered as a domain for analysis of R&D determinants (firm-, macroeconomic-, and institutional-level), the impact of R&D and the financing of

R&D. Given the importance of emerging markets for the global economy, this study considers emerging markets as a specific domain. Emerging markets have great future potential for rapid social, political and economic development. Moreover, global competition, increased knowledge-based technologies, changing customer demands and strategic international cooperation boost emerging markets to invest in R&D (Gorodncihenko et al., 2008). In return, R&D investment may help emerging markets to gain timely access to emerging research, technologies and markets and revolutionise their global R&D groups (Edward, 2010). Lederman and Malony (2003) have provided evidence that returns from R&D investment in emerging countries are higher than in advanced countries. Therefore, emerging markets are considered as lands of opportunity and low-cost innovation centres. As a result, in recent years emerging markets have invested increasingly in R&D. Thus, by investing in innovative activities, emerging capital markets may contribute more to world development and become developed capital markets.

1.2 Purpose of the study

The relationship between R&D and emerging markets raises issues that will be examined in this study.

The recent financial crisis has affected global markets adversely. Hud and Hussinger (2015) have pointed out that the recent recession has severely affected OECD countries, and it is assumed that it has also impacted negatively on emerging markets. Thus, this study examines the relationship between the financial crisis and R&D investment in emerging markets. The existing literature has shown that the impact of recession varies by firm, industry and market. Therefore, in this study, local and MNE markets are split based on the level of multi-nationality, and innovative and non-innovative industries. It is expected that the R&D investments of MNEs will be affected to a greater extent than local firms due to their international exposure, foreign currency risk and export orientation.

From an industry perspective, an innovative industry continues to invest in R&D during a recession, while non-innovative firms reduce R&D expenditure during a crisis.

The economic growth of a country depends mainly on innovation (Rosenberg, 2004). Thus, it is assumed that the greater the innovation, the higher the economic development of a country. On the other hand, economic factors such as foreign direct investment (FDI), GDP growth, trade policy and interest rates affect the innovative activities of a country (OECD, 2007a). For example, an open trade policy impacts on innovation policy. However, in many ways, the economic policies of emerging markets are different from those of advanced markets. In implementing macroeconomic policy, emerging markets usually follow the strategies of advanced markets. Therefore, a comparative analysis of the behaviour of macroeconomic factors between emerging and developed markets will be helpful for policy makers in emerging markets seeking to promote innovative activities.

Institutional determinants play an important role in facilitating or creating a favourable environment for R&D investment (OECD, 2007a). When the institutional setting of a country is strong, financial factors become more effective in boosting R&D investment. Moreover, institutions provide incentives and resources for innovation (Edquist and Johnson, 1997). Thus, institutions are considered as an infrastructure for innovation. Peng et al. (2008) has emphasised the importance of institutional settings for investment decisions in emerging markets. Therefore, this study examines which institutional factors are important for R&D expenditure in emerging markets.

The institutional framework, including factors such as investor protection and national governance, may also influence the relationship between R&D investment and firm performance. However, not all factors moderate this relationship. In the presence of investor protection or national governance factors, the relationship between R&D and firm performance may be strengthened or weakened. Thus, the current study attempts to

identify which factors play a greater role in moderating the relationship between R&D and firm performance.

Financing of R&D behaviour may vary from firm to firm and country to country. Due to the availability of resources and access to financing, local firms and MNEs may use different sources of funding for R&D. Therefore, this study examines this issue. R&D financing behaviour is also embedded in the specific environment of the firm, such as its financial systems. For example, in a bank-based economy, most investment financing is obtained from a bank or other financial institutions. Thus, this study also observes how financial systems relate to R&D financing in emerging markets.

1.3 Contributions of the study

In examining the relationship between R&D investment and capital markets, this study makes empirical, theoretical and methodological contributions to R&D-related research and policy making.

1.3.1 Empirical contribution

The existing literature has examined the impact of financial crises on R&D investment (Fillippetti and Archibugi, 2011; Paunov, 2012; Archibugi et al., 2013a, 2013b). However, most have been based on a specific region or country (for Europe, see Fillippetti and Archibugi, 2011; Archibugi et al., 2013a, 2013b; for Latin America, see Paunov, 2012), whereas this study considers all emerging countries from an entire region, including Africa, Asia, Europe, Latin America and the Middle East. Moreover, this study adds to the existing literature by considering the relationship between markets and industries and the financial crisis, based on emerging markets. This thesis separates the markets of local and multinational firms and examines the relationship between local/multinational firms and the financial crisis. The results suggest that multinational firms tend to be affected more greatly than local firms by a financial crisis. This thesis also splits industries into innovative and non-innovative firms and observes their behaviour during the financial

crisis. The results suggest that innovative and non-innovative firms behave differently in the presence of a financial crisis due to their different nature and purpose. These new findings have policy implications for firms in terms of risky investments such as R&D during a financial crisis.

Grilichies (1979) has examined the determinants of R&D, but very few researchers have examined these determinants in the presence of a financial crisis. This study aims to shed light on the existing R&D literature by examining this issue. In addition, this thesis separates emerging countries into crisis-affected countries and less/unaffected countries and examines behavioural differences between the two in terms of R&D determinants. The results show that, whether or not a country is affected, firm age, firm size, export orientation, debt ratio and foreign ownership play important roles in R&D investment decisions during a financial crisis, and that the resource-based view (RBV) holds true even during a financial crisis. This implies that firm resources and capabilities matter for innovation activities, even during a crisis period. Therefore, the findings of this research will be of particular interest to top-level management, such as CEOs and managers, because it indicates that they should continue to invest in innovation during future crisis periods in order to be crisis-resilient.

This study extends the existing literature by examining macroeconomic determinants. Although a few previous studies have observed macroeconomic determinants, this study conducts a comparative analysis of the macroeconomic determinants of advanced and emerging countries in terms of R&D expenditure, observing that they behave differently. In terms of R&D investment, the results suggest that GDP growth, exports, trade openness, patents and financial crisis are the main macroeconomic determinants for advanced countries, while trade openness, FDI, patents and market size are the key macroeconomic determinants for emerging markets. This comparison helps establish how economies work at the macroeconomic level (Montiel, 2011). It has been assumed that emerging markets

follow the growth strategies of advanced markets; therefore, this study will help policy makers in emerging markets to develop new strategies or follow advanced market strategies to grow more robustly.

This study is among the first to examine the effect of institutional determinants of R&D expenditure in emerging markets. It is widely accepted that there are institutional differences between developed and emerging markets, and that institutional differences between countries have a strong impact on firms' innovation activities (Storz and Schäfer, 2011), financing policies, international operations and managerial behaviour. The results show that government effectiveness, rule of law, political instability and corruption are institutional determinants of R&D activities in emerging markets, and that firm-level determinants and institutional factors are similarly important in decisions about R&D investment. This study will improve understanding of the importance of the external environment for R&D investment. In addition, the findings will facilitate shareholders and policy makers in making R&D investment decisions in emerging markets.

This study is unique in comparing the moderating effects of country-level factors on the relationship between R&D and firm performance. The analysis considers investor protection factors, such as disclosures, directors' liability and shareholders' ability, as well as national governance factors, such as government effectiveness, rule of law, regulatory quality, control of corruption, political stability and accountability. It is found that investor protection tends to moderate the relationship between R&D and firm performance more than country-level governance. This study contributes to the debate on which factors have a greater influence on the relationship between R&D and firm performance in emerging markets. It also contributes to research on investor protection and its influence on that relationship.

In the context of the recent global financial crisis, the changing competitive environment, credit policy and incremental R&D investment, this study examines sources of financing

for R&D investment. In doing so, it contributes to R&D research by providing a more comprehensive understanding of R&D financing behaviour in emerging markets**.** It extends the existing R&D literature by examining multinationality and institutional settings in terms of R&D financing, incorporating the market behaviour of local firms and MNEs in R&D financing in emerging markets. It also considers the behaviour of both bank-based and market-based financial systems in this context. Emerging markets were chosen because little previous research has focused on these. It is found that multinational firms use both internal and external funds for R&D investments in emerging markets, while local firms do not use external funds. This result implies that access to funding plays a role in R&D financing. The findings also show that the financial system of the country in which firms are embedded influences their choice of sources of finance. Firms with bank-based financial systems use external funding, while those with market-based financial systems use internal funding for R&D investments in emerging markets. Thus, studying the source of financing for R&D investments will direct firms' management, R&D investors and lenders to make cost-effective financial policies and reach financial goals.

1.3.2 Theoretical contribution

As this thesis focuses on various dimensions, including firm-, country-, and institutional-level determinants, financing and the impact of R&D investment, it does not fit a single theory. Therefore, the analysis of this study adopts various theories, including cyclical, anti-cyclical, RBV, institutional theory, financial slack and pecking order theory. Although these theories have been tested on developed countries, very few have been tested on emerging markets. Thus, this study contributes to existing research by testing these theories on emerging markets.

In this study, the relationship between the financial crisis and R&D investment is examined by applying cyclical and anti-cyclical theory. It is found that local and multinational firms follow cyclical theory. On the other hand, innovative firms follow anti-cyclical, while non-

innovative firms follow cyclical theory. From these findings, it is difficult to generalise which types of firms will follow which theory. Thus, the results emerging from this research contribute to knowledge with regard to the development and refinement of existing theory.

In addition, R&D determinants have previously been examined using RBV, testing whether or not RBV holds true even during a financial crisis. Currently, the theory is only supported during a normal period; however, there is a gap in the existing literature in terms of testing whether this theory holds true during a crisis period. The results of this study show that RBV does hold true during a financial crisis. It therefore contributes to existing theory by extending the scope of RBV theory. Managers might use this model even during a financial crisis period to gain optimal benefits from R&D investment.

National institutional settings have a significant impact on firms' investment decisions, such as in R&D (Jorde and Teece, 1990; Daude and Stein, 2007; Wang, 2010). However, institutional settings vary from country to country. Peng et al. (2008) have emphasised the importance of institutional settings for investment decisions in emerging markets. However, there is a little evidence in the literature regarding the applicability of institutional theory to R&D investment in emerging markets. Thus, this thesis examines the institutional determinants of R&D investment based on institutional theory in emerging markets. In doing so, it contributes to existing research by extending the area of institutional theory. Moreover, policy makers in emerging markets might use this theory once they have made decisions on R&D activities.

In this study, sources of finance for R&D in emerging markets are tested based on financial slack and pecking order theory. It is found that local and multinational firms behave differently with regard to R&D financing in emerging markets, in accordance with financial slack theory. On the other hand, bank-based markets use external funding, whereas market-based countries use internal funding for R&D investments. The results

contribute to the research by providing new evidence from emerging markets. Investors and lenders might follow this theory in financing innovative activities in emerging markets.

1.3.3 Methodological contribution

The study expands the scope of R&D literature using advanced econometric techniques. Generalised methods of moment (GMM) estimation has been applied in the analysis, and an instrumental variable (IV) approach has been used. These methods were used to control for the problem of endogenous variables during the analysis. Moreover, GMM estimation better addresses the problems of heteroscedasticity and auto-correlation. Pair-wise Granger causality tests and ordinary least squares (OLS) regression were also used in the analysis, and panel data methodologies were used to address individual firm heterogeneity. The application of advanced econometric methods confirms that the results are unbiased and consistent.

1.4 Structure of the thesis

The structure of the thesis is as follows. Chapter 1 provides a general background to and the purpose of the study, and justifies its contributions. Chapter 2 presents a theoretical model relating to R&D, including RBV, financial slack, pecking order theory and institutional theory. Chapter 3 reviews relevant literature and debates on issues in R&D. Chapter 4 presents the estimations used in the analysis: an IV approach and GMM are used with OLS and Granger causality tests for the analysis. Chapter 5 examines the determinants of R&D investment during a financial crisis, and explores the relationship between financial crises and R&D from the perspective of markets (local versus MNEs) and industries (innovative versus non-innovative). Chapter 6 examines the macroeconomic determinants of R&D in emerging markets, in particular macroeconomic behavioural differences in R&D investment between advanced and emerging countries. Chapter 7 observes institutional determinants of R&D in emerging markets and examines how factors

in institutional settings, such as government effectiveness, political stability, rule of law and corruption, have an impact on firm-level R&D investment in emerging countries. Chapter 8 examines the moderating effects of country-level factors on R&D investment, and explores the moderating effects of investor protection factors (safeguards) and country governance factors (systems) on the relationship between R&D and firm performance. Chapter 9 looks at the R&D financing behaviour of firms in emerging markets, and relates the R&D financing behaviour of local firms and MNEs, and bank-based and market-based countries in emerging markets. Chapter 10 presents conclusions from the study.

1.5 Summary

This chapter has established the context of the study, and set out the aims and objectives of the research. It has also outlined the purpose of the study, and has explained its potential contributions. The structure of the thesis has also been described.

As is evident from the above discussion, the study concerns R&D investment in emerging markets. Its focus is on the determinants of firm-, macroeconomic- , and institutional-level R&D investments, the relationship between R&D investment and firm performance in emerging markets, and sources of financing for R&D investments in emerging markets.

Chapter 2: Theory

2.1 Introduction

Any analysis depends on a theory or model. The aim of this chapter is to outline theories relevant to R&D investment. The literature on R&D expenditure has drawn on theories such as Schumpeter's theory, RBV, endogenous growth theory, behavioural theory of the firm, real option theory, cyclical theory, pecking order theory, financial slack and institutional theory. The following sections present these theories.

2.2 Schumpeter's theory

The literature on R&D expenditure and firm value has generally been based on Schumpeter's (1942) innovation theory. Innovation theory was derived from Schumpeter's analysis of different economic and social systems. Schumpeter defined innovation as a whole process, from opportunity identification, ideation or invention to development, prototyping, production marketing and sales, whereas entrepreneurship only needs to involve commercialisation. Schumpeter argued that innovation comes about through new combinations made by an entrepreneur, resulting in a new product, a new process, the opening up of a new market, a new way of organising the business or a new source of supply. The drivers of innovation are financial pressure to reduce costs and increase efficiency, increased competition, shorter product lifecycles, value migration, stricter regulation, industry and community needs for sustainable development, increased demand for accountability, demographic, social and market changes, rising customer expectations regarding service and quality, a changing economy, and greater availability of potentially useful technologies coupled with a need to exceed the competition in these technologies. Schumpeter argued that innovation efforts are institutionalised in R&D activities. Innovation theory argues that innovation through R&D expenditure is the foundation of a firm's long-term growth and success (Han and Chuang, 2011). Schumpeter argued that firms that enjoy monopoly positions are incentivised to innovate in order to avoid the entry

of potential rivals; a monopoly position also ensures long-run performance (Askenazy et al., 2007). The R&D sector develops ideas that grant a monopoly position. Schumpeter suggested that these temporary monopolies are necessary to provide the incentives necessary for firms to develop new products and processes (Pol et al., 2006), superior access to capital, ability to pool risks and economies of scale in the maintenance of R&D laboratories. However, critics have claimed that large bureaucracies reduce R&D activities.

2.3 Cyclical theory

Cyclical theory posits that a country's investment and development follow cycles that rise and fall with economic factors such as financial crises and inflation. For example, when an economy faces crisis, economic output tends to decrease. The National Bureau of Economic Research (NBER) has defined a financial crisis as "a significant decline in economic activity for several months reflected in lower GDP, lower individual income, reduced employment level, reducing industrial production and consumption". According to Haralambie (2011), a financial crisis is "a manifestation of the economic crisis which reflects distrust in the financial system, a significant decrease in the volume of transactions on stock exchanges, disruption of market mechanisms, stock market is the business barometer of the economy dealing business in different sizes and from different sectors". The negative impact of a financial crisis on a country's demand, export performance, production, consumption and employment reduces investment. Moreover, tightened credit conditions adversely affect a country's investment levels.

The OECD (2012) has identified three factors which influence R&D investment during recessions: uncertainties about demand trends, access to finance, and governments' responses to R&D policy. Given uncertainties in demand trends, investors seek not to expose themselves to additional risks by investing in risky and uncertain investments such as R&D. Moreover, financial tightening during a crisis makes them step back from innovative activities. Filippetti and Archibugi (2011) have pointed out that financial

constraints play an important role during a crisis, as firms use internal funds as much as they can. According to Cincera et al. (2012), even fast-growing emerging market firms face problems with credit finance during crises. Such crises encourage investors to make deposits to cover for an uncertain future rather than current R&D investments. Overall, to a greater or lesser extent, financial crises cause firms to reduce their investment in R&D (Cincera et al., 2012).

2.4 Counter-cyclical theory

Counter-cyclical theory predicts that economic output increases during an economic downturn. This implies that some economic indicators move in the opposite direction from the financial crisis, one of which is innovative activity. There are several reasons why innovative activity, particularly R&D investment, seems to be counter-cyclical. First, knowledge creation or inventions through innovative activity are not curtailed by financial crises. They are ongoing activities that continue in the same way during boom and bust. Thus, innovative activity is not driven by economic fluctuations (Schumpeter, 1939). Geroski and Walters (1995) found that innovative activities turn out to have many properties of random walk; however, innovation has a tendency to cluster during economic booms. Second, the opportunity costs of R&D investment are lower during crises; thus, firms are likely to continue to invest in R&D during crises. Third, innovation may create market demand through multiplier or accelerator effects (Kleinknecht and Verspagen, 1990). Fourth, internal funding plays an important role in whether or not innovation is counter-cyclical. If a firm has more internal funding during a recession, it will not cut R&D investment. Therefore, Lopez-Garcia et al. (2012) found that if a firm's internal funding increases by more than four per cent, it increases its R&D investment during a recession.

2.5 Resource-based view

RBV was first recognised by Wernerfelt (1984), who explored the usefulness of analysing firms from a resource perspective rather than from a product perspective. RBV stresses the heterogeneous internal resources and capabilities that create competitive advantage and determine a firm's performance (Barney, 1991; Teece et al., 1997). Internal resources, which are the basic unit of analysis for RBV, include physical, human, organisational (Barney, 1991), financial, commercial and technological assets used by firms to develop, manufacture and deliver products and services to their customers. Resources that are valuable, rare, inimitable and non-substitutable, such as patents, trademarks, brand names, reputation, installed base, organisational culture, employees' knowledge, experience and skills may lead to the creation of competitive advantage (Wright et al., 1994). Firms that have greater competitive advantage will be more successful in emerging markets (Makhija, 2003). R&D investment is one of the main resources of a firm, creating assets which are difficult to imitate and substitute in order to achieve competitive advantage. Moreover, R&D investment helps firms to gain competitive advantage by increasing technological knowledge, raising product quality, improving products and processes and enhancing customer satisfaction. On the other hand, a firm's innovative activities depend on its resources and activities. A study by Canto and González (1999) identified rules relating a firm's resources and activities to R&D spending. Similarly, Galende and Fuente (2003) found that internal resources and innovation have a significant and interesting relationship. However, critics have claimed that resources alone may not contribute to a firm's performance; a firm also needs entrepreneurial strategies and entrepreneurial abilities, which are overlooked in RBV (Akio, 2005). Moreover, Priem and Butler (2001) have stated that RBV ignores managerial implications and operational validity. Although RBV states that managers need to obtain strategic resources which are non-imitable and rare, it does not explain how managers can do this. RBV also overlooks the need for co-operation between resources to facilitate firm performance. In addition, RBV only focuses on

internal resources; however, external factors such as the economic, social and political environment may play an important role in firm performance. Thus, even if a firm has sufficient internal resources, owing to corruption and political turmoil they may not contribute to firm performance.

2.6 Institutional theory

Institutional theory asserts that institutional quality and environment may influence the structure of social and economic development. Institutions create formal and informal rules that organise legal, social, economic and political behaviour (North, 1990; Hodgson, 2006). Thus, differences in institutional settings affect the outcome of development. Institutional theory acknowledges the role of the external environment in shaping a firm's decisions and level of activities. Oliver (1997) and Brawn et al. (2001) have observed that institutions influence firm-level strategy. For instance, R&D activities are legitimised by the institutional environment. Hillier et al. (2011) found that institutional settings facilitate investment in R&D activities. Similarly, Pattit et al. (2012) have reported that institutional quality influences technological innovation and emerging technological opportunities. Institutions may facilitate R&D investment in several ways. First, strong institutions may attract foreign investors (Bénassy-Quéré, 2007) and help access external finance (La Porta et al., 1997). Second, institutional quality increases investor protection by protecting intellectual property rights, thereby encouraging investors to invest more in innovative activities. Moreover, strong external support provides managers and investors with a favourable environment in which to do business.

2.7 Pecking order theory

According to Myers' (1984) "pecking order" theory, the financing of different investment projects is prioritised, and their order depends on the cost of asymmetric information. The theory suggests a hierarchy in financing projects, using internal funds first, and then external fund-issuing debt and/or equity. Empirical research has shown that R&D

financiers prefer internal funding because it is easier to raise and lower costs (Himmelberg and Petersen, 1994; Lee and Hwang, 2003; Brown et al., 2009). Moreover, owing to agency problems, it is preferable to finance R&D investment internally (Schumpeter, 1942); the question of whether debt or equity is preferred for R&D financing arises only when internal funding has been exhausted. According to Hottenrott and Peters (2012), when internal funding is exhausted, firms use debt for R&D investments because issuing new equity may be costly and often unwanted. Similarly, Brown et al. (2009) have observed that, when internal funding is exhausted and debt is not an option, firms must turn to new equity issues. However, Chen et al. (2010) have argued that, in order to avoid the costs of debt requirements and maintain sufficient financial slack, firms prefer equity financing. Moreover, equity financing reduces financial obligations to pay regular interest (Wang and Thornhill, 2010).

2.8 Financial slack

Myers' (1984) pecking order theory emphasises the use of first internal funding and then external funding for R&D investment. The main problem with this theory is determining which firms follow pecking order theory for R&D investment, and to what extent. The theory of the general flow of funds (Dhrymes and Kurz, 1967) holds that firms use internal and external funding simultaneously for R&D investment. This raises questions about their capacity to obtain debt for R&D investment, as there is a problem of information asymmetry. Modigliani and Miller's (1958) theory, popularly known as M-M theory, denies these concepts. They argued that it does not matter how a firm is financed. However, their one main assumption was a perfect capital market, which is almost absent in emerging markets. Given controversies between existing theories, financial slack provides more flexibility in choosing sources of funding for R&D investment. Financial slack is a facilitator of R&D investment (Lee, 2011), as slack provides the necessary sources of funding for R&D activities (Cyert and March, 1963). A firm may use cash (or

near cash) and/or debt capacity when opportunities appear, but not in a strict or orderly fashion as simultaneous finance. In general, it can be said that firms may use internal or external funding, or both, for new investments. The choice of sources of funding depends on the availability of financial slack. In other words, firms with lower levels of financial slack use internal funding only, and firms with higher levels of financial slack use both sources of funding for investments.

2.9 Endogenous growth theory

Endogenous growth theory, popularly known variously as neo-Schumpeterian growth theory, the Romer model, the Grossman-Helpman model or the Aghion-Howitt model, also acknowledges the role of internal factors but focuses on internal sector characteristics and technological regimes. Endogenous growth theory holds that investments in innovation, knowledge and human capital are significant contributors to economic growth. It suggests progression from R&D intensity to patenting, patenting to technological progress, and technological progress to economic growth (Zachariadis, 2003). Jones (1995) criticised the fact that the theory incorporates a scale effect property (Zachariadis, 2003). His evidence shows that resources devoted to R&D have been increasing exponentially, but growth rates in total factor productivity (TFP) and per capita output remain roughly constant over time (Dinopoulos and Sener, 2007). Jones (1995) then proposed a "semi-endogenous" growth theory. According to this model, although growth in the extended model is generated endogenously through R&D, long-run growth depends only on parameters that are usually taken to be exogenous, including the rate of population growth. Madsen (2008) found that, while endogenous growth theory is consistent with time-series evidence but inconsistent with cross-sectional evidence, semi-endogenous growth theories are consistent with neither time-series nor cross-sectional evidence. In contrast, exogenous growth theory, also known as the neoclassical growth model or Solow-Swan growth model, assumes that economic

growth is determined mainly by external factors such as the savings rate (Harrod-Domar model) and the rate of technological change (Solow model), rather than internal factors.

2.10 Cornot Duopoly game theory

In an "era of cheap innovation" (Galbraith, 1952, cited in Kaiser, 2002) and ever increasing complexity and costs, many have claimed that even large firms do not have all the necessary assets to develop new technology, so they must combine their research efforts (Hinloopen and Encore, 2003). D'Aspremont and Jacquemin (1988) derived a two-stage Cornot duopoly game, also called resource joint venture (RJV), which emphasised R&D co-operation and R&D competition. R&D co-operation takes place at the pre-competitive stage, in which firms share basic information and efforts in R&D, creating common policies at the product level, but compete in the market place, as in the European Strategic Programme for R&D in Information Technology (ESP-RIT) and the Microelectronics and Computer Technology Corporation (MCC) in the US. They emphasised that co-operative research efforts bring fierce competitors together. Studies by Hinloopen and Encore (2003) and Kaiser (2002) have revealed that co-operating firms invest more in R&D than non-cooperating firms. Hasnas et al. (2011) treated the Cournot duopoly as a differential game in which firms investing less in R&D enjoy higher profits than their rivals. Henriques (1990) has pointed out that this theory only holds if spill-overs are large.

2.11 Encultural innovation model

While the two-stage Cornot duopoly game focuses on R&D co-operation between two firms, in the encultural innovation model (also known as the co-operative model or interactive model) co-operation occurs between R&D activities, structural links, tacit knowledge, interactive learning, the cultural context, social processes, national and regional innovation systems, and customer and supplier relations (Lundvall, 1992; Campagni, 1991, cited in Johannessen et al., 1999). An emphasis on a variety of

knowledge types, such as systemic, explicit, tacit, hidden and relationship knowledge and the links between them, is regarded as the most valuable resource in the encultural model, and learning is regarded as the most important process. In this model, knowledge development, integration and application are the main productive assets of the firm. Innovation research is the fundamental study of change processes, knowledge development and knowledge integration for the purpose of generating new combinations. The model presupposes that the innovation process varies from firm to firm, and that there is a pattern of interactive processes that generates innovation activity in the firm. The dominant feature pertaining to the model is the importance given to collaboration, as opposed to an emphasis on competition (Johannessen et al., 1999). However, Scherer (1980) observed that a lack of competitive pressure leads to bureaucratic inertia, which discourages innovation.

2.12 Spence's dynamic model

Spence's (1984) dynamic model analysed the effect of R&D spill-overs on industry performance. Intra-industry R&D spill-over effects lead to reduced costs, as knowledge expands for the receiving firm, and production structures are affected as demands change in response to spill-over and rates of capital accumulation. Spence assumed that, through spill-overs, a firm's R&D expenditure reduces the production costs of rival firms (Bernstein and Nadiri, 1989). In Spence's model, the firm's own and rival R&D activities are perfect substitutes. This may be a reasonable characterisation of industries with "discrete" technologies, in which innovations stand more or less alone as isolated discoveries, as in the chemical and drug industries (Levin, 1988). As spill-overs generate free-rider problems, firms' incentives to undertake R&D activity are diminished (Bernstein and Nadiri, 1989). However, patent law seeks to resolve this tension between incentives for innovation and the widespread diffusion of benefits (Levin et al., 1987). Reinganum (1981) proposed a model of R&D with rivalry. Contrary to the prediction of Spence's model, in

electronics-based industries, R&D expenditure is not discouraged by a high level of spill-over (Levin, 1988).

2.13 Behavioural theory of the firm

According to Cyert and March (1963), the behavioural theory of the firm offers a good platform for integrating development and decision-making ideas for innovation. This theory takes the firm as its basic unit, with the goal of predicting firm behaviour with respect to decisions such as price, output and resource allocation, emphasising the actual process of organisational decision making (Mahoney, 2004). Developing innovation is a form of organisational search (Greve, 2003). According to Cyert and March (1963), information is required to make the most appropriate decisions. However, information gathering itself is not costless and requires resources (Mahoney, 2004). This model specifies that R&D expenses increase when low performance causes problemistic search and when excess resources cause slack search (Greve, 2003). Problemistic search is triggered when managers find that organisational performance falls below their aspirations (Cyert and March, 1963). When performance relative to aspirations decreases, R&D intensity increases (Greve, 2003). Slack search occurs when increased organisational resources allow experimentation and organisational change (March, 1981). When organisational slack increases, R&D intensity increases (Greve, 2003). However, critics claim that this theory is unnecessarily complicated.

2.14 Real option theory

Real option theory is a standard framework for the valuation of investment projects under uncertainty and flexibility. It describes the resemblance between financial options and real-world investments. This theory is related to scenario and decision tree analysis, and is more adequate than expected net present value theory for investment decision analysis. The main assumptions of this theory are first, that investments are incremental; that is, a firm may undertake a small investment to establish a foothold in an area and, once uncertainty

regarding the future profitability of the investment is lifted, increase the investment to the needed scale to reap the benefits. Second, investments are immediate; that is, they will instantly materialise once the decision to invest has been made. Third, options are available to the firm; that is, the firm can undertake an investment once it has decided to do so (Cuervo-Cazurra and Un, 2010). There are six types of real options: the option to differ an investment project, the time-to-build option, the option to abandon an investment project, the option to contract, expend or temporarily shut down an investment, the option to switch input or output, and the growth option (Perlitz et al., 1999). R&D-intensive industries are highly unlikely to evaluate the chances and risks of a project as well as choosing the right one (Perlitz et al., 1999) at the right time (Cuervo-Cazurra and Un, 2010). Real option theory explains a method of R&D project evaluation, when valuing R&D investment and the frequency of investments in R&D. Real option pricing (ROP) methods are used to evaluate R&D projects (Hartmann and Hassan, 2006). A firm that lacks internal knowledge resources is more likely never to invest in R&D; a firm that has both internal and external knowledge resources is more likely sometimes to invest in R&D; while a firm that has internal knowledge resources but lacks external knowledge resources is more likely always to invest in R&D (Cuervo-Cazurra and Un, 2010). Investment in formal R&D is viewed as part of a sequential option in which the firm first invests in R&D to create growth options that can later be exercised with additional investment, such as prototype development, production and marketing (Pindyck, 1991; McGrath, 1997, cited in Cuervo-Cazurra and Un, 2010). The Black-Scholes (B/S) equation offers an analytical solution, and the Geski model provides an extension of B/S for the valuation of sequential options (Hartmann and Hassan, 2006).

2.15 Summary

This chapter has described theories relevant to R&D investment. Several theories explain the causes of firm-level R&D investment. For example, Schumpeter's theory and RBV explain the determinants of R&D, while institutional theories explain the importance of institutional determinants for R&D expenditure. Pecking order theory and financial slack posit possible sources of financing for R&D activities, while cyclical and anti-cyclical theories describe the relationship between financial crises and R&D investment.

Chapter 3: Literature Review

3.1 Introduction

This chapter reviews the relevant literature on R&D investments, in particular the literature relating to relationships between financial crises and R&D investments, firm-level R&D spending determinants, macroeconomic and institutional determinants of R&D investments, the impact of R&D on firm performance, and sources of finance for R&D investment. This will serve as a foundation for the discussion and analysis of subsequent chapters. A review of empirical studies of R&D will help identify gaps in the existing body of knowledge.

The chapter is structured as follows. Section 3.2 presents a meaning and definition of R&D, Section 2.3 defines emerging markets, and Section 2.4 relates the financial crisis to R&D investment. Sections 2.5, 2.6 and 2.7 describe firm-level, macroeconomic, and institutional determinants respectively. Section 2.8 examines the impact of R&D on firm performance, Section 2.9 looks at sources of finance for R&D, and Section 2.10 summarises the chapter.

3.2 Research and development (R&D)

Research is the primary search for technical or scientific advancement, and development is the translation of such advancement into product or process innovations (Link, 1982). These two words, research and development (R&D), are generally used together because research needs development to create something that the market wants. R&D expenditure is used as a proxy for information asymmetry, managerial discretion, product differentiation or growth opportunities (Hirschey et al., 2012). Shin and Kim (2011) have pointed out that R&D expenditure creates intangible assets, affects profitability, and generates excessive stock returns in the stock market. Morbey's (1988) empirical evidence confirms that R&D expenditure is an important factor in determining the sales growth and profitability of a firm.

As defined by the OECD (2000), R&D expenditure is money spent on creative work undertaken on a systematic basis to increase the stock of knowledge, and the use of this knowledge to devise new applications. Consistent with this, the Frascati Manual (OECD, 2015a) has recently added that R&D activity must (at least in principle) meet the following five criteria:

- Novel– aimed at new knowledge and findings
- Creative– new concepts and ideas that improve existing knowledge
- Uncertain– uncertain about the final results
- Systematic – conducted in a planned way
- Transferable and/or reproducible – allowing others to reuse and reproduce the results.

The Frascati Manual (OECD, 2002a) identified three areas covered by R&D: basic research, applied research and experimental development.

- Basic research is experiential research or theoretical work undertaken for new knowledge generation.
- Applied research relates to original research that obtains new knowledge.
- Experimental development is systematic research on existing knowledge directed to produce new processes or systems or improve existing systems.

According to Driver and Guedes (2012), R&D is characterised by specific features:

- Its assets are intangible (and thus largely sunk or irreversible).
- Its gains are difficult to appropriate in full unless protection is available through patents, secrecy or unique complementary assets.
- Its cash flows are both long-term and unusually risky.

According to Statement of Financial Accounting Standards (SFAS) No. 2 (1974), the elements of R&D expenditure are:

- The salaries, wages and other related costs of personnel engaged in R&D activities

- The cost of materials and services consumed in R&D activities
- The depreciation of buildings, equipment and facilities, and amortisation of other assets such as patents and licences to the extent that they are used for R&D activities
- Overhead costs relating to R&D activities, payments to outside bodies (research laboratories, universities, etc.) for R&D projects related to the enterprise
- Expenditure incurred in obtaining patents for new products/processes
- Other costs that can be directly attributed to R&D activities and can be identified with specific projects.

This expenditure excludes routine product testing, quality control costs, market research and market testing costs, the legal costs of patent applications and the sale and licensing of patents.

In terms of microeconomic aspects, R&D treats R&D expenditure, R&D investment and R&D spending as a single or homogeneous activity. R&D is also known as technical or technological development, and is sometimes used interchangeably with the term "innovation".

3.3 Emerging markets

Generally, the term "emerging markets" refers to countries which are growing rapidly, with favourable economic liberalisation, and integrating with global markets (Arnold and Quelch, 1998; Hoskisson et al., 2000). According to the World Bank, which introduced the term in 1980, emerging markets are those markets that have not reached the minimum gross national product (GNP) per capita of $9,656 associated with developed markets. The International Finance Corporation (IFC) has defined an emerging market as a stock market that is in transition, increasing in size, activity or level of sophistication. In particular, the IFC (1999) has stated that, to be included in the emerging markets list, a stock market needs to meet two criteria: first, that it is located in a low-to middle-income country

according to World Bank criteria; and second, that its invested market capitalisation is low relative to most recent GDP figures.

According to Kvint (2009):

> An emerging market country is a society transitioning from a dictatorship to a free-market-oriented economy, with increasing economic freedom, gradual integration with the global marketplace and with other members of the GEM [global emerging market], an expanding middle class, improving standards of living, social stability and tolerance, as well as an increase in cooperation with multilateral institutions.

The distinguishing characteristics of emerging markets are that, besides their size and openness of economy, these countries' standards of living are rapidly improving, with a growing middle class. Marr and Reynard (2010) have stated that emerging markets represent 80 percent of the world's population and almost three-quarters of its land mass. Moreover, they have pointed out that 70 percent of global foreign exchange reserves, more than half of global energy consumption and close to half of both the world's exports in purchasing power parity terms and its GDP were accounted for by emerging markets in 2010. On the other hand, the IMF (2014) has observed three disadvantages of emerging markets: rising global trade, reflecting an expanding supply chain; easy financing conditions driven by lower interest rates in advanced markets; and high and rising commodity prices. In addition, owing to cheap labour costs, emerging markets have become key suppliers of a variety of man-made products to the rest of the world.

Due to their competitive advantages, coupled with continued trade and liberalisation, emerging markets facilitate a surge of capital inflows and investment (IMF, 2014). As emerging markets are considered in terms of low-cost innovation and investment opportunities, foreign investors are attracted to invest in them. Thus, emerging markets are considered as lands of opportunity.

Various organisations, including the IMF, Goldman Sachs and The Economist have defined emerging markets from different perspectives. For example, the IMF defined them by GDP-per-capita ratio, while Goldman Sachs selected them based on macroeconomic stability, political maturity, trade openness, investment policies and educational quality criteria. As a result, the list of emerging markets may vary from one organisation to another (see Appendix 2 for a list of emerging markets). For example, Goldman Sachs identified 11 emerging markets: Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, South Africa, Turkey and Vietnam. On the other hand, the IMF included Argentina but excluded South Korea as an emerging market. Although the lists of emerging markets differ, the main criterion for selection is a growing economy.

3.4 Financial crisis and R&D investment

The relationship between financial crises and innovation is not straightforward. The cyclical view suggests that financial crises impact negatively on R&D investment, while the anti-cyclical view suggests the opposite. In the context of the business cycle, R&D activity evolves with economic fluctuations such as GDP. Financial constraints, lower customer demand for products and services, and a "pessimistic mood" make R&D investment pro-cyclical. This pro-cyclical view has also been supported by Barlevy (2007), who has stated that there is a dynamic externality inherent in R&D that makes entrepreneurs myopic and concentrates their innovation in booms, even when it is optimal to concentrate it in crises. R&D maybe pro-cyclical because a large proportion of research is oriented towards short-term needs: it is devoted to adapting existing goods to new requirements or new markets, and hence follows demand fluctuations (Guellec and Ioannidis, 1997). Stiglitz (1993) and Hall (2002) have argued that firms may decrease their R&D investment due to credit rationing and limited internal funding during financial crises. Moreover, Freeman et al. (1982) stated that firms reduce their investment during recession because of low profit margins and a general "pessimistic mood". Consistent with

Freeman et al. (1982), Lerner (2011) has argued that investors who are risk averse avoid committing to new obligations during recessions, although tough times such as financial crises may be good times for firms to develop new ways of doing things (Rae-Dupree, 2008; Hausman and Johnston, 2014). A crisis period may be an opportune time, particularly for emerging market firms, as they can capitalise on foreign markets (Ma et al., 2014). This implies that the same financial crisis may impact differently on firms based on the nature, development and institutional settings of the countries in which they operate.

On the other hand, the anti-cyclical view, also known as the Schumpeterian (1934) model, states that financial crises induce R&D investment in order to replace old and inefficient production techniques with newer ones. This is popularly known as "creative destruction". Opportunity costs, the availability of internal funding, high adjustment costs and the size of firms makes R&D investment counter-cyclical. The opportunity costs of R&D investment are lower than other short term investments during crises; thus, firms are unlikely to reduce their R&D investment. Moreover, R&D investments depend primarily on the availability of internal funding (Himmelberg and Petersen, 1994). If a firm has more internal funding during a recession, it will not cut down on R&D investment. Firms whose internal funding increases by more than four percent increase their R&D investment during recession (Lopez-Garica et al., 2012). Supporting the anti-cyclical view, Guellec and Ioannidis (1997) argued that fluctuations in R&D are limited by high adjustment costs. R&D is a sunk, non-tradable and irreversible cost; thus, the cost of stopping an ongoing project is high. Moreover, larger firms increase their R&D investment during downturns following a fall in industry demand (Rafferty and Funk, 2004). The main weakness of this theory is that it fails to identify specific firms and/or industries that will continue to invest or increase their R&D investment during financial crises.

Following the recent financial crisis, the OECD (2009, 2012) and Archibugi et al. (2013a) found that firms reduced their investment in innovation and R&D. Paunov (2012)

addedthat,on average, one in four firms reduced their innovation projects during this financial crisis, based on panel data from 1,548 firms in eight Latin American countries. However, in a later paper, Archibugi et al. (2013b) found that firms, particularly fast growing new firms and those that were already highly innovative before the crisis, invested in innovation during the crisis. In their earlier paper, they used Innobarometer survey data from 27 EU member states, Norway and Switzerland, designed and collected by the European Commission, while the later paper used panel data from a UK Community Innovation Survey (CIS). This indicates that a country's institutional setting does matter in response to crises. Consistent with Archibugi et al. (2013b), Kanerva and Hollanders' (2009) study, using Innobarometer survey data from 27 European countries, documented that more innovative firms continued to invest in innovation during the 2008 crisis. Both sources have indicated that innovative firms may play different roles during a crisis. This is because most innovative firms are comparatively less affected by recession (Kanever and Hollanders, 2009).

Like innovative firms, the responses of multinational firms to financial crises may be different from those of local firms. Bellak (2004) has stated that, as MNEs have greater international exposure and sectoral affiliation, they are hit harder by crises than domestic firms. On the other hand, Dachs (2014) has argued that, as MNEs are less dependent on external finance and have greater internal funding, they have a competitive advantage over local firms and may continue to invest during a crisis period. Moreover, they have greater ability to spread the risk of R&D projects across a larger number of countries (Dachs, 2014). However, there is no empirical evidence of any difference between local firms' and MNEs' reactions to financial crises. Wang et al. (2005) and Varum and Rocha (2011) found that local firms and MNEs were equally affected by the financial crisis, although these results may vary within countries (Filippov, 2013). For instance, Varum and Rocha (2011) examined MNEs' and domestic firms' responses to crisis within Portugal.

The inconclusive empirical evidence indicates a considerable degree of heterogeneity in the impact of crises on R&D (Dachs, 2014). According to Cincera et al. (2012), it depends how companies react to a financial crisis and how they manage the R&D process, as well as collaboration or outsourcing. Firms follow cyclical theory when at risk of falling behind competitors who are continuing to invest in R&D. In contrast, firms follow the anti-cyclical view when they wish to gain competitive advantage during a downturn. Moreover, the impact of economic crises on R&D investment depends on firms' size, export orientation and access to credit. Export-oriented firms increase R&D during a crisis, while large firms and those with limited access to credit reduce R&D (Correa and Lottey, 2011). Paunov (2012) observed that firms with no credit constraints are less likely to abandon innovation projects, and that those who lose out on export market sales are more likely to stop innovating. In line with Paunov (2012), the OECD (2009) reported that export-oriented and quality-certification firms increased their R&D investment during the recent financial crisis. Therefore, firms' risk management, nature, orientation and financing policies have important implications in responding to financial crises.

3.5 Firm-level R&D determinants

Most empirical work on the determinants of R&D has focused on firm-level R&D investment (Lall, 1983; Kumar and Saqib, 1996; Galende and Suarez, 1999; Galende and Fuente, 2003; Lai et al., 2015), although the evidence has been inconclusive for most of these determinants. For example, the accelerated principle of investment supports profitability, while failure-inducement theory finds profitability largely irrelevant to R&D. Some authors support demand-side pull factors, such as sales, while others support technological push factors in R&D investment. On the other hand, RBV posits that R&D activity depends on internal resources. The main reasons for these inconclusive results are variations in the estimation, sample selection, sample period and domain selected for

analysis. The common determinants of R&D investment used in the literature are described below.

3.5.1 Firm age

Age represents knowledge, skills and managerial capabilities; in other words, a firm's stock of knowledge, skills and managerial capabilities increases with firm age (Pamukcu and Utku-Ismihan, 2009). Moreover, experienced firms may expect higher rates of appropriation as they have existing routes through which to exploit new inventions (Abdelmoula and Etienne, 2009). Mishra (2007) added that older firms have more experienced scientists and better-equipped laboratories than new firms. Thus, it is assumed that R&D investment increases with firm age. Empirical evidence also shows a significant positive influence of firm age on R&D investment (Lall, 1983; Kumar and Saqib, 1996), although this positive relationship does not always hold true. For instance, Klepper (1996), Lynskey (2004) and Murro (2013) found no relationship between the two. Similarly, as new firms have more technological opportunities, they have greater competitive advantage than older firms in innovative markets (Duqi and Torluccio, 2010), which facilitates investment in R&D (Abdelmoula and Etienne, 2009). This indicates that newer firms may also influence R&D investment, although, in a recent study, Coad et al. (2016) found that investment in R&D is riskier for new firms than older firms. Thus, the empirical evidence shows mixed results regarding the relationship between firm age and R&D investment.

3.5.2 Firm size

According to Schumpeter's (1942) hypothesis, larger firms make greater investments in R&D. They tend to be more diversified, more technologically complex and better aware of technological opportunities (Lall, 1983). They also have more resources to invest in R&D activities (Duqi and Torluccio, 2010) and the ability to benefit from returns on their innovative activities (Pamukcu and Utku-Ismihan, 2009).However, large size does not always predict firm innovation because large firms may gain no advantage from R&D

expenditure owing to communication difficulties, and may have insufficient motivation mechanisms to encourage R&D employees (Howe and McFetridge, 1976; Scherer, 1980; Bhattacharya and Bloch, 2004). Moreover, Kriaa and Karray (2010) have claimed that smaller size may have positive effects on R&D activities due to better networks of communication, co-ordination and informal controls. In contrast, Hertog and Thurik (1993) found that firm size has no significance in explaining R&D investment. Thus, Cohen et al. (1987) observed that it is not size that influences R&D investment, but that the latter depends on unique conditions of technological opportunity and appropriability. Although there is no consensus in the empirical results concerning the relationship between firm size and R&D investment, it is expected that, during critical moments such as a financial crisis, firm resources may play an important role.

3.5.3 Exports

Most of the existing literature (Braga and Willmore 1991; Ito and Pucik, 1993; Kumar and Saqib, 1996; Tan and Hwang, 2002; Galende and Fluente, 2003; Zemplinerova and Hromadkova, 2012) has shown a significant positive relationship between export orientation and R&D investment. Export-oriented firms will be more aware of new technological developments (Pamukcu and Utku-Ismihan, 2009) and strive harder to maintain the competitiveness of their technologies (Lall, 1983) so that they can compete more effectively in international markets, thereby increasing their level of R&D investment. Moreover, since export markets usually consist of several segmented sub-markets, and each sub-market varies in terms of consumer preferences, entry barriers and elasticity, the likelihood that R&D will increase demand in some of these markets may be higher than in the domestic market (Parameswaran, 2010). Thus, exports allow firms to produce on a large scale and thereby exploit increasing economies of scale, made possible by fixed investments such as R&D. However, large-scale production by export-oriented firms does not ensure a high level of R&D expenditure because exports generally involve

highly standard, non-innovative products (Abdelmoula and Etienne, 2009). Thus, the more the firm exports, the smaller is its probability of investing in R&D.As most empirical studies have shown a positive influence of export orientation on R&D investment, it is assumed that, due to the high export orientation of emerging market firms, there is a positive relationship between them.

3.5.4 Import of technology

The international technology transfer hypothesis explains that benefits from foreign R&D activities may be transmitted through trade and may affect domestic R&D investment decisions. R&D is subsequently required because imported technologies are often not entirely appropriate, for example to domestic consumers' tastes, market size and factor prices (Katrak, 1985), so they require adaptations and modifications to suit local conditions, raw materials and patterns of use (Parameswaran, 2008). Moreover, emerging market firms may not receive efficient support for innovation from domestic institutions (Peng, 2003; Hsu et al., 2015). Thus, it may be more feasible to import technology rather than engaging in in-house R&D activity (Parameswaran, 2008). However, easy importation of technology may increase the propensity for imitation rather than innovation and therefore, according to Pillai (1979), technology importation may reduce R&D investment because it discourages firms from innovating. Although it is believed that emerging market firms may improve production inputs and outputs through the importation of technology from advanced countries, empirical results have not reached a consensus concerning the relationship between firms' importation of technology and their R&D investment. Thus, it would be interesting to observe this relationship based on emerging markets.

3.5.5 Diversification

The endogenous growth model (Romer, 1990) emphasises new products and product diversification for long-term growth. A more diversified firm will be better able to exploit

unexpected research outputs than those with narrower operations (Grabowski, 1968). In a diversified firm, R&D divisions may share their technological innovations, taking advantage of economies of scale in innovation efforts (Teece, 1980). Thus, it is expected that a higher degree of diversification will impact positively on a firm's profit expectations from R&D investment (Nelson, 1959, cited in Grabowski, 1968). Consistent with this, empirical studies such as those by Grabowski (1968), Chen (1996), Galende and Fluente (2003) and Chiang and Mensha (2004) have shown a positive influence of diversification on R&D investment. However, once a firm patents its diversification, this may discourage further innovation. Mukherjee (2005) assumed that greater product differentiation, which may occur for reasons other than product characteristics, such as brand name or after-sales service, increases the possibility of lower R&D under product patents. In addition, Hoskisson et al. (1993) noted that ROI-based compensation for divisional managers in a diversified firm is likely to result in myopic behaviour, leading them to sacrifice longer-term investments such as innovative activities. These inconclusive results need to be resolved through empirical work in emerging markets.

3.5.6 Sales growth

Demand-pull theory indicates that the greater the market demand, the greater the percentage of expenditure will be allocated to R&D. A high sales growth rate indicates a firm's potential to increase its R&D investment: "The faster a firm's sales are increasing, the more confidence it will have about its ability to secure the benefits from uncertain R&D projects, and the more patience it can afford to show in waiting for these benefits" (Mueller, 1967). Similarly to Manganelli's (2010) results, Morbey (1988) found that firms that invest a larger percentage of sales in R&D benefit from a greater growth rate than their competitors, irrespective of their industrial classification. These findings suggest that major established firms that invest at least four per cent of sales growth in R&D show significant sales growth, that investing three per cent or more of sales in R&D produces an 80 percent

chance of long-term growth at a rate of no less than half the rate of increase in GNP, and that investing less than two per cent of sales in R&D leads to growth at a rate equal to or better than GNP. Firms with R&D investment at this low level tend to be sales laggards. Morbey (1988) suggested that investing three per cent or more of sales in R&D ensures reasonable long-term growth, and that firms investing at lower levels are probably only supporting their current business. Moreover, Leonard (1971), Howe and McFetridge (1976), Lynskey (2004), Cheng and Chen (2006) and Manganelli (2010) have reported a positive influence of sales on R&D investment. Thus, in terms of the effect of sales alone, the relationship has been shown to be fairly straightforward.

3.5.7 Profitability

According to the acceleration principle of investment, growing GDP influences business in general to increase profits, leading to an increase in R&D investment by generating sales and cash flow. Growth in profits through realisation of greater earnings means that a firm is lucrative and successful, encouraging executives who expect higher profits from R&D investments to decide to invest more in R&D activities (Lee and Hwang, 2003). Moreover, firms may seek to avoid taking out loans, and thus those with higher profits will be more inclined to invest in R&D (Pamukcu and Utku-Ismihan, 2009). However, Kalayci (2013) has claimed that a single year's profit is a very poor indicator of financial investment in R&D because R&D investment is long-term and requires vast sources of funds. Sometimes declines in profit may encourage firms to invest in innovation to maintain market competitiveness or to retain their market share by doing something new. Moreover, declining profits signal a firm's decline, leading management rapidly to increase R&D in an attempt to ensure the firm's long-term viability. Thus, declining profitability may lead to increased R&D investment, and empirical studies such as those by Hundley et al. (1996), Kumar and Aggarwal (2005), Liu (2011) and Kalayci (2013) have found a negative

relationship between the two. These inconclusive results need to be resolved by empirical work on emerging markets.

3.5.8 Cash flow

According to Myers' (1984) pecking order theory, R&D projects are financed in a particular order, turning first to internal funds (measured by cash flow) and then to external finance. Schumpeter's (1942) hypothesis also emphasised that it is preferable to finance investments such as in R&D internally due to agency problems and the discretion required (Martinsson, 2009). In addition, internal funds theory argues that the financial status of a firm determines its level of investment. Internal funds for R&D investment can be raised more easily than external funding (Lee and Hwang, 2003). Other things being equal, the greater the internal cash flow, the lower the weighted average cost of capital to the firm. Similarly, the lower the cost of capital, the greater the value of all assets, including intangible R&D assets, that will be acquired by the firm (Howe and McFetridge, 1976).In this regard, Bhagat and Welch (1995) pointed out that R&D occurs most frequently when firms have greater operating cash flows and are thus able to avoid the costs of external capital markets. Similarly, during a period of financial constraint such as a financial crisis, when firms are confronted with a decline in productivity growth and reduced cash flow, the pool of funds available for R&D investment is reduced (Rafferty and Funk, 2005). As a result, Giacotto et al. (2005) found a significant positive influence of cash flow on R&D investment. However, firms from advanced countries with bank-based financial systems, where external funding can easily be raised, and large and well-established firms such as MNEs, which also have easy access to external funding, the relationship between cash flow and R&D investment may be different. Bhagat and Welch (1995) found no relationship between cash flow and R&D investment for Japanese, European and UK firms. As the relationship between cash flow and R&D investment is not straightforward, it needs to be determined by empirical work in emerging markets.

3.5.9 Debt

Transaction cost theory and the positive theory of agency argue that debt financing may discourage R&D investment. In this regard, Long and Ravenscraft (1993) stated that most theories predict a negative association between debt and R&D investment. Debt finance may be expensive for R&D projects due to risk and uncertainty. With higher risk and uncertainty and constrained resources, firms with greater debt-equity ratios will spend relatively less on R&D. Firms without financial slack will not have the resources to develop new technologies or innovative applications, or to adapt existing technologies to new products (Cumming and Macintosh, 2000). Therefore, empirical studies such as those by Hall (1990), Cumming and Macintosh (2000) and Cheng and Chen (2006) have documented a significant negative influence of debt on R&D investment. However, Galende and Fuente (2003) have argued that debt finance in a company has an impact in the sense that more incremental than radical innovations are generated. They found a positive impact of debt finance on R&D investment. On the other hand, Bhagat and Welch's (1995) study produced mixed results. They observed a negative relationship between the debt ratio and R&D investment of US firms and a positive relationship for Japanese firms, with no significant relationship for Canadian, British and European (German, French and Dutch) firms. They surmised either that US firms have more need to safeguard their R&D expenditure from possible financial distress without assuming large amounts of debt, or that US lenders are less willing to finance R&D projects, while, in contrast to the US tax code, the Japanese tax code manages to encourage R&D. Thus, the existing literature has shown that the relationship between debt and R&D spending is inconclusive.

3.5.10 Ownership concentration

Francis and Smith (1995) suggested a positive relationship between ownership concentration and R&D investment. They found that the lower the ownership

concentration, the lower the R&D investment, and argued that ownership concentration effectively alleviates the agency and contracting costs associated with innovation. In a related study, Stein (1989) stated that the problem of a lack of R&D investment can be reduced through appropriate ownership concentration, and a long-term horizon has a positive impact on R&D investment. Baysinger et al. (1991) found that equity concentrations among institutional investors have positive effects on corporate R&D strategy, and Lee's (2012) study produced similar results. On the other hand, Morck et al. (2000) reported that concentrated ownership has a negative effect on R&D intensity. They suggested that concentrated ownership may result in little net advantage from R&D expenditure as the owners control multiple firms. Thus, the results in the existing literature are inconclusive. In this regard, Lee (2012) observed that the results may vary due to the risk attitudes and time horizons of large shareholders. Therefore, Shleifer and Vishny (1988) emphasised that a certain degree of concentration may impact favourably on innovation activities.

3.5.11 Foreign ownership

Empirical research has produced mixed results regarding the relationship between foreign ownership and R&D investment. Foreign ownership may induce a firm to undertake R&D if knowledge from the parent needs to be adapted to local conditions or if specific projects require collaboration with the foreign owner (UNCTAD, 2003). However, Pamukcu and Utku-Ismihan (2009) have claimed that large MNEs usually undertake innovative activities at their home base; only rarely do they engage in innovative activities in the host country. Studies by Veugelers and Houte (1990), Un and Cazurra (2008), Zemplinerova and Hromadkova (2012) and Kalayci (2013) have also found that foreign-owned firms rely on knowledge generated by their parent firms, and thus carry out little R&D in the host country, resulting in a significantly depressing effect of foreign ownership on R&D investment. Since the recent financial crisis adversely affected most developed countries

(Velde, 2008), it decreased the attractiveness of investment in developed countries due to probable losses from such investments. Thus, foreign investors may have shifted more of their investments to emerging markets to earn greater profits. Moreover, foreign investors may be willing to take the opportunity of short-term gains such as dividends over long-term gains through R&D investments in emerging markets. As a result, firms in emerging markets have sufficient resources to invest in R&D even during an economic slowdown. In addition, low-cost innovation in emerging markets may attract foreign investment. Thus, further research is required to examine the association between foreign ownership and R&D in emerging markets.

3.5.12 Institutional ownership

Graves (1988) examined the relationship between institutional ownership and R&D spending and found a significant negative association between them. He stated that institutional owners are reluctant to invest in R&D because their emphasis is on short-term results as opposed to more profitable long-term investments in R&D. Graves (1990) later studied the same topic from a multi-industry perspective, assuming that institutional ownership has a limited effect on R&D expenditure and the effect varies by firms. His findings revealed that aerospace, drug and pharmaceutical industries show a positive relationship, chemical and computer industries show an insignificant positive relationship, and soap and detergent industries show an insignificant negative relationship with institutional ownership. However, Hansen and Hill (1991) observed that, after controlling for intervening effects, a higher level of institutional ownership is associated with greater R&D expenditure. They explained that this positive relationship arises because institutional owners' decisions are long-term oriented and they are effectively locked into their stockholdings. As the existing literature has shown inconclusive results, there is a need to examine the role of institutional ownership in R&D in emerging markets.

3.5.13 Human capital

According to human capital theory, human capital is the stock of knowledge, skills and competencies, which are the main drivers of R&D activity. Owing to their scientific nature, formal R&D activities are human-capital intensive (Bebczuk, 2002). Human capital injects higher skills and knowledge into an organisation, which is positive for the realisation of R&D activities (Kriaa and Karray, 2010). As firms grow larger and chains of command become increasingly stretched, the presence of talented individuals who can effectively communicate ideas and results may make the difference between a company's R&D performance and that of its opposition (Liu, 2011). Similarly, the innovativeness of a company may attract creative employees, and help to increase productivity and reduce staff turnover (Kyrgidou and Spyropoulou, 2013). Therefore, it is assumed that human capital positively impacts on R&D investment. Empirical studies such as those by Tan and Hwang (2002), Galende and Fuente (2003), Cheng and Chen (2006), Mishra (2007) and Kriaa and Karray (2010) have also documented a positive relationship between human capital and R&D investment. However, in order to handle risky and uncertain investments such as R&D, firms need skilled employees. Kriaa and Karray (2010) have argued that innovating firms have lower rates of skilled employees in R&D. As a result, Negassi (2004) and Kriaa and Karray (2010) found no relationship between human capital and R&D investment. Thus, the existing literature has been inconclusive in defining the relationship between human capital and R&D investment.

3.5.14 Wages

In general, owing to the unavailability of educational background data, wages are used to measure the skills and capacity of employees in a firm. Lall (1983) argued that greater skills enhance the absorptive capacity of R&D. However, Tan and Hwang (2002) pointed out that absorptive capacity may rest mainly in the most skilled employees, rather than in the general workforce. Dijk et al. (1997) stated that higher wages result in more skilled

employees. Their results show that higher wages are significantly related to R&D spending for small firms, but are insignificant for large firms. Owing to increased competition, firms in advanced countries and MNEs offer higher wages for skilled employees, who may take advantage of such opportunities. As a result, firms in emerging markets may suffer from a lack of skilled employees for innovation. Lall's (1983) study, based on the emerging market of India, found a negative relationship between wages and R&D investment, while and Tan and Hwang's (2002) study, based on the Taiwanese electric industry, found no relationship between the two. Thus, the existing literature has been inconclusive regarding the relationship between wages and R&D spending.

3.5.15 Patents

Invention motivation theory explains that anticipation of patents provides motivation for useful inventions. Moreover, according to the theory of inducing commercialisation, patents on inventions attract the investment required to develop and commercialise those inventions. Patents allow the innovator to produce a particular product and ensure monopoly power over the market, thus increasing its profits and creating additional incentives for investment in R&D (Mukherjee, 2005). Wang (2010) argued that the strength of patents increases the market share of the owners of new goods (or processes) and prohibits the entrance of imitators; hence, producers invest in R&D in order to cover a larger market. Thus, the greater a firm's belief that it will obtain a patent protecting the results of its R&D investment, the more the firm will be willing to spend on R&D (Cumming and Macintosh, 2000). As a result, Grabowski (1968) found a significant positive influence of patents on R&D investment, and Gilbert and Shapiro (1990) and Klemperer (1990) reached the same conclusion, although the relationship between patents and R&D may change where patent protection is less strong. Allred and Park (2007), for instance, found no significant impact of patent strength on R&D in emerging economies. Moreover, the cost of patents may play a role in this relationship. Almedia and Teixiera

(2007) have argued that making patents easier to obtain may actually cause a decline in R&D expenditure. In this sense, raising patent costs and standards may stimulate R&D. Therefore, this inconclusive relationship requires further examination based on emerging markets.

3.5.16 Dividends

In imperfect markets such as emerging markets, the relationship between financial policy and R&D is measured through dividend policies (Gaffard and Salies, 2010). The funds flow identity framework considers dividend payments as one element in a global system of interacting financial decisions made by firms. Dividend payments represent the future growth of firms, signalling future increases in profitability to investors (Hughes, 2008). Tax relief on dividends encourages the payment of high dividends, which discourages R&D investment, regardless of the tax regime (Thomas et al., 2003), since it may restrict internal cash flows for R&D investment. Under a residual dividend policy, investment policy is considered to be the only determinant of firm value. In this case, companies decide first on the optimal investments necessary to grow and to maximise shareholder wealth; then, depending on the availability of funds, they set the level of dividends (Lasfer, 2002). Under an independent dividend policy framework, dividends are the prime consideration and investments in R&D are adjusted accordingly. Moreover, dividend cuts may help finance R&D investments if firms are reluctant to issue risky securities because of information asymmetry or high transaction costs. As a result, there is a negative relationship between dividends and R&D investment (Lee and Hwang, 2003). Thus, the relationship between dividends and R&D spending is straightforward in the existing literature.

Similarly to firm-level factors, R&D investment is also influenced by the macroeconomic conditions of a country, including GDP growth, exports, FDI, patents, trade openness, interest rates, tax credits and government subsidies. The next section will discuss the

relationship between macroeconomic conditions and R&D investment in emerging markets.

3.6 Macroeconomic determinants of R&D expenditure

A growing body of literature has examined the macroeconomic determinants of R&D expenditure (Becker and Pain, 2008; Wang, 2010; Sameti et al., 2010; Guloglu et al., 2012). The existing literature has considered factors such as GDP growth, patents, exports, FDI and trade openness as the main determinants of a country's R&D investment.

3.6.1 GDP growth

Baumol and Wolff (1983) investigated the relationship between the rate of productivity growth and the level of R&D investment. They stated that productivity growth may affect R&D in two ways: first, productivity affects the quantity of resources available for investment in general and R&D investment in particular; second, it affects the output price, and hence the cost of R&D relative to output price. Similarly, based on a study of 30 OECD countries for the period 1996-2008, Sameti et al. (2010) documented that GDP growth has a positive impact on R&D investment. They found that a 10 per cent increase in GDP growth results in a 1.1 per cent increase in R&D intensity. However, from a study of 26 OECD countries using extreme-bounds analysis (EBA) for the period 1996-2006, Wang (2010) found that GDP growth is a fragile determinant of R&D investment. The reason for this is that the R&D investment targets of OECD countries are set by governments or other international organisations, and are not determined by GDP growth. This study took no account of the emerging market context. As emerging markets are growing faster than developed and OECD countries, it is expected that growth will contribute to their innovative activities. While economic growth has an impact on R&D investment, the existing literature has also shown the opposite effect.

Silaghi et al. (2014) used a dynamic panel data model of generalised method of moments (GMM) estimation for the period 1998-2008 to examine the impact of R&D on economic growth. They found that a one per cent increase in business R&D investment boosted economic growth in ten Central and Eastern European countries by 0.050 per cent over the short run and by 0.213 per cent over the long run. In contrast, Akinwale et al. (2012) investigated the impact of R&D and innovation on economic growth based on the emerging market of Nigeria using a least squares method for the period 1977-2007. They documented that gross expenditure on R&D (GERD) has a significant negative impact on economic growth, and argued that weak institutions, high corruption, low interaction between academics and industry and uncorrelated industrial clusters, among other factors, are reasons for this relationship. In this regard, Pessoa (2010), following Jones and Williams (1998), suggested that the precise relationship between R&D and economic growth differs from country to country, and that country-specific factors, rather than innovation policy alone, are crucial to the link between R&D and economic growth.

3.6.2 Exports

Existing research has found an inconclusive relationship between exports and R&D investment. Guloglu et al.'s (2012) study, based on G7 countries, showed that high-technology exports enhance technological change. Similarly, Bratti and Felice (2012) used an IV approach based on Italian manufacturing firms to investigate the effect of a firm's export status on the likelihood of it introducing product innovations. They found a significant correlation between the two, derived from learning from their export strategy. In contrast, Damijan et al. (2010) separated their sample into process and product innovation-driven firms, and documented that export status has an impact on the former, but not on the latter. Lin and Tang (2013) found that exporting firms increase their R&D intensity by more than five per cent, raise their R&D investment by more than 33 per cent, and are four per cent more likely to engage in R&D activity than non-exporting firms in

China. They also documented that exporting has a smaller impact on innovation in firms that export processed goods, specifically those in the electronics sector, located in coastal provinces and foreign-owned. Similarly, Kumar and Saqib (1996) reported from a study of Indian manufacturing firms that export orientation influences R&D investment. However, due to variations in the industry, export performance may contribute differently to R&D. For example, in research also on India but using a sample of 100 engineering firms in 1978, Lall (1983) found that exports are negatively related to R&D investment. He argued that greater international orientation seems to produce lower technology effort in the sample firms.

3.6.3 Trade openness

Varsakelis (2001) found no relationship between trade openness, indicated by the black-market premium, and R&D investment intensity in 50 countries. Cross-industry analysis may be a cause of this result. Similarly, based on 88 countries for the period 1980-1990, Bebczuk (2002) found that trade openness has a negative impact on R&D investment, but this effect is mitigated as per capita GDP and trade with OECD countries increase. International trade in technology-intensive goods reduces duplications in R&D efforts, and cross-border technology inflows act as a substitute for domestic R&D. Meanwhile, Wu et al.'s (2007) study, based on nine OECD countries for the period 1985-1995, documented modest empirical support for a positive impact of trade openness on business R&D investment. Trade openness works as a channel of knowledge and rent spill-over, as well as an extension of the market; thus, it matters for private R&D investment. They found that a 10 per cent increase in trade openness results in an approximately seven per cent increase in business R&D investment. Rather than studying business R&D, Hammadou's (2014) study revealed that trade openness also affects public R&D, based on 14 European countries between 1994 and 2006. Similarly, Yang and Lin's (2012) research, based on Chinese provincial-level panel data over the period 1997-2007, found that trade openness,

in terms of FDI and high-technology exports, has a positive impact on regional innovation due to the effect of knowledge spill-overs. This inconclusive relationship between R&D and trade openness requires further examination based on emerging markets.

3.6.4 Foreign direct investment (FDI)

The existing literature has shown a relationship between FDI and R&D investment. FDI may impact on innovation by developing manufacturing capability, increasing competition and improving firm performance (Bertschek, 1995; Hsu and Chen, 2009). In an empirical study based on G7 countries, Guloglu et al. (2012) documented that FDI inflows are a determinant of innovation. However, the effect of FDI on innovation has changed over time in emerging markets. Kathuria's (2008) study of Indian small and medium-sized high-tech firms, using Probit and Tobit models, analysed the impact of FDI inflows on R&D investment in the country's post-reform period. He found that, in the initial period after 1991, increased FDI inflows had a negative impact on domestic R&D, whereas in the later period, the impact was not significant, indicating that firms' expectations changed as a result of the reforms. At the beginning, the reforms may have caught firms off guard, thereby affecting their R&D investment. The second round of reforms, which started around 1997, increased the pace and scope of inward investment. In a later paper, Sasidharan and Kathuria (2011) examined FDI and R&D investment by 1,843 Indian manufacturing firms after the reform using a Heckman two-step procedure, and found, when their sample was separated on the basis of equity ownership, that FDI and R&D complement each other. Using Tobit IV and the linear GMM method based on Chinese enterprises for the period 1999-2005,Girma et al. (2008) found that sectoral-level inward FDI is positively related to domestic innovative activity only among firms that engage in their own R&D activities (that is, have some absorptive capacity) or have good access to domestic finance. Similar results were obtained by Bertschek (1995). Thus, from the existing literature, it can be assumed that FDI has an impact on R&D.

3.6.5 Patents

The relationship between patents and R&D is bidirectional. Countries with a strong patent framework invest more in R&D (Varsakelis, 2001). Thus, according to the OECD (1997), patents have traditionally been considered as one of the main incentives for R&D. However, Wang (2012), following Encaoua and Guellec (2006), has reported that patent protection does not appear to be an effective way to promote R&D because patenting may stem the free flow of knowledge across firms' boundaries (Bhaskarabhatla and Hegde, 2014). Nevertheless, in an empirical study, Allred and Park (2007a) found a positive impact of patents on innovation, and suggested that countries use patents to encourage, protect and reward innovation. However, the impact of patents on R&D is not straightforward, but may depend on countries' levels of financial and legal development. In a later paper, Allred and Park (2007b) separated their sample into developed and developing countries. They documented that for developing countries, patent strength negatively affects domestic patent filings and insignificantly affects R&D and foreign filings, while for developed countries, patent strength positively affects domestic patent filings and R&D and negatively affects foreign patent filings. They argued that global patent protection standards may not be conducive to developing-country innovation systems based largely on incremental, adaptive and imitative research. Pazderka (1999) investigated the impact of intellectual property rights on Canadian pharmaceutical firms' R&D investment after two legislative patent protection steps taken in 1987 and 1992. He found that, as a result of tightening patent protection, R&D investment increased after 1987.

On the other hand, the reverse causality of R&D investment to patents was confirmed by Baraldi et al. (2014), who applied a Granger causality test. Similarly, studies by Grilichies (1988) and Beneito (2006) have documented that R&D investment has an impact on patents. Generally, patents are considered as an output of R&D investment. As a result, the

greater the R&D activity in a country, the greater the number of patents. Although there is a direct relationship between R&D and patents, it takes time for R&D projects to succeed. Kondo's (1999) study of Japanese industries over the period 1970-1980 found that R&D investment created patent applications with a time lag of about a year and a half, both directly and through technology stock. Prodan (2005), following Kondo (1999), tested whether the number of patent applications is dependent on R&D investment, based on OECD and Central European countries for the period 1981-2001. He showed that there is a strong positive correlation between R&D investment and a country's number of patent applications, and that R&D investment creates patent applications with a time lag, but this varies from country to country. Based on a study of OECD countries using dynamic panel data, Kumazawa and Gomis-Porqueras (2012) found that domestic R&D per capita increases domestic patents per capita only for European Patent Convention (EPC) countries that have decentralised approaches to innovation. Thus, the existing literature has shown a bi-directional relationship between a country's R&D investment and patent applications.

3.6.7 Financial crisis

Most of the empirical literature examining the effects of financial crisis on innovation has concluded that it has a negative effect on R&D expenditure. Consistent with cyclical theory, Correa and Lootty (2011) stated that this is firstly because R&D investment is financed from internal funds, which contract in a crisis, and secondly because of the credit constraints of funding authorities. However, Barlevy (2007) reported that even relatively financially-unconstrained firms reduced their R&D investment during the recent crisis, whereas firms with no credit constraints were less likely to abandon innovation projects (Paunov, 2012). Using the latest three waves of UK Community Innovation Survey (CIS) panel data, Archibugi et al. (2013b) documented that fast-growing new firms and firms that were already highly innovative before the crisis also invested in innovation during the

crisis. Results from the OECD (2009, 2012) and Archibugi et al. (2013a) support the cyclical theoretical argument, finding that firms reduced their investment in innovation and R&D during the financial crisis. Similarly, Paunov (2012) found that, on average, one in four firms reduced their innovation projects during the financial crisis. Therefore, it is assumed that when emerging markets are affected by a financial crisis (Didier et al., 2011), they reduce their R&D activities.

3.6.8 Market size

Although much of the literature has shown a relationship between firm size and R&D investment, very few studies have examined market size and R&D investment. According to Acemoglu and Linn (2004), large market size has an impact on innovation. Their study, based on the US pharmaceutical industry, revealed that a one per cent increase in market size led to a four per cent increase in non-generic drugs and new molecular entities. Based on the same industry, Cerda's (2007) study found that continuous increases in population and market size during the second half of the twentieth century played a fundamental role in explaining the large-scale creation of new drugs. Both studies found a significant impact of market size on new drug introduction. Using a GMM method for OECD and non-OECD countries, Ulku (2004) concluded that OECD countries with larger markets, including the G7, Australia, the Netherlands, Spain and Switzerland, are able to increase their innovation by investing in R&D. Thus, following Acemoglu and Linn (2004), he argued that market size is an important factor in the effectiveness of R&D. Desmet and Parente (2010) found a positive relationship between market size and R&D investment, following the proposition that larger markets increase competition and facilitate process innovation. Moreover, larger markets have larger populations and more trade openness, and support a wider variety of goods, resulting in a more crowded product space.

3.6.9 Interest rates

Relatively little empirical literature to date has shown a relationship between interest rates and R&D expenditure. Becker and Pain (2008) tested the industry characteristics and macroeconomic factors that influence R&D expenditure, and found that real interest rates have a significant negative impact on the level of R&D expenditure. They documented that, with a rise of one percentage point in the real interest rate, it is possible to decrease R&D expenditure by 12.5 percent. They also discovered that the marginal effect of real interest on levels of R&D expenditure is between -0.12 and -0.13. They argued that the long payback period of some projects and the continuous rise in sterling since 1996 may have had a negative impact on levels of R&D expenditure. They also pointed out that a rise in interest rates may reduce outputs, raise external competition and put financial pressure on firms. They applied a panel data model to 11 broad manufacturing industry groups in the UK over the period 1993-2000.

3.6.10 Market competition

Market competition is important in explaining a country's R&D spending and productivity (OECD, 2002b). In order to counter increased competition and defend market share, firms invest strategically in R&D (Becker and Pain, 2008). Moreover, fierce competition may increase R&D investment, particularly if the survival of a firm and its management are at risk (IMF, 2002). On the other hand, firms that already have market power are less able to extract benefit from R&D investment; therefore, greater competition reduces incentives for R&D activities (Becker and Pain, 2008). Similarly, greater competition may reduce R&D investment and firms' ability to profit from innovation (IMF, 2002). Moreover, Ayyagari et al. (2011) observed that greater competition decreases a firm's freedom to deviate from efficient R&D investment policies. As a result, empirical results for the relationship between competition and R&D investment have been inconclusive. Geroski (1990), Blundell et al. (1999) and Becker and Pain (2008) found a positive relationship between

market competition and R&D investment, while Spence (1984) and Vives (2004) found a negative relationship between the two. In contrast, more realistic results were obtained by Aghion et al. (2005), who found a U-shaped association between competition and R&D. Using unbalanced panel data based on the UK, they found that competition discourages laggard firms from R&D but encourages competitive firms to engage in R&D activities. The combined effects of competition and the equilibrium of industry structure generate an inverted-U.

3.6.11 Government subsidies

Government subsidies provide firms with absorptive capacity, which can be used to acquire external knowledge or to generate new products or processes, increasing the productivity of firms' R&D (Kriaa and Karray, 2010). Thus, subsidies encourage R&D activities in firms. Empirical studies, such as those by Branstetter and Sakakibara (2002) and Lin and Lin (2012), have also found a positive association between government subsidies and R&D investment. Becker and Pain (2008) observed that a one per cent increase in government subsidies is associated with an increase of 1.8 per cent in R&D spending. The main idea behind firm-level R&D subsidies is that social returns on R&D due to positive spill-over effects are higher than private returns, and thus governmental support for business R&D is justified (Arrow, 1962). Government subsidies for innovation are especially necessary during a period of financial crisis in order to maintain national innovation capability and employment levels (Hud and Hussinger, 2015). Moreover, subsidies may help recovery from a recession by fostering innovation, leading to national growth (Hud and Hussinger, 2015). However, Mamuneas and Nadiri (1996) claimed that, owing to a crowding out effect, higher levels of government subsidies may sometimes reduce private R&D. Lee and Hwang (2003) added that there may be a negative effect, since the moral hazard and burden of a result-sharing agreement as a result of a subsidy may result in disincentives to conduct R&D activities. However, evidence for this has

varied (Lach, 2002). For example, according to Guellec and Potterie (1997), subsidies have long-term effects on R&D investment. Thus, the existing literature has shown an ambiguous relationship between government subsidies and R&D investment.

3.6.12 Tax credits

Countries generally have tax relief rules to encourage R&D investment. Bloom et al. (2002) noted that tax credits vary across types of asset, country and time. Germany and the UK do not give any substantial, generally-available tax incentives for R&D. Japan is in an intermediate position. France gives more generous tax credits, but also caps the total amount of credit that can be claimed. However, Bloom et al.'s (2002) study showed a positive relationship between tax credit and R&D investment. R&D-related tax subsidies increase with a firm's marginal tax rate, helping the development of new production processes and, to some extent, the development of new products; thus, there is a positive relationship between tax credits and R&D investment (Cappelen et al., 2012). However, according to Guellec and Potterie (1997), tax credits have only short-term effects on R&D investment. Higher future corporate tax rates (compared with current tax rates) may provide a disincentive to invest (Bhagat and Welch, 1995). Castellacci and Lie (2015) added that sector affects the influence of tax credits on R&D spending. They found that tax credits have, on average, a stronger impact on R&D spending for SMEs and firms in service and low-tech sectors with an increment scheme. Therefore, this inconclusive relationship between tax credits and R&D requires observation in the emerging market context.

In addition to the above factors, other factors that impact on country-level R&D investment include the proportion of scientific researchers (Wang, 2010), import volumes (Potterie and Lichtenberg, 2001), real exchange rates (Becker and Pain, 2008) and national culture (Varsakelis, 2001). Although these economic factors impact on R&D investment, institutional factors also play an important role in a country's R&D investment.

3.7 Institutional determinants of R&D investment

The institutional environment may stimulate R&D activity by providing resources beyond the capacity of an individual firm (Wu et al., 2016). For example, a weak institutional environment signals low investor confidence and indicates an investment risk. In such an environment, managers are likely to undertake only riskier projects with high expected future profits (Cherchye and Verriest, 2016). Thus, Srholec (2011) stated that attributes of firms as well as the framework conditions within which they operate have an effect on innovation. Legal, political and social factors in the institutional environment function as a base or framework for investment.

3.7.1 Political system

According to political theory, the political environment has a significant influence on a country's investment. Wan and Hoskisson (2003) stated that the political system is a foundation for business transactions. One important reason is that FDI depends heavily on the political situation of a country. Thus, Henisz (2002) observed that a favourable political environment is crucial to financial and technical progress and conducive to infrastructural development, particularly in R&D activities. In connection with this, Varsakelis (2006) examined the impact of political institutions on national innovation systems in 29 countries for the period 1995-2000. His random-effect panel data model showed that improving civil and political rights results in more productive national innovation systems. Similarly, Allard et al. (2012) concluded that political instability impacts negatively on a country's innovation systems. They argued that political instability creates a barrier to firm-level R&D spending and reduces the quality of scientific institutions. They applied seemingly unrelated regression (SUR) to data from 107 countries, including both developing and developed nations, over the period 2000-2005. The relationship between the political environment and R&D appears straightforward, but there is little evidence from an

emerging-market perspective, where political systems are weaker than those of developed countries.

3.7.2 Legal system

Rule of law measures the judicial strength of a country (Wan and Hoskisson, 2003). A sound legal environment ensures the likelihood of safe investments. Pindado et al. (2015) pointed out that strong legal systems ensure greater investor protection, and that the more effective is investor protection, the higher the market valuation of R&D. They argued that the characteristics and enforcement of laws play important roles in decisions to undertake R&D projects. Moreover, La Porta et al. (1997) found that strong legal systems help firms to access external finance to support strategic investments such as R&D. Greif (1993) and Wan and Hoskisson (2003) stated that a favourable legal environment helps firms to engage in complex transactions with anonymous parties, which facilitates productivity. Thus, Hiller et al. (2011) reported that effective legal protection facilitates R&D investment. On the other hand, a weak legal environment may increase investment risk. Hiller et al. (2011) separated their sample between countries with common law and those with civil law and found that R&D in common-law countries is less sensitive to cash flow fluctuations than in civil-law countries because the legal systems of the former mitigate asymmetric information more effectively. Similarly, in a recent analysis, Anderlini et al. (2013) compared rigid and flexible legal systems in their ability to keep pace with technological development. They found that rigid legal systems are preferable, in terms of welfare and rate of output growth, at the early stage of innovation. Although the overall legal system has an impact on R&D investment, it may vary according to common or civil law, or a rigid or flexible legal system.

3.7.3 Education system

Varsakelis (2006) examined the impact of education system quality on innovation productivity based on panel data for 29 countries and found that the quality and orientation

of a country's education system impacts on innovative productivity. He argued that education systems create a pool of high-quality human resources, as well as high-quality demand for outputs of the innovation process. Moreover, a good education system makes society aware of new technologies to improve growth opportunities. A similar argument has been made by Baptista et al. (2011), who have argued that the presence of higher education institutions is highly related to the number of technological entrepreneurs. Using a policy evaluation methodology and panel data for the period 1992-2002, they found that the establishment of higher education institutions has a positive and significant impact on subsequent levels of knowledge-based firms in municipalities, but is negatively related to other sectors such as low-tech manufacturing. Studies by Furman et al. (2002) and Lundvall et al. (2002) have also reached the conclusion that there is a positive correlation between education and innovation. This relationship needs to be checked in the emerging market context.

3.7.4 Financial system

Tylecote (2007) argued that availability of finance impacts on firms' activities, and financial systems are central actors in national systems of innovation. However, availability of finance depends mainly on financial institutions that have authority to make decisions regarding which firms should be given resources to innovate (Schumpeter, 1996). Thus, Beck and Levine (2002) observed that greater availability of finance is correlated with the financial development of a country. Consistent with this, Pindado et al. (2015) suggested that better financial institutions mitigate market imperfections, and consequently reduce financing costs, thus facilitating innovation. Using a GMM estimation of panel data for Europe, the US and Japan over the period 1986-2003, they found that more highly financially-developed countries impact positively on R&D investment than less financially-developed countries. Using the same methodology for 32 developed and emerging markets, Hsu et al. (2014) have reported that equity market development is

positively related to innovation, while credit market development discourages innovation. The relationship between bank-based and market-based systems and innovation in emerging markets requires further investigation.

3.7.5 Corruption

Corruption increases the cost of investment, because investors must pay bribes to officials to obtain permits and licences (Daude and Stein, 2007). Thus, corruption has adverse effects on investment and growth (Bardhan, 1997). On the other hand, controlling corruption may impact positively on innovation. Veracierto (2008) documented that detecting corruption or making small reductions in corruption by introducing penalties may result in large increases in R&D investment. Using panel data for 64 countries, Anokhin and Schulze (2009) obtained similar results. Mauro (1995) found that, for one standard deviation increase in control of corruption, there is a probability that investment will increase by 2.9 percent of GDP. This means that controlling corruption enables firms to increase their R&D investment. However, taking a slightly different focus, Shleifer and Vishny (1993) suggested that corrupt firms use high technologies, even though they are not essential. This implies that R&D activities seem large only due to the presence of corruption (Mahagaonkar, 2009). Although the existing literature has shown an inconclusive relationship between corruption and R&D investment, as emerging market firms suffer from this problem, it is expected that there is a negative relationship between them.

3.7.6 Government effectiveness

Government effectiveness and quality of regulation are an essential part of a strong institutional environment (Williams and Martinez, 2012). High government effectiveness reduces the likelihood of uncertainty of return from risky investments such as R&D. Moreover, fiscal policies set out by the government provide internal incentives to the firm and promote entrepreneurial activities (Jiao et al., 2015). In addition, Mahmood and Rufin

(2005) have stated that an active role played by government accelerates technological innovation as a result of spill-overs creating networks between firms and individuals. Williams and Martinez (2012) added that government effectiveness affects firms' international strategies positively. Therefore, it is assumed that a more effective government will result in more innovative activities, more international trade and growth. Varsakelis (2006) suggested that effective governance may improve a country's R&D productivity, leading to improved growth prospects. He also found that innovative activities increase with the level of government efficiency. Jiao et al. (2015) also concluded that government effectiveness impacts positively on R&D investment in an emerging market. Therefore, this hypothesis needs to be examined with respect to other emerging markets.

3.7.7 Regulatory quality

Regulatory quality is considered to be another important institutional component. Djankov et al. (2002) suggested that strict entry regulations are detrimental to firm performance. In a later paper (Djankov et al., 2006), they found that good and efficient business regulations promote growth. In addition, Jalilian et al.'s (2007) study, based on data from 117 countries, suggested a strong causality between regulatory quality and economic performance. This implies that regulatory quality is important for growth and performance. Mahendra et al. (2015) examined the impact of the quality of local regulation on innovation and found that regulatory quality and access to finance impact positively on innovation. They also reported that regulatory quality varies across different sizes of firm, and that it is more relevant to large firms. Blind (2013) reported from a study of 21 OECD countries that social, economic and institutional regulations have different impacts on innovation. This relationship may vary in emerging markets, due to variation in regulatory quality. Therefore, the association between regulatory quality and R&D spending needs to be examined in the context of emerging markets.

3.8 R&D and firm performance

Growing attention has been given in the literature to the relationship between R&D and firm performance. This section reviews the literature on R&D investment in terms of firm performance, investor protection (safeguards) and country-level governance (systems).

3.8.1 R&D and firm performance

The resource-based view was developed by Wernerfelt (1984). RBV stresses that heterogeneous internal resources and capabilities (Barney, 1991) determine a firm's performance (Barney, 1991; Teece et al., 1997). Resources that are valuable, rare, inimitable and non-substitutable may create competitive advantage (Wright et al., 1994). Capabilities are defined as clusters of activities that a firm does especially well in comparison with others. They allow firms to create new markets and add value for the customer (Henry, 2007). Canto and Gonzalez (1999) confirmed the relevant role of resources and capabilities in R&D activities. Empirical studies such as those by Ehie and Olibe (2010) and Hasmi and Stojcic (2013) have found that investment in R&D activities has a significant positive impact on firm performance because it ensures the introduction of new products and processes, resulting in increased market share and productivity through technological progress (Coad et al., 2016.) On the other hand, substandard performance stimulates R&D investment (Bolton, 1993) to improve performance and reputation and gain market position. Thus, there is a direct relationship between R&D and firm performance.

However, the measurement of firm performance is multifaceted, using indicators such as sales growth, profitability and productivity. Regarding sales growth, Morbey (1988) found a strong correlation between R&D intensity and subsequent sales growth. Morbey and Reithner (1990) re-examined the influence of R&D on sales, and their results fully supported those obtained from earlier studies. Sales growth may be achieved through the introduction of new and improved products or processes, or by improving the company's

competitive position with a mature or declining product. Morbey (1988) also showed a stronger correlation between R&D investment and sales growth as the growth period lengthens, with a 0.46 correlation co-efficient between initial R&D intensity and sales growth over a five-year period (1976-1981), and 0.57 over a 10-year period (1976-1985). Garcia-Manjon and Romero-Merino (2012) have added further evidence that this correlation is more intense in high-technology firms than in low-technology firms, because the latter do not obtain clear market responses to their R&D efforts.

However, Del Monte and Papagni (2003, p.1006) argued that, "There are many reasons why it is not easy to find such a relationship empirical [*sic*]." A study by Booz Allen Hamilton (BAH) of the 1,000 public firms around the world that spent most on R&D in 2004 reported that there is no relationship between R&D spending and sales growth (Jaruzelski et al., 2005). However, the same study showed that spending too little on R&D may harm firm performance. According to Jaruzelski et al. (2005), when a firm is seeking to grow through innovation, it is more important to develop a robust business model and good cross-functional capabilities than to boost the R&D budget.

Innovation has direct and indirect impacts on firm profitability (Geroski et al., 1993). Innovation directly affects profitability through the development of new products or the introduction of new processes, and impacts indirectly on how firms generate profits, because it signals the transformation of a firm's internal capabilities associated with the process of innovating. Hanel and St-Pierre (2002) added that R&D has a direct, positive effect on profitability, especially in industries with effective patent protection. Patent protection and other barriers to rapid imitation permit firms to enjoy significant temporary monopolies on inventions (Scherer, 1965). Moreover, Johansson and Loof's (2008) study of Swedish manufacturing firms for the period 2002-2004 revealed that a continuous strategy of R&D is associated with more than 40 percent greater profitability than for non-R&D firms. In addition, Lev and Sougiannis (1996), Hanel and St-Pierre (2002) and

Eberhart et al. (2004) documented a positive relationship between R&D and profitability. Karjalainen (2008) suggested that widespread information leakage, availability of equity financing and active corporate control strengthen the relationship between R&D expenditure and future firm profitability.

However, Morbey's (1988) study suggested that the relationship between R&D expenditure and profitability is weak. He claimed that economic climate and market competitiveness may contribute to profitability. Morbey and Reither (1990) re-examined the relationship between R&D and profitability, using data from 134 firms in the US, and did not find any direct relationship. This is consistent with the analyses of Scherer (1965) and Wagner (1984), although they found a positive relationship between R&D expenditure per employee and profitability. Thus, they described the relationship between R&D intensity and profitability as "complex", arguing that this relationship is influenced and dominated by firm productivity. On the other hand, Parcharidis and Varsakelis (2007) provided mixed results based on Greek data, and found that R&D investment impacts negatively on profit in the year of the investment but, similarly to Natasha and Hutagaol's (2009) Indonesian study, they showed a strong positive relationship two years later. They argued that new product development, new production methods and information technology need time to produce results.

With regard to productivity, Griliches (1979) first introduced a model that described the relationship between innovation and the knowledge production function. The model assumed that production of new knowledge depends on investment in current and past new knowledge (i.e. current and past R&D investment), as well as some other factors, including capital and labour (Johansson and Loof, 2008). Guellec and Potterei (2004) argued that R&D expenditure results in new goods and services, higher quality of output and new production processes, which are sources of productivity growth. Guellec and Potterie (2001) analysed 16 OECD countries using panel data for 1980-1998 and found that a one

percent increase in R&D investment produces a 0.13 percent increase in productivity growth. Using panel data for the period 1965-2005, Bravo-Ortega and Marin (2011) estimated that a ten per cent increase in R&D per capita generates an average increase of about 1.6 per cent in long-run TFP.

However, the relationship between R&D investment and productivity is mixed in emerging markets. Lee and Kang's (2007) study of Korean manufacturing firms found a positive relationship between innovation and productivity growth. Jefersson et al. (2006) and Liu et al. (2013) obtained similar results based on Chinese and Taiwanese data respectively. Crespi and Zuniga (2010) examined six Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama and Uruguay) using micro-data from an innovation survey and found that firms that innovate have higher labour productivity than those that do not. However, Benavente (2006), based on Chile, and Perez et al. (2005, cited in Crespi and Zuniga, 2010), based on Mexico, found no relationship between the two. Hall and Mairsee (2006, cited in Crespi and Zuniga, 2010) argued that this is because emerging markets may reflect different circumstances surrounding innovation. Moreover, Acemoglu et al. (2006) stated that emerging countries are too far from the technological frontier, and incentives to invest in R&D are weak or absent.

The existing literature has provided inconclusive results for the impact of R&D on firm performance, whether considered in terms of sales, profit or productivity. According to Zhu and Huang (2012), the first reason for these inconclusive results is that some researchers have tested the relationship between R&D and performance in the same year as the investment, but R&D investment takes time to show results (Natasha and Hutagaol, 2009), so such a model may undervalue the contribution of R&D. Secondly, most researchers have focused on manufacturing firms, but R&D activity may have different impacts on firm performance across different types of industry. Existing research has paid little attention to this difference. Thirdly, and perhaps most importantly, R&D reporting is

not mandatory for all countries. Moreover, some countries treat it as an expense and show it in the profit and loss account, whereas others treat it as capital, which is shown on the balance sheet.

3.8.2 Investor protection (safeguards)

Defond and Hung (2004) observed that investor protection fosters good governance, which, in turn, increases investor confidence. When investor rights are protected, external investors and entrepreneurs are willing to pay more for financial assets such as debt and equity, leading to financial development (La Porta et al., 2002). Similarly, Volpin (2002) suggested that stronger investor protection reduces the risk of expropriation, allows separation of ownership and control, and increases growth. Thus, investor protection has an influence on firm performance. Moreover, firm-level strategic decisions, such as R&D investments, are also influenced by investor protection. McLean et al. (2012) examined a sample of 44 countries over the period 1990-2007 and found that investor protection plays a role in the relationship between investment and financial activities. They found that the relationship between investment and Tobin's q and cash flow becomes stronger when a country has strong investor protection, and contended that investor protection reduces firms' financial constraints and enables them to access external finance. Supporting this theoretical argument, Brown et al. (2013) found that firms in countries with stronger investor protection use significantly more external finance, and therefore make significant investments in R&D activities. Their analysis was based on data from 5,300 firms across 32 countries over the period 1990-2007. Moreover, the OECD (2000) reported that R&D investment, R&D personnel and patents tend to rise with investor protection. Stronger investor protection reduces managers' opportunistic behaviour in diverting cash flows to themselves; therefore, more resources are employed in value-enhancing capital projects such as R&D (Ghosh and He, 2015).

In addition, stronger investor protection is related to better capital allocation efficiency (Wurgler, 2000), which ensures sufficient investment in R&D activities. Xiao (2013) observed that investor protection is an effective tool to improve the efficiency of firms' R&D investment by reducing over- and under-investment. He argued that investor protection increases efficiency in two ways. First, investor protection enables firms to access external financing and so reduce under-investment in R&D activities. Second, it mitigates agency problems, and thus reduces the likelihood of R&D over- and under-investment. Based on panel data from 38 countries over the period 1993-2008, he also found that investor protection moderates the relationship between R&D investment and firm growth. The results reveal that the difference in economic effect between the strongest and weakest investor protection is as large as 19 per cent per year.

In comparing the impact of investor protection on R&D investment, both McLean et al. (2012) and Brown et al. (2013) emphasised external finance, while Xiao's (2013) study gave more attention to efficiency of capital allocation. Thus, empirical studies have shown that investor protection facilitates R&D investment by allowing firms to access external finance and encouraging the efficient allocation of capital. Moreover, in the presence of strong protection, risky and uncertain investments such as R&D may influence firm performance more effectively. In recent years, emerging markets have taken steps to increase investor protection; therefore, it is expected that investor protection moderates the relationship between R&D investment and firm performance. In particular, investor protection may strengthen the relationship between R&D and firm performance in emerging markets.

3.8.3 Country-level governance (systems)

The existing literature has confirmed the importance of country-level governance factors (systems) for R&D investment (Hillier et al., 2011; Pindado et al., 2015), although whether country-level or firm-level factors better explain the relationship is unresolved (Pindado et

al., 2015). In this regard, Francis et al. (2012) stated that country-level and firm-level corporate governance are substitutable in the case of financial contracts. Their results conflict with Klapper and Love (2004), who argued that the relationship between country-level and firm-level governance factors is far from obvious. They supposed that, firstly, firms in countries with weak corporate governance will want to adopt strong firm-level corporate governance to counterbalance that weakness. Secondly, there may be a positive relationship between them, in that firm-level governance follows country-level governance. They found a positive relationship between country-level factors and firm-level governance based on 14 emerging countries. From a study of 22 countries, Anderson and Gupta (2009) found that a country's financial structure and legal systems jointly affect the relationship between corporate governance and firm performance. Although there is some sort of relationship (Daniel et al., 2012), owing to their distinct nature and characteristics, they may play different roles in explaining firm-level decisions.

Ngobo and Fouda (2012) have argued that a good governance system reduces investment risk and leads to high returns. Therefore, it is assumed that strong national governance systems encourage risky investments such as R&D. In addition, Hiller et al. (2011) found that national systems facilitate R&D investment. They applied GMM estimation to data from11 countries over the period 1990-2003, and concluded that good governance facilitates the availability of external financing for R&D investment. In line with this, Clarke's (2001) study of developing countries found that R&D investment tends to be lower in countries where institutional quality, such as rule of law and protection of property rights, is weak and the risk of expropriation is higher. It can thus be argued that a favourable institutional environment increases a firm's capacity and ability for R&D investment, which in turn improves firm performance (Volberda, et al., 2012; Hong et al., 2015) through risk reduction, learning by doing and access to finance.

In a recent empirical paper, Pindado et al. (2015) examined how country-level governance factors moderate the relationship between R&D and market values. They supported Demirguc-Kunt and Maksimovic's (2002) notion that legal and financial systems reduce the magnitude of market imperfections caused by agency problems where R&D is characterised by information asymmetries. Moreover, they computed the elasticity for the coefficient of each variable for each model, showing that the explanatory power index is 0.5152 for control mechanisms, 0.4505 for corporate governance, 0.3680 for financial systems, and 0.2974 for effective investor protection, which supports the importance of country-level governance factors. Their results were based on GMM estimation on a sample of 12 countries comprising the EU, Japan and USA over the period 1986-2003. Therefore, the existing literature has shown that institutional setting and country-level governance play an important role in explaining the relationship between R&D and firm performance.

3.9 Financing of R&D

Firms may finance R&D investment from internal (Hall, 1992) or external funds (Httenrott and Peters, 2012), or both (Brown and Peterson, 2009). According to Myers' (1984) pecking order theory, R&D projects are financed in a particular order. First internal funds are used, followed by external funding, and issuing debt and/or equity. Schumpeter (1942) emphasised that, due to agency problems, it is preferable to finance R&D investment internally. Similarly, Hall (1992) argued that the extreme riskiness of R&D projects and the cost of revealing information about such projects may lead firms to prefer internal finance. Moreover, internal funding can be raised more easily (Lee and Hwang, 2003) and costs less (Brown et al., 2009). Thus, Himmelberg and Petersen (1994) considered it as the main determinant of R&D investment because of capital market imperfections, although size of firm is an important factor in relying on internal funding (Himmelberg and Petersen, 1994). For instance, Bougheas (2004) found that many small firms in the USA

and UK, and to a lesser extent in Canada, do not have access to external capital markets, and thus rely on internal finance for R&D investments. On the other hand, large and well-established firms may have easy access to external funds because of their established track record (Oliner and Rudebusch, 1992; Chiu et al., 2012). Similarly, firm age, liquidity and dividend policy also have impacts on choosing internal funding. Fazzari et al. (1988) and Chiu et al. (2012) found that young, low-liquidity and low-dividend firms are more likely to use internal funding due to information asymmetry. Thus, in an empirical study, Himmelberg and Petersen (1994) found that internal funding has a positive impact on R&D investment. As a result, Martinsson (2009) observed that R&D investment depends on internal funding. However, Bloch (2004) has stated that dependence on internal funding indicates that R&D-intensive firms are financially constrained. He assumed that, if firm borrowing is constrained, R&D investment will be dependent on internal funding. Therefore, the ability of internal funding to explain R&D investment provides evidence of financial constraints. Moreover, internal funds may vary due to changes in labour costs, interest rates, oil prices and exchange rates (Brown et al., 2009). Therefore, Mueller (1967) and Elliot (1971) found no relationship between internal funding and R&D investment. Similar results were obtained by Ayyagari et al. (2011), based on 47 emerging markets. They also found that innovation by foreign firms depends on external finance.

However, external finance, and specifically debt, is not a favoured form of finance for R&D investment (Hall, 1992). Hall (1992) argued that servicing debt usually requires a stable source of cash flow, making it more difficult to find the funds for R&D investment. Chaio (2002) re-examined and confirmed Hall's (1992) hypothesis for science-based firms but not for non-science-based firms, and stated that non-science-based firms neither spend more on R&D nor own high R&D capital stock. He suggested that Hall (1992) may not have considered the heterogeneity of firms in different industries and the simultaneous nature of investment and debt; thus, he separated science-based and non-science-based

firms. He used an OLS regression method, while Chaio (2002) applied GMM to US firm-level data. Moreover, empirical studies such as those by Aghion et al. (2004), Ho et al. (2006) and Chen et al. (2010) have found a negative relationship between debt financing and R&D investment. The reasons for this negative relationship are problems of information asymmetry (Bloch, 2004), adverse selection (Stiglitz and Weiss, 1981), moral hazard (Holmstrom and Tirole, 1997) and agency costs (Chen et al., 2010). These problems may lead investors to restrict financing of R&D investment. Information asymmetries may occur more frequently in R&D for two reasons. First, the nature of R&D makes it difficult for lenders to appraise R&D projects accurately. Second, managers generally withhold R&D information for confidentiality reasons, because information transmitted to lenders may also convey useful technological knowledge to rivals (Chen et al., 2010). Adverse selection problems may occur due to the inherent riskiness of R&D projects (Stiglitz and Weiss, 1981). In the case of limited liability, firms may be willing to take on greater risk than otherwise when projects are financed by debt. Agency-cost problems between debt holders and firms render debt financing of R&D investments more expensive (Chen et al., 2010). Moreover, debt financing increases a firm's transaction costs (Kochhar, 1996). As a result, external financing is more expensive for R&D investments than for normal investments (Heshmati and Lööf, 2005). Thus, firms will reduce debts arising from investments in R&D in order to avoid the burden of higher interest (Chai, 2010).

On the other hand, firms use debt for R&D investments because internal funding is naturally limited and issuing new equity may be costly and often unwanted (Hottenrott and Peters, 2012). Moreover, the disciplinary role of debt acts as a positive influence on managerial behaviour, reining in managerial discretion (Ho et al., 2006). Managers are more concerned with insolvency, as debt increases the chance of bankruptcy. Furthermore, managers are highly likely to lose their jobs in case of bankruptcy (Ogawa, 2004).

Financing R&D with bank loans may be feasible, especially if banks are willing to monitor the investment activities of their clients (Bougheas, 2004). On the other hand, R&D investment firms provide more real collateral to lenders than others. R&D investments improve firms' efficiency, and consequently their goodwill, as time goes on, and may offer increasing real collateral guarantees to potential lenders (Martinez-Ros and Tribo, 1999). Debt financing reduces over-investment (Amihud and Lev, 1981) and is less expensive than equity financing due to tax shields (Wang and Thornhill, 2010). Moreover, firms prefer to use debt rather than new equity for R&D investments as it involves giving up less control rights (Aghion et al., 2004). Thus, Szewczyk et al. (1996), Zantout (1997), Chiao (2002) and Martinsson (2009) have found a positive relationship between debt and R&D investment. Zantout (1997) explained that one reason for this positive relationship is that management plans to increase R&D expenditure may imply an increase in a firm's investment risk, resulting in the transfer of wealth from bondholders to shareholders, the severity of which is positively related to the debt ratio. A second reason is that a high percentage of managerial ownership of the firm's common stock gives managers incentives to make decisions that increase shareholder wealth.

Bhagat and Welch's (1995) study produced mixed results. They observed a negative relationship between debt ratio and R&D investment for US firms, and a positive relationship for Japanese firms. Their interpretation was that US firms either have more need to safeguard their R&D expenditure from possible financial distress without assuming a large amount of debt, or alternatively that US lenders are less willing to finance R&D projects, whereas, in contrast to the US tax code, the Japanese tax code manages to encourage R&D. Bhagat and Welch (1995) used regression analysis on R&D data from 6,549 firm-years of US, Canadian, British, European and Japanese firms for the period 1985-1990. Ghosh (2012) examined the inter-linkage between R&D efforts, leverage and firm ownership, and found that a ten per cent rise in leverage lowers R&D by 0.2 percent.

His study revealed that the dampening effect of R&D-intensity on leverage is highest for foreign private firms, and R&D activity appears to be positively related to leverage for state-owned firms, by virtue of state-owned firms' access to subsidised government loans. Ayyagari et al. (2011) argued that even state-owned firms have access to external finance, but they are still less innovative. Overall, the existing literature has provided mixed results regarding the relationship between debt finance and R&D investment. In this regard, Chiao (2002) argued that this relationship depends on characteristics of industries such as intensity of R&D activities.

In the absence of internal and external funding, what are the potential financing sources for R&D? Brown et al. (2009) observed that, when internal funding is exhausted and debt is not an option, firms must turn to new equity issues. The asset substitution hypothesis suggests that firms involved in R&D activities will prefer equity financing to debt financing. Bah and Dumontier (2001) added that firms will prefer equity because a significant proportion of their market value is accounted for by growth opportunities. Equity financing is important for R&D activity because bank loans are difficult to obtain for R&D projects (Muller and Zimmermann, 2009). These results show that firms with higher equity ratios are more involved in R&D. Moreover, firms prefer equity financing in order to avoid the costs of debt requirements and maintain sufficient financial slack (Chen et al., 2010). In this regard, Ou and Haynes (2006) argued that high-growth innovative firms are more likely to depend on equity owing to highly uneven profits, information asymmetries and lack of collateral. In addition, equity financing provides managers with autonomy in project selection (Dittmar and Thakor, 2007). Using equity finance enables a firm to avoid the liquidity pressure of making loan repayments and reduce the risk of running out of cash while trying to compete on the basis of innovation (Chen et al., 2010). Moreover, equity financing reduces the financial obligation to pay regular interest (Wang and Thornhill, 2010). However, financial theories predict that the marginal cost of equity

will increase due to adverse selection (Myers and Majluf, 1984; Krasker, 1986, cited in Brown et al., 2009). Other than equity, venture capital and FDI are used as alternative external sources for R&D investment (Guariglia and Liu, 2014). Thus, the existing literature has shown that firms' sources of R&D financing depend on the cost of funding, firms' resources and capabilities, and managers' discretion.

In addition, differences between countries' institutional settings, such as financial systems, need to be considered in financing R&D investments (David et al., 2008). There are two main types of financial system, bank-based and market-based. In bank-based financial systems, banks and other financial intermediaries tend to be larger, more active and more efficient, as in Austria, France, Germany, Hong Kong, Japan, the Netherlands and Switzerland (Demirguc-Kunt and Levine, 1999). The bank-based theory stresses that banks are more effective than the market in financing development in emerging countries (Ujanwa et al., 2012). Demirguc-Kunt and Levine (1999) pointed out that, in market-based systems, stock markets tend to be larger, more active and more efficient, as in the USA and the UK. They argued that countries with a common-law tradition, strong protection of shareholder rights, good accounting regulations, low levels of corruption and no explicit deposit insurance tend to be more market-based. The market-based theory identifies the role of the market as a source of permanent capital for businesses, an avenue for mobilising savings for investment, a mechanism for redistributing wealth among investors, and a good measure of economic performance (Ujanwa et al., 2012). Levine (2002) argued that bank-based and market-based financial systems may co-exist and complement each other.

The existing literature has shown that a country's financial systems determine the available sources of finance for R&D investment. Empirical studies (e.g. Bougheas, 2004; David et al., 2008) have found a significant positive relationship between external financing under bank-based systems and R&D investment. Bougheas (2004) found that firms in bank-based financial systems such as in Germany, France, and especially Japan, have access to bank

loans to finance R&D. Under bank-based systems, it is expected that firms and banks will develop mutual relationships. Relational banking provides the hierarchical governance essential to aligning the interests and incentives of investors in and managers of R&D-intensive firms (David et al., 2008). Moreover, Bougheas (2004) argued that bank-based financial systems may finance R&D if banks are willing to monitor investment activities. Monitoring by banks helps to overcome agency problems (Bhattacharya and Thakor, 1993) and mitigate informational asymmetries (Boot, 2000). However, Levine (2002) has stated that bank-based systems may curtail technological innovation due to the highly risky nature of R&D projects. On the other hand, firms in market-based financial systems, such as in the USA, UK and Canada, rely on internal funding to finance R&D (Bougheas, 2004). Bougheas assumed that a lack of tangible assets forces them to rely on internal funding. Martinsson (2009) revealed that external financing is inappropriate in market-based systems for strategic investments such as R&D. He argued that market-based systems do not provide the necessary disclosure of R&D project-related information and suffer the problem of inflexibility. From a corporate governance viewpoint, David et al. (2008) stated that market-based systems rely on market governance and cannot provide the strong exchange safeguards needed for R&D investments. Therefore, the inconclusiveness of previous research regarding the choice of R&D financing, along with the effect of the recent global financial crisis, sets the context for examining sources of finance for R&D investment.

3.10 Summary

This review has identified some important gaps in the literature. First, the existing literature has examined the relationship between the recent financial crisis and R&D investment, while ignoring how local firms and MNEs, and innovative and non-innovative firms, have behaved in terms of R&D investment. An understanding of how firms behave with regard to innovative activities during a financial crisis is important because it explains

why some firms continue to invest in innovative activities while others do not. Second, empirical studies have focused on the macroeconomic determinants of R&D investment, but have not distinguished between advanced and emerging markets. Research on this aspect would be helpful to policy makers in emerging markets, which tend to follow the strategies of developed countries. Moreover, it would help them to increase their innovative activities. Third, virtually no studies have tested the institutional determinants of R&D investment. However, examining institutional determinants would determine their importance in addition to firm-level determinants for R&D investment. Fourth, the existing literature has described the relationship between R&D and firm performance, while ignoring which of the two makes a greater contribution to this relationship. Such analysis would enable firms to make changes to their strategies to increase their R&D activities. Fifth, the empirical evidence reveals relevant financing sources for R&D investment, while ignoring the role of local and MNE markets and market- and bank-based systems on financing strategies. However, identifying an appropriate channel through which to finance R&D investment under a particular market and financial system will promote the long-term growth of the firm. Finally, most of the empirical evidence has been drawn from developed countries, while little evidence is available from emerging countries. The current study seeks to close this gap in the literature by researching emerging markets.

Chapter 4: Methodology

4.1 Introduction

This chapter revolves around four questions: First, what is the relationship between financial crisis and R&D investment in emerging markets, and what are the firm-level determinants of R&D investment during a financial crisis? Second, what are the macroeconomic and institutional determinants of R&D investment in emerging markets? Third, in terms of the impact of R&D on firm performance and investor protection or country-level governance, which contributes more to the relationship between R&D and firm performance in emerging markets? Fourth, how are R&D investment projects financed in emerging markets? In order to address these questions, an appropriate method must be used. This chapter will explain how suitable methods were chosen to address these questions, and how the data were analysed.

4.2 Research strategy and design

There are two main types of research: empirical and theoretical. Empirical research supports the development of new ideas and/or thoughts based on data, while theoretical research supports the discovery of new ideas from existing works using theories and explanations. In other words, theoretical research focuses mainly on theory or concepts, while empirical research tests the theory based on data. From the perspective of theory construction, these two approaches are different. However, they are interrelated in the sense that empirical studies depend on theoretical studies. Nowadays, many studies are empirical, because results or evidence that are not in accordance with theory may contribute to a body of knowledge or help build a new theory. This study mainly follows an empirical research strategy to address the research questions, although a theoretical approach is followed to develop and operationalise the research objectives.

Another important aspect that may guide the structure and direction of the research process and design is the research philosophy. There are two types of research design: positivist

and interpretive. The positivist approach is commonly used to test a theory, while the interpretive approach is used to build a theory. Positivist designs look for general patterns based on an objective view of reality (Bhattacherjee, 2012). According to Mukherji and Albon (2014), in order to understand a phenomenon, we need to observe events in a systematic way and then work out the underlying theory that causes the event to occur. This approach also helps define cause and effect relationships among variables. On the other hand, interpretive designs look for subjective interpretations of social phenomena from the perspectives of the subjects involved (Bhattacherjee, 2012). In other words, interpretive designs deal with how people experience phenomena and define their meanings in reality. This can be achieved by subjective analysis. For this study, a positivist design was chosen for the following reasons:

1. Positivist designs facilitate coverage of a wide range of situations by representing wider populations, and are easy to replicate in order to arrive at a general conclusion. A lack of restriction on replication of a study leads to the production of more acceptable generalisations. In contrast, according to Remenyi et al. (1998), it is difficult to generalise using an interpretive approach.
2. Positivist results are more likely to be expressed quantitatively, while interpretive results are usually expressed qualitatively (Kielmann et al., 2011). As the current study uses numerical data and quantitative methods to address the research questions, the positivist approach is better suited to this study.
3. The positivist paradigm is more economical than the interpretive approach when time and resources are limited. This study had a limited time frame, so is better suited to a positivist approach.
4. The positivist approach aims to make statistical comparisons (Kielmann et al., 2011), which contributes to the depth of analysis of this study.

4.3 Choice of methods

The choice of research methodology is closely related to the choice of research philosophy. Kielmann et al. (2011) observed that the positivist approach usually has quantitative characteristics, while the interpretive approach is more qualitative. Quantitative methods deal with data to measure what people think, while qualitative research focuses on why people make choices, and what and how they choose. Therefore, qualitative research provides a deeper knowledge and understanding of the phenomena being researched (Gramatikov et al., 2010). On the other hand, quantitative research reveals more important facts about the data, such as trends, demographics and differences among the group. In quantitative research, researchers gather, organise and analyse data using an appropriate method. In qualitative research, researchers use interview techniques or conduct face-to-face or telephone interviews with a target group to analyse a certain concept. This study examines firm-, macroeconomic- and institutional-level R&D determinants, the relationships between R&D and firm performance, and sources of financing for R&D. The variables selected to analyse these objectives are based on the literature review and are quantifiable and measurable. Moreover, hypotheses are developed and tested using a quantitative approach. In addition, most previous published research on these topics has been based on quantitative research. This study also adopts a quantitative methodology to examine the stated objectives.

4.4 Data sources

In order to fulfil the objectives of this study, secondary data were drawn from various sources, including DataStream, companies' annual financial reports, LexisNexis, the World Bank's Development Indicators, Worldwide Governance Indictors and Protecting Minority Shareholders data, and the International Country Risk Guide (ICRG) database. Data from DataStream, annual financial reports and LexisNexis were used to examine firm-level determinants in the presence of a financial crisis and the relationship between

financial crisis and R&D in emerging markets. Data from annual reports were used to fill missing values in the DataStream data. LexisNexis was used to collect more details about firms, such as their years of establishment and their nature, whether local or MNE. Yearly data were collected for the period 2003-2012 to fill gaps in the latest data. Only firms with 10 consecutive years of data were chosen. Owing to the differing nature of financial firms, in terms of corporate structure and strategy, these were excluded from the analysis. Details of the data are presented in Chapter 5.

The World Bank's Development Indicators and Worldwide Governance Indictors were used to make macroeconomic comparisons between advanced and emerging markets. Country-level data were collected to observe the macroeconomic determinants of aggregate R&D expenditure. Owing to data availability and to minimise gaps in the latest data, the chosen sample period was from 2002 to 2011. Details of the macroeconomic data are presented in Chapter 6.

DataStream and ICRG data were used to examine institutional determinants. DataStream was used to collect firm-level data, while ICRG was used for institutional variables. A sample period of 2006-2013 was chosen based on data availability. Details of the institutional data are presented in Chapter 7.

Data were collected from DataStream, and the Protecting Minority Shareholders and ICRG databases to examine the relationship between R&D and firm performance and investor protection or country-level governance, and to establish which makes a greater contribution to the relationship between R&D and firm performance in emerging markets. Firm-level data, such as sales growth, sales, fixed assets, total assets and debt, were drawn from DataStream, investor protection data were gathered from the Protecting Minority Shareholder database, and country-level governance data were taken from ICRG. Owing to data availability, particularly in the Protecting Minority Shareholder data, the selected sample period was 2006-2013. To be included in the sample, firms must have five

consecutive years of data. Financial firms were excluded from the analysis due to the nature of their corporate structure and strategy. Details of these data are presented in Chapter 8.

Data from DataStream, annual financial reports and LexisNexis were used to study the financing behaviour for R&D investments in emerging markets. Annual financial reports were used to fill in missing values in the DataStream data. LexisNexis was also used to gather further details about the firms. In order to minimise gaps in the latest data, yearly data were collected for the period 2003-2012. Only firms with 10 consecutive years of data were selected. Financial firms were excluded due to the nature of their corporate structure and strategy. Details of these data are presented in Chapter 9.

4.5 Data structure

There are three types of data: cross-sectional, time series and panel data (or time series cross-sectional data).Cross-sectional data describe multiple individuals at the same time, for example sales growth data for Tesco, Sainsbury's and Morrisons for the year 2015. Time series data deal with single individuals over multiple time periods, for example sales growth for Tesco from 2000 to 2015. Panel data are a combination of cross-sectional and time series data, using datasets with multiple individuals for multiple time periods, such as sales growth data for Tesco, Sainsbury's and Morrisons from 2000 to 2015.

Panel data were used for their distinct advantages over cross-sectional and time series data. The advantages of panel data are described below.

1) Panel data provide great flexibility in modelling differences in behaviour across individuals over a cross-sectional dataset (Greene, 2003). Moreover, Pindado and Requejo (2014) observed that panel data deal with unobservable heterogeneity. It is crucial to consider unobservable heterogeneity in analysis of R&D investment, as it depends on firm strategy, corporate culture and the propensity to innovate (Hiller et al.,

2011). Therefore, in order to control for unobserved heterogeneity, panel data were used rather than cross-sectional or time series data.

2) Panel data provide more informative data, more variability, less collinearity between variables, more degrees of freedom and more efficiency (Baltagi, 2013), whereas time series studies may have problems of collinearity. Panel data are useful for identifying and measuring effects that are not measurable in cross-sectional or time series data. In addition, panel data help to test more complicated behaviour. For instance, panel data are better for analysing technical efficiency (Koop and Steel, 2001).
3) According to Pindado and Requejo (2015), panel data help to study the dynamics of adjustments in firm-level decision making. Baltagi (2013) stated that cross-sectional data hide amultitude of changes. Moreover, panel data mitigate the bias of aggregation which may arise when time series estimations are used to characterise individual behaviour.
4) Panel data allow a composite error term to be split into sub components, for example $\varepsilon_{it} = \eta_i + d_t + v_{it}$ (Pindado and Requejo, 2015). First, individual heterogeneity which is denoted by η_i, can be used to control for individual or firm-specific effects. Second, panel data by nature incorporate the time-series dimension, which controls macroeconomic effects on dependent variables. By using the time dummy, d_t, on the right hand side, it is possible to control for macroeconomic effects that would otherwise be included in the error term.
5) Panel data analysis simplifies computations. For instance, panel unit root tests have standard asymptotic distribution and do not suffer from the problem of non-standard distributions encountered in time series analysis (Baltagi, 2013).

However, the major problem of panel data analysis is data collection. Due to the nature of panel data, researchers need to collect data on multiple individuals for multiple time periods; however, non-responses, and problems with coverage, frequency of interviews,

firm listings and bankruptcy, mean it is not always feasible to work with panel data. Moreover, panel data do not always account for cross-sectional dependency. This problem may arise when a researcher uses macro-panel data on countries or regions over long time periods (Baltagi, 2013). In addition, Cameron and Trivedi (2013) have stated that panel data estimations are more complicated than cross-sectional estimations, and require much richer models and estimation methods.

4.6 Data analysis

In order to undertake the analysis for this study, panel data estimation was carried out using STATA software. This study mainly used a GMM approach for several reasons. First, it was used to control for the endogeneity problem (Hillier et al., 2011). According to Pindado and Requejo (2015), most finance studies face endogeneity problems. Generally, these may arise when there is a relationship between the explanatory variables and the error term. Wooldridge (2010) found three factors that may create endogeneity problems: omitted variables, measurement errors and causality. Omitted variables may correlate with explanatory variables. For instance, some firms invest more in R&D than others due to growth opportunities or firm culture, which may create omitted variable bias. Measurement error may occur in any dependent or explanatory variables. Causality issues may arise when a dependent variable and at least one explanatory variable are determined simultaneously. For example, R&D investment and firm size have a simultaneous relationship. Owing to their high resource capacity and growth opportunities, large firms invest more in R&D activities. On the other hand, high R&D investment may increase product quality and foster sales performance, which ultimately impacts on firm size.

Second, the endogeneity problem can also be controlled by an IV approach. However, in order to apply this approach, the researcher must find external instruments, which are sometimes very difficult to obtain, from both theoretical and empirical points of view. In this regard, Liu et al. (2015) and Pindado et al. (2014) have pointed out that external

instruments may not be readily available and finding them is extremely complex. On the other hand, GMM uses lags of variables as instruments for estimations, and therefore provides efficient estimations. Strategic investments such as R&D follow the path-dependent hypothesis (Garcia-Quevedo et al., 2014), and cumulativeness of information and knowledge implies that the current year's R&D investment follows that of the previous year. Therefore, use of lagged values of dependent variables as instruments may produce biased results. However, GMM estimations control for lagged values of the dependent variable (David et al., 2006).

Third, both heteroscedasticity and auto-correlation problems can be addressed by GMM estimations. Heteroscedasticity may arise because different countries in the sample have different characteristics, thus residuals are unlikely to be constant across observations. Auto-correlation may arise as a result of using the lag of the dependent variable for the hypothesis test. These problems cannot be controlled by OLS. Moreover, Baum et al. (2003) observed that, in the presence of heteroscedasticity, IV estimations provide inconsistent estimations of standard errors. However, GMM provides more consistent estimations than two-stage least squares (2SLS) in the presence of heteroscedasticity and auto-correlation (David et al., 2006).

Fourth, according to Hansen (1982), GMM estimations provide a general framework within which to take into account issues of statistical inference, as they encompass many estimators of interest to econometrics. In this regard, Worrall (2008) stated that, within a single framework, GMM nests several estimations, such as OLS, 2SLS and IV. Moreover, as GMM estimations use richer sets of instruments than IV estimators, they provide a higher level of efficiency estimation (Arellano and Bond, 1991).

Finally, previous researchers (e.g. David et al., 2006; Hillier et al., 2011; Pindado et al., 2015) have applied GMM estimation to this topic.

4.7 Summary

This chapter has explained the research methods used for this study, focusing in particular on the research philosophy, data collection and choice of methodology. The research adopts a positivist approach using a quantitative methodology. For the analysis, secondary data were collected from sources such as DataStream, annual financial reports, LexisNexis, the World Bank's Development Indicators, Worldwide Governance Indicators and Protecting Minority Shareholder data, and the ICRG database. GMM estimation is the main technique used for data analysis. In addition, OLS, the IV approach and Granger causality tests are used for data analysis.

Chapter 5: Financial Crisis and R&D Investment in Emerging Markets

5.1 Introduction

It has long been recognised that R&D has a significant impact on firms' long-term performance. It has also been proved that R&D investment may improve ability to learn, quality and efficiency of work, and incorporation of new knowledge and technologies into machinery and other equipment (OECD, 2011). As a result, R&D investment emerges as firms' choice for growth, innovation, networking and technological advance. Thus, from Grilichies (1979) onwards, a key interest of research has been to observe the determinants of R&D. However, changing customer demands, globalisation, increasingly knowledge-based technologies and, most importantly, the recent financial crisis have sparked renewed interest in rediscovering the determinants of R&D investment. Empirical works following RBV show that the most common determinants of R&D investment are firm age, size, sales and debt. However, as a result of the negative impact of the financial crisis, the nature of the relationship between these determinants may have changed. Thus, this study focuses on the relationship between financial crisis and R&D investment, and the common determinants of R&D in the presence of financial crisis.

There is controversy about the relationship between financial crisis and R&D investment. The cyclical view suggests that financial crises have a negative impact on R&D investment, while the anti-cyclical view suggests a positive relationship between the two. Therefore, it is presumed that financial crises have a dramatic impact on R&D investment, but the impact may vary substantially across firms, industries and countries (Fillippetti and Archibugi, 2011; OECD, 2012). The reasons for this variation are, first, the nature of firms. For example, fast-growing new firms and highly innovative firms continue to invest in R&D during recessions (Archibugi et al., 2013). Second, market demand for a product, profit and technological opportunities are reasons for this variation at industry level (Filippetti and Archibugi, 2011). Finally, stock market efficiency, financial systems

(Filippetti and Archibugi, 2011) and the extent to which a country is affected by a financial crisis may play a role, although relatively little attention has been given to these issues in emerging countries. The aims of this study are to close this gap, and firstly to examine whether local firms and MNEs behave differently with regard to R&D investment during a recession, and secondly whether innovative firms continue to invest in R&D during a financial crisis.

RBV (Barney, 1991; Wernerfelt, 1984) stated that firm-specific internal resources and capabilities enable them to achieve competitive advantage, leading to superior performance. Galende and Fuente (2003) found that internal resources and R&D activities are significantly related. Following RBV, the internal resources and factors that explain R&D investment are firm age (Galende and Fuente, 2003), firm size (Lai et al., 2015), debt and sales (Galende and Fuente, 2003). However, not all internal factors play the same role during a financial crisis. The negative impact of the recent financial crisis may have changed the direction of internal factors. For example, Galende and Fuente (2003) found that debt impacts positively on R&D investment. However, due to credit constraints during a financial crisis, debt may impact negatively on R&D investment, although emerging countries were not all equally affected by the recent financial crisis. Thus, this study also examines whether RBV holds true in the presence of a financial crisis and whether the drivers of R&D behave differently in affected and less-/unaffected emerging countries in the presence of a financial crisis.

Emerging countries are growing faster than developed and under-developed ones (Lague, 2011). It is assumed that the growth rate of emerging markets will be three times higher than that of advanced economies by 2020. This faster growth may lead to higher rates of return than on similar investments in developed countries (Logue, 2011). Moreover, global market competition, changing customer demand and strategic international cooperation between businesses boost emerging markets to invest in R&D (Gorodnichenko et al.,

2008). Therefore, in recent years, emerging markets have considerably increased their R&D investment; for example, according to Booz & Company (2012), India and China increased their R&D spending by about 28 per cent in 2011. However, there is a lack of literature examining the common determinants of R&D investment in emerging markets. In addition, it is important to establish which factors played a role during the recent financial crisis in emerging countries.

This study contributes to the existing R&D literature in several ways. First, it complements previous studies of the impact of the 2007-2008 financial crisis on R&D in emerging markets. There is a gap in the existing R&D literature that examines the impact of recessions on R&D. Most previous studies have been based on specific countries or regions (for Europe, see Kanever and Hollanders, 2009; Correa and Lottty, 2011; Fillippetti and Archibugi, 2011; Mannasoo and Merikull, 2011; Cincera et al., 2012; Archibugi et al., 2013a, 2013b; Adcock et al., 2014; and for Latin America, see Paunov, 2012). However, this study considers all emerging markets in the regions of Africa, Asia, Europe, Latin America and the Middle East. Second, the study adds value to the current R&D literature by examining the relationship between locality and multi-nationality, innovativeness and non-innovativeness during the recent financial crisis. While a few studies have shown a relationship between innovation/non-innovation and financial crisis, there is a lack of evidence for a relationship between local/multinational firms and financial crisis. Thus, this study examines the impact of financial crisis on R&D from held true during the recent financial crisis. In addition, it adds value to the literature on how R&D factors in affected or less-/unaffected countries behaved during the financial crisis.

Fourth, most earlier studies (Correal and Lottey, 2011; Filippetti and Archibugi, 2011; Cincera et al., 2012; Paunov, 2012; Archibugi et al., 2013b) have been based on cross-sectional data, which have many limitations. For example, cross-sectional data are unable to control for individual heterogeneity, data distributions that look relatively stable may

hide a multitude of changes, and the effects of identifying and measuring data are undetectable in cross-sectional data (Baltagi, 2013). Thus, when using cross-sectional data for innovation/R&D investment, there is a risk of obtaining biased results because R&D investment decisions are very closely related to firm specificity (Pindado et al., 2010). Moreover, most earlier studies have been based on surveys rather than panel data (e.g. Archibugi et al., 2013a). Survey data have problems such as failure to show in-depth dynamic behaviour and failure to reveal the actual impact of a crisis. This study is among the first to use comprehensive firm-level panel data. In addition, examining this issue may help policy makers, investors, managers and senior executives in emerging markets to make decisions on R&D investment.

This chapter is organised as follows. Section 5.2 introduces the financial crisis and emerging markets, Section 5.3 presents the variables and hypotheses of the study, Section 5.4 explains the data and research methodology, Section 5.5 presents and discusses the results, and Section 5.6 provides conclusions from this study.

5.2 Financial crisis and emerging markets

The 2007-2008 financial crisis started in the USA but quickly spread across the world. Any shock to US markets is bound to have global effects because US financial assets represent 31 percent of global financial assets and 62 percent of reserve currency assets (Claessens et al., 2010). Moreover, emerging markets and the USA are closely related owing to exchange rates, exports of goods and services and the spill-over of information, in terms of both returns and volatility. Lahrecha and Sylwester (2011) and Graham et al. (2012) found a strong co-movement between the USA and emerging markets, although the impact of a financial crisis may vary across countries (Fillippetti and Archibugi, 2011; OECD, 2012). For example, the recent financial crisis had only a limited effect on Argentina, China and

Estonia (OECD, 2012). To check the extent to which the sample countries were affected by the recent financial crisis, a Granger causality test was performed (see Table 5.1)[1].

Table 5.1: Granger Causality Test

Group-A: Causality

Observations	Lags	Country	F-Stat	Country	F-Stat
1564	2	USA	7.641**	Greece	61.559***
1564	2	USA	9.399***	Hong Kong	420.37***
1564	2	USA	8.115***	Indonesia	253.13***
1042	3	USA	13.81***	Israel	87.945***
521	4	USA	8.101*	Malaysia	199.34***
1564	2	USA	6.272**	Mexico	11.491***
1564	2	USA	7.575**	Philippines	477.94***
1564	2	USA	5.791*	South Africa	235.41***

Level of significance: * < 0.10, ** < 0.05, ***<0.01.

Group-B: No causality

Observations	Lags	Country	F-Stat	Country	F-Stat
521	4	USA	1.045	Bangladesh	3.0516
521	4	USA	5.664	Brazil	34.061***
521	4	USA	2.769	Chile	30.361***
521	4	USA	2.181	China	38.253***
521	4	USA	2.799	India	59.588***
521	4	USA	2.182	Pakistan	12.553**
521	4	USA	3.487	Peru	16.837***
521	4	USA	2.345	Poland	61.567***
521	4	USA	4.239	Russia	81.687***
521	4	USA	1.391	Sri Lanka	31.996***
521	4	USA	0.839	Thailand	144.69***
521	4	USA	2.299	Turkey	59.979***

Level of significance: * < 0.10, ** < 0.05, ***<0.01.

Affected countries are considered to be those with a causal relationship with the USA, and less-/unaffected countries are those that have no causal relationship. Consistent with Lahrecha and Sylwester (2011) and Graham et al. (2012), the results show that Greece,

[1] The daily stock price index was used for 10 years from 1 January 2003 to 31 December 2012 for all 20 emerging markets and the USA. The stock price data used in this paper were drawn from the main stock market indexes using the common denominator USD for pair wise Granger causality tests. As this test is used to examine whether a past value of a series, X_t, will help to predict the value of another series in the present, Y_t, taking into account the past value of the Y_t, (Granger, 1988), a maximum lag value of 4 was taken for this test. Prior to lag selection, lag order selection was based on AIC criteria. Before performing the Granger causality tests, the two series were tested for stationarity using the augmented Dickey-Fuller (ADF) unit root test.

Hong Kong, Indonesia, Israel, Malaysia, Mexico, the Philippines and South Africa have a bi-directional relationship with the USA, meaning that these countries were affected by the financial crisis. However, Bangladesh, Brazil, India, Chile, China, Pakistan, Peru, Poland, Russia, Sri Lanka, Thailand and Turkey have no causal relationship with the USA, implying that these countries were less-/unaffected by the financial crisis. This is because some emerging markets have different characteristics from developed markets like the USA, such as high returns and high volatility (Graham et al., 2012); and many emerging markets, such as Asian countries, were well prepared as they had experienced crises before. Some markets are not integrated into the world market, some countries' banking laws and regulations are very strict, as in Latin America (Wenn, 2013), and some have strong internal stock markets.

5.3 Hypotheses to be tested

In general, due to the recent financial crisis, local firms' sales, profits, exports, FDI, and even sources of finance, were reduced (Wu, 2012). This had a direct effect on long-term investment. Garicano and Steinwender (2015) found that local firms cut down on long-term investments such as R&D during the crisis. Moreover, investment in R&D is risky, uncertain and long-term (Hud and Hussinger, 2015); therefore, local firms were reluctant to engage in it during the crisis, preferring to invest in physical assets or projects that would give quick returns. In addition, local firms are small and imitative by nature. Hence, their investment rate in R&D is generally lower and the crisis allowed them to make real investments rather than invest in R&D. In addition to local firms, MNEs were affected by the recent financial crisis. Varum and Rocha (2011) suggested that local firms and MNEs were equally affected by the crisis. Moreover, according to the Central Bureau of Statistics, MNEs in Israel, such as Intel, Microsoft and IBM, drastically reduced their R&D during the crisis. The credit crunch during the crisis made MNEs focus on real investments and reduced their investments in R&D. However, some believe that, as MNEs have greater

international exposure, foreign exchange risk and reliance on exports than local firms, their R&D investments were more affected by the financial crisis. Therefore, the following hypothesis is postulated:

> **Hypothesis 1:** *The financial crisis had a negative impact on the R&D investments of local firms.*
>
> **Hypothesis 2:** *The financial crisis had a negative impact on the R&D investments of MNEs, and MNEs were affected more by the financial crisis than local firms.*

Innovative firms are different from other firms (Aghion et al., 2004), as they emphasise new knowledge creation and technology advancement. Even during the financial crisis, they adopted bold strategies of investing in R&D, expecting to gain high profits and market share during the market up-turn. For example, Samsung Electronics and Google strongly increased their R&D investment during and after the "new economy" collapse of 2001(OECD, 2009). Koksal and Ozgul (2007) have argued that, despite all the financial limitations imposed by a financial crisis, increasing R&D investment during a crisis has an important impact on performance. It is considered to be a "good cost" during a crisis. Innovative firms concentrated similarly on R&D during the financial crisis. Moreover, as R&D investment is a long-term project, it cannot be captured by short-term responses to the financial crisis (Archibugi et al., 2013). On the other hand, non-innovative firms did not have the same commitment to R&D investment as innovative firms, and did not concentrate similarly on R&D during the financial crisis. The reason for this is that non-innovative firms do not visibly profit from R&D spending (García-Manjón and Romero-Merino, 2012). Non-innovative firms in emerging markets prefer to imitate (Kumar and Saqib, 1996) and are less resource-intensive. Thus, due to financial constraints during the financial crisis, non-innovative firms reduced their R&D investments. Therefore, the following hypothesis is postulated:

> **Hypothesis 3:** *The financial crisis had a positive impact on the R&D investment of innovative firms.*

Hypothesis 4: *The financial crisis had a negative impact on the R&D investment of non-innovative firms*.

While focusing on the impact of the financial crisis on R&D investment, the existing literature (see Table 5.4) has suggested that R&D investment was also affected by other factors, such as firm age, firm size, export orientation, diversification, sales growth, profitability, debt ratio, foreign ownership and institutional ownership. These are considered as control variables in the analysis and are discussed below.

Firm age is used as a proxy for accumulated learning and knowledge. Thus, it is believed that the higher the firm age, the greater the firm's experience and knowledge. By gathering experience and knowledge, a firm can develop or increase its skills and capacity, and therefore invest in innovative activities. Accumulated learning, experienced scientists and better-equipped laboratories determine a firm's likelihood of engaging in R&D investment. According to this view, older firms are more likely to engage in innovative activities. However, empirical evidence shows an inconclusive relationship between firm age and R&D investment. For instance, Lall (1983) and Kumar and Saqib (1996) found a positive relationship, while Klepper (1996), Lynskey (2004) and Murro (2013) found no relationship between them. As emerging markets are growing, it is reasonable to believe that there will be a large number of new or young firms, increasing the probability of negative or no relationship with R&D investment.

Firm size reflects the firm's financial performance. Generally, large firms have greater market power, resources and access to external finance, which increase their probability of investment in R&D. This notion is supported by Schumpeter's (1942) hypothesis. Similarly, Lall (1983), Katrak (1985), Kumar and Saqib (1996), Tan and Hwang (2002), Galende and Fuente (2003), Griffiths and Webster (2010) and Murro (2013) found a significant positive influence of firm size on R&D investment. However, industry plays an important role in the relationship between size and R&D investment. For example, even small firms in an innovative industry (such as software, pharmaceuticals and computers)

have a tendency to make large investments in R&D. Therefore, as Cohen et al. (1987) observed, it is not size by itself that influences R&D investment, but the conditions of technological opportunity and appropriability. However, it is expected that, during a crisis, due to their greater internal funding and capacity, large firms will be better able to invest in R&D.

Export orientation reflects a firm's international market participation. In order to increase firm competitiveness in the international market by increasing product quality and sales, firms need to invest in R&D. Although increasing product standards does not necessarily mean investing in R&D (Abdelmoula and Etienne, 2009), R&D investment helps firms to make products that people want to buy. In this regard, Kumar and Saqib (1996) observed that firms can compete more effectively in international markets by investing in R&D activities. Similarly, Galende and Fluente (2003) and Zemplinerova and Hromadkova (2012) found a positive relationship between export orientation and R&D investment. Therefore, it is assumed that the greater the export orientation, the greater the propensity for investment in R&D. Moreover, it is expected that firms with more international links will be more able to alleviate crisis risks.

Product diversification may relate to R&D investment in several ways. First, greater diversification means firms have higher product classification and greater differentiation, which can be achieved by R&D investment. Second, in order to achieve diversification, firms need diversified human capital and a broad range of knowledge that boosts them to invest in R&D. Third, a more diversified firm will be better able to exploit more resources and capacity, which facilitates R&D activities. Thus, the empirical evidence shows a positive relationship between product diversification and R&D investment. Baysinger and Hoskisson (1989) found that, in large multi-product firms, there is a positive relationship between diversification and R&D spending; yet, Mukherjee (2005) claimed a negative relationship because, under product patents, greater product differentiation increases the

possibility of lower R&D. Moreover, agency theory confirms a negative relationship between diversification and innovation. However, following the endogenous growth model, it is predicted that the positive effect of product diversification on R&D investment will dominate in emerging markets.

According to the demand-pull theory, higher demands generate optimistic expectations and growth opportunities that boost innovative activities. Cumming and Macintosh (2000) stated that demand-pull encourages R&D investment as there is less financing risk. Moreover, sales growth makes investors more confident about future returns from R&D investment; therefore, firms with higher sales growth invest more in R&D to maintain performance and grab future potential opportunities. As a result, Coad and Rao (2010) and Morbey (1988) found that R&D investment increases following growth in a firm's sales. However, Bhattacharya and Bloch (2004) found an insignificant relationship between growth and R&D expenditure. From the emerging markets perspective, where market demand has increased significantly, it is reasonable to expect that firm performance will influence firm-level decisions such as R&D investment.

The relationship between profitability and R&D expenditure is inconclusive. Tan and Hwang (2002) and Bhattacharya and Bloch (2004) found a significant positive impact of profitability on R&D investment, whereas Hundley et al. (1996), Kumar and Aggarwal (2005), Liu (2011) and Kalayci (2013) found a significant negative impact. As R&D investment involves a high degree of risk and uncertainty, it faces external financial constraints. To overcome this problem, retained earnings can be used as a source of funding for R&D spending (Grabowski, 1968). Due to lower transaction costs, firms may gain advantages from using retained earnings rather than external financing (Anwar and Sun, 2013). This implies that higher profits motivate investment in R&D. On the other hand, according to the failure inducement hypothesis (Antonelli, 1989), lower profits induce firms to invest in R&D. Earning lower profits provides an incentive to engage in

R&D activities, which may help a firm to improve business performance (Anwar and Sun, 2013).

According to pecking order theory, firms first use internal funding, and then external funding such as debt or equity to finance R&D investments. In addition, Himmelberg and Petersen, (1994) observed that firms prefer to use internal funding for R&D investments. Moreover, transaction cost theory posits that debt financing may discourage R&D investment. Due to higher costs of interest, firms are less likely to use external funding for R&D investments. Moreover, the highly risky and uncertain nature of R&D investments makes it difficult for firms to obtain loans from outsiders. In this respect, Hall (1992) pointed out that servicing debt usually requires a stable source of cash flow, making it more difficult to find the funds for R&D investments. In addition, the recent financial crisis imposed external financing constraints on emerging countries. As a result, Hall (1990), Cumming and Macintosh (2000) and Cheng and Chen (2006) found a significant negative impact of debt on R&D investment. Therefore, it is assumed that, due to the recent financial crisis, firms will avoid debt financing of R&D investments.

As emerging markets grow faster, they attract considerable interest from foreign investors. David et al. (2006) found that foreign ownership enhances strategic investment decisions such as R&D when firms have high growth opportunities. Moreover, foreign ownership influences firms to undertake R&D if knowledge from the parent needs to be adapted to local conditions or if specific projects require collaboration with the foreign owner (UNCTAD, 2003). In addition, foreign ownership facilitates R&D investment by enabling money to be raised from foreign sources. Funding secured from multiple sources or parties is likely to be supportive in determining the level of long-term investments such as R&D (David et al., 2006). Multiple owners also help to monitor managers (Allen, 1993). Moreover, empirical evidence shows a significant positive relationship between foreign ownership and R&D investment (Gannicott, 1984; Becker and Pain, 2008; Parameswaran

2008; Kriaa and Karray, 2010; Lee, 2012). Thus, it is expected that foreign presence in emerging markets will foster innovative activities.

A number of existing empirical studies have found that institutional ownership has a significant impact on R&D investment decisions, but the results have been inconclusive. Institutional ownership has a positive impact on R&D investment, as institutional investors are able to diversify the risk of R&D investments (Baysinger et al., 1991).Moreover, according to Chauvin and Hirschey (1993), large numbers of institutional investors are associated with greater R&D investment in IT firms by increasing their competitiveness. On the other hand, Graves (1988) found a significant negative relationship between institutional investors and R&D investments. He observed an emphasis of institutional ownership on short-term results as opposed to more profitable long-term investments in R&D. However, David et al. (2001) found that activism by institutional investors may put pressure on managers to undertake long-term R&D investments. This relationship may be stronger when R&D spending is more likely to improve firm value.

5.4 Data and methodology

5.4.1Data

Different organisations have defined emerging markets from different perspectives. For example, the IMF has defined the min terms of GDP-per-capita ratio, while Goldman Sachs selected them based on their macroeconomic stability, political maturity, trade openness, investment policies and educational quality criteria. As a result, the list of emerging markets may vary from one organisation to another. To avoid this problem, all emerging markets from all organisations' lists (IMF, Goldman Sachs, FTSE, MSCI, The Economist, S&P, Dow Jones, BBVA and Columbia University EMGP) were selected for this study (see Appendix 2 for a full list of emerging markets). Thomson Reuter DataStream was the main source of data for a sample of 51 emerging markets. In addition, LexisNexis and firms' annual financial reports were used. In order to avoid sample

selection bias, all listed firms in an emerging market were considered. First, data on 25,251 firms were searched on DataStream. In the case of missing values or unrealistic figures on DataStream, for example where R&D expenditure was missing, these values were dropped from the dataset. South Korea, Taiwan and Singapore were excluded from the sample because these are now considered as emerged countries. To be included in the sample, the country must have at least two firms and these firms must have 10 years of consecutive data. As DataStream provided some data with missing values, data from annual reports were used to fill the gaps. LexisNexis was used to collect data on firm age and level of multinationality. After taking these issues into account, DataStream, annual reports and LexisNexis provided 310 firms from 20 emerging markets (see Tables 5.2 and 5.3). The time periods before and after the financial crisis were considered, as the main variable of interest was the financial crisis. Following Erkens et al. (2012), 2007 and 2008 were considered as financial crisis years in emerging markets. 2009 was excluded from the crisis years because emerging countries started to recover from 2009 (Didier et al., 2011). Gaps in the latest data were minimised as far as possible. An equal time period was taken before and after the crisis. Thus, the 10-year sample time period chosen was from 2003 to 2012. Balanced panel data were used for sample firms. Panel data were used because they enable control for firm heterogeneity, provide more information, variability and degrees of freedom, avoid multicollinearity problems, provide more efficient results, and are more suitable for identifying and measuring effects that are not detectable in pure cross-sectional or pure time series data (Baltagi, 2013).

Table 5.2: Sample Selection

Description	No. of countries	No. of firms
Initial search on DataStream	51	25,251
Firms with10 years of consecutive data	37	892
Countries with more than one firm	23	878
Dropped: Countries that had already emerged	3	568
Final sample	**20**	**310**

Source: DataStream, LexisNexis and Annual reports

Table 5.3: Sample by Country

Country	No. of firms	Percentage of firms	Cumulative percentage
Hong Kong	62	20.00	20.00
India	52	16.77	36.77
Turkey	30	9.68	46.45
China	23	7.42	53.87
South Africa	23	7.42	61.29
Israel	22	7.10	68.39
Bangladesh	21	6.77	75.16
Greece	19	6.13	81.29
Malaysia	13	4.19	85.48
Philippines	8	2.58	88.06
Indonesia	7	2.26	90.32
Sri Lanka	5	1.61	91.94
Brazil	4	1.29	93.23
Mexico	4	1.29	94.52
Pakistan	4	1.29	95.81
Russia	4	1.29	97.10
Chile	3	0.97	98.06
Peru	2	0.65	98.71
Poland	2	0.65	99.35
Thailand	2	0.65	100.00
Total	**310**	**100.00**	**100.00**

Source: Author's calculations

Table 5.4 gives definitions of the variables. The existing literature has found these variables to have a significant effect on firms' R&D investment. In this paper, R&D expenditure is considered as a dependent variable which takes the logarithm of firms' annual R&D expenditure. The main independent variable is the financial crisis. The extensive list of control variables are age, size, export orientation, diversification, sales growth, profitability, debt ratio, foreign ownership and institutional ownership. All

variables are standardised to a common USD exchange rate. Some explanatory variables have higher scales than others. Moreover, the absolute value of variables increases the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, natural logarithms are adopted for R&D and size variables, gross profit to sales ratio, debt to total asset ratio, and percentage of foreign and institutional shareholders.

Table 5.4: Summary Variables

Variable	Type of data	Description	Empirical study
R&D	Continuous	R&D expenditure of the firm in a year (In log)	Howe and McFetridge (1976)
Age	Continuous	Calculated by subtracting the year the firm was incorporated from 2003	Mishra (2007)
Size	Continuous	Measured by total assets (In log)	Murro (2013)
Export orientation	Dummy	Takes a value of 1 if a firm exports	Kumar and Saqib (1996)
Diversification	Dummy	Takes a value of 1 if a firm has more than one segment	Galende and Fluente (2003)
Sales growth	Ratio	Annual sales growth of the firm	Bhattacharya and Bloch (2004)
Profitability	Ratio	Annual gross profit of the firm scaled to total sales	Bhattacharya and Bloch (2004)
Debt ratio	Ratio	Measured by the ratio of debt to total assets	Cumming and Macintosh (2000)
Foreign ownership	Percentage	Percentage of foreign shareholders	Kriaa and Karray (2010)
Institutional ownership	Percentage	Percentage of institutional shareholders	Hansen and Hill (1991)
Financial crisis	Dummy	Takes a value of 1 during the crisis years 2007 and 2008	Archibugi et al. (2013)
Industry dummy	Dummy	Takes a value of 1 if the firm is innovative, and 0 if it is non-innovative	
Market dummy	Dummy	Takes a value of 1 if the firm is an MNE, and 0 if it is local	
Country dummy	Dummy	Takes a value of 1 if the firm was affected by the US financial crisis	

Table 5.5 reports summary statistics for all sample firms in emerging markets. The descriptive statistics show the diversity of R&D investment, age, sales growth, foreign ownership and institutional ownership across emerging markets. For example, there are more foreign ownership firms in China than in any other emerging markets. This is because some emerging markets are growing faster than others. For example, BRIC markets (Brazil, Russia, India and China) are growing more rapidly than the N-11 emerging markets (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Turkey, South Korea and Vietnam). It is predicted that, in terms of economic growth, BRIC's emerging markets will overtake the G7 in 2032.

Table 5.5: Summary Statistics for All Firms

Variable	Mean	Standard Deviation	Minimum	Maximum
R&D	2.79086	1.51199	0	6.36103
Age	33.75530	23.45550	1	125
Size	5.63202	0.87318	2.84073	8.57482
Export orientation	0.45731	0.49825	0	1
Diversification	0.86751	0.33907	0	1
Sales growth	0.28787	3.62369	-0.94655	182.106
Profitability	0.27238	0.31782	-10.9659	2.83380
Debt ratio	0.20378	0.18306	0	0.89991
Foreign ownership	14.26220	24.02330	0	95
Institutional ownership	3.87731	9.90616	0	92.92
Financial crisis	0.19986	0.39996	0	1
Industry dummy	0.57343	0.49465	0	1
Market dummy	0.56918	0.49527	0	1
Country dummy	0.51292	0.49991	0	1

Source: Author's calculations

Table 5.6 displays summary statistics for countries affected and less-/unaffected by the recent financial crisis. Older firms were less affected than newer firms due to their experience of handling bad situations. In contrast to the common view, the results show that sales growth was higher in affected countries than in less-/unaffected countries. This can be explained by the fact that, as a result of the financial crisis, firms reduced their costs but retained the same sales strategies.

Table 5.6: Summary Statistics for Affected and Less-/Unaffected Countries

	Affected countries				Un-/Less-affected countries			
Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
R&D	2.877021	1.456446	0	6.13468	2.752176	1.585581	0	6.36103
Age	31.2317	24.48936	2	125	37.46772	21.7465	3	116
Size	5.578379	0.8120117	2.840730	7.86357	5.760626	0.9190695	3.1038	8.57482
Export orientation	0.471926	0.4993887	0	1	0.4414414	0.4967456	0	1
Diversification	0.897655	0.3032098	0	1	0.8363363	0.370109	0	1
Sales growth	0.332571	5.113939	-0.946546	182.107	0.2289178	1.452534	-0.94491	51.3413
Profitability	0.300943	0.2386868	-3.462360	0.948974	0.2493804	0.2232613	-1.0631	2.83381
Debt ratio	0.184219	0.1620047	0	0.887209	0.2210901	0.1961689	0	0.888627
Foreign ownership	19.462	26.21891	0	95	8.918769	19.98745	0	94
Institutional ownership	2.936745	6.182581	0	54	5.184767	12.5395	0	92.92
Financial crisis	0.22317	0.4165194	0	1	0.2222222	0.4158959	0	1
Industry dummy	0.546553	0.4980051	0	1	0.6021021	0.489648	0	1
Market dummy	0.683014	0.4654676	0	1	0.4512012	0.4977999	0	1

Source: Author's calculations

Higher sales generate higher profits; thus, affected countries had higher profitability than unaffected countries. Firm financing was constrained by the financial crisis. The results show that debt capacity reduced more in affected countries than in less-/unaffected countries. To protect investors' interests, shareholders reshaped corporate governance practices in order to deflect any threats resulting from the economic and political crisis (Roe, 2003). Therefore, increases or decreases in foreign and institutional ownership were likely. Thus, it can be seen that, in affected countries, foreign ownership was higher and institutional ownership lower than in less-/unaffected countries during the crisis.

Table 5.7 reports summary statistics for local firms and MNEs in emerging markets. Following Bae and Noh (2001), local firms are those that operate domestically, whereas MNEs operate in multiple countries. The theory of the multinational suggests that MNEs have greater resources and opportunities, enabling them to gain greater returns on intangible assets, use their market power, spread their market risks, and seek less expensive inputs and less price-sensitive markets (Kim et al., 1993). Thus, MNEs have more product diversity than local firms (Bae and Noh, 2001). The same conclusion was reached by Tallman and Li (1996). Similarly, MNEs tend to be more export-oriented than local firms. The firm-specific advantages of MNEs allow them to manage disadvantageous positions by lowering transaction costs and overcoming international trade barriers in foreign markets. The export behaviour of firms is also influenced by ownership structure (Athukorala et al., 1995). It is widely accepted that MNEs have greater foreign ownership than local firms. As most MNEs' parent companies are administered or controlled by two or more countries, they are likely to have more foreign ownership than local firms. For example, Unilever is an MNE in Bangladesh which is controlled by British and Dutch interests and had61 percent foreign ownership in 2011.

Table 5.7: Summary Statistics for Local Firms and MNEs

	Local Firms				MNEs			
Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
R&D	2.55441	1.50699	0	5.98412	2.96982	1.49147	0	6.36103
Age	33.2460	22.5931	2	125	34.1408	24.0871	1	123
Size	5.44093	0.90273	2.9818	8.57482	5.77665	0.82133	2.84073	8.55341
Export orientation	0.35383	0.47834	0	1	0.53563	0.49887	0	1
Diversification	0.80637	0.39528	0	1	0.91379	0.28075	0	1
Sales growth	0.27685	2.17612	-0.9465	53.5833	0.29621	4.41498	-0.8789	182.107
Profitability	0.28791	0.20814	-1.0631	0.97959	0.26063	0.38000	-10.966	2.83381
Debt ratio	0.21814	0.19976	0	0.89991	0.19291	0.16858	0	0.88721
Foreign ownership	9.66711	20.1514	0	95	17.7403	26.0536	0	90
Institutional ownership	4.24200	11.6357	0	92.92	3.60127	8.35565	0	73
Financial crisis	0.19969	0.39992	0	1	0.20000	0.40011	0	1
Industry dummy	0.57858	0.49397	0	1	0.56954	0.49528	0	1
Country dummy	0.37737	0.48491	0	1	0.61551	0.48661	0	1

Source: Author's Calculations

However, local firms have more institutional ownership than MNEs. Generally, institutions do not seek to invest in foreign firms; they tend to try to encourage local firms.

Following Kallunki et al. (2009), the sample firms were split between innovative and non-innovative industries (see Table 5.8).

Table 5.8: Innovative versus Non-Innovative Industries

Innovative Industries	**Non-innovative Industries**
Aerospace and defence	Beverages
Automobiles	Coal
Biotechnology and medical research	Containers and packaging
Construction materials	Food and tobacco
Communications and networks	Hotels and entertainment
Electronics	Leisure products
Engineering	Office equipment
Healthcare equipment and supplies	Oil and gas
Machinery and equipment components	Paper and forest products
Renewable energy	Media and publishing
Pharmaceuticals	Transport infrastructure
Metals and mining	Textiles and apparel
Software and IT	Water utilities
Telecommunications	Miscellaneous

Table 5.9 reports summary statistics for innovative and non-innovative firms in emerging markets. In general innovative firms are more technology-intensive than non-innovative firms.

In comparison, innovative firms put more emphasis on bringing new knowledge to markets, advancing technology, and increasing employees' skills, internal competencies and capabilities. Thus, innovative firms spend more on R&D than non-innovative firms (Tabrizi, 2005). As a result of new, diversified and improved production and manufacturing, innovative firms have higher sales growth rates than non-innovative firms. Similar results were found by Baldwin and Gellatly (2003). Easy access to knowledge, information and technology attract foreign customers to invest in innovative firms. Thus, innovative firms have more foreign ownership than non-innovative firms.

Table 5.9: Summary Statistics for Innovative and Non-Innovative Firms

	Innovative				Non-Innovative			
Variable	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
R&D	3.12196	1.32447	0	6.13468	2.34574	1.63013	0	6.36103
Age	30.2076	21.8795	1	125	38.5245	24.6365	1	123
Size	5.46076	0.83588	2.8407	7.93519	5.86224	0.86962	3.26245	8.57482
Export orientation	0.48944	0.50003	0	1	0.41411	0.49275	0	1
Diversification	0.89731	0.30362	0	1	0.82745	0.37799	0	1
Sales growth	0.36631	4.76479	-0.9465	182.107	0.18243	0.50128	-0.9449	10.959
Profitability	0.25238	0.35626	-10.966	1.19263	0.29927	0.25491	-4.0428	2.83381
Debt ratio	0.17966	0.17559	0	0.88721	0.23621	0.18789	0	0.89991
Foreign ownership	17.1386	25.1242	0	95	10.3955	21.8795	0	90
Institutional ownership	3.75664	8.86774	0	89	4.03954	11.1523	0	92.92
Financial crisis	0.20022	0.40028	0	1	0.19938	0.39969	0	1
Market dummy	0.56531	0.49585	0	1	0.57438	0.49462	0	1
Country dummy	0.49001	0.50004	0	1	0.54371	0.49827	0	1

Source: Author's Calculations

However, non-innovative firms tend to be older than innovative firms. Emerging countries are considered as late-industrialised countries, which implies that they started their innovative activities later. For example, China began to strengthen its innovation systems in 1980 and technological advancement through innovation in 1990 (World Bank, 2013).

5.4.2 Method of study

Panel data were estimated using GMM. Several econometrical issues led to the choice of this specification.

First, individual heterogeneity is important for this analysis because R&D investment decisions depend entirely on firm-specific features such as strategy, firm culture and the propensity to innovate (Hillier et al., 2011). Thus, there is a probability of obtaining biased results. In order to obtain bias-free results, the analysis needed to control for individual firm heterogeneity, taking η_i as individual effects in the model and then eliminating by taking the first differences of the variables. Thus, the model for the analysis is as follows:

$$In(R\&D_{it}) = \alpha_i + \beta_1(Age_{it}) + \beta_2 In(Size_{it}) + \beta_3(Export\ oriented_{it}) + \beta_4 (Diversifications_{it}) + \beta_5\ (Sales\ Growth_{it}) + \beta_6(Profitability_{it}) + \beta_7\ (Debt\ ratio_{it}) + \beta_8(Foreign\ ownership_{it}) + \beta_9(Institutional\ Ownership_{it}) + \beta_{10}(Financial\ Crisis_{it}) + \eta_i + C_i + I_i + M_i + \varepsilon_{it} \quad \textbf{(1)}$$

Besides individual firm effects, country, industry, market and time dummies were included in the empirical model. The country dummy captures country-specific effects, the industry dummy captures industry-specific effects, the market dummy captures market-specific effects, and the time dummy captures time-varying effects that control the macroeconomic variables of firm value. Moreover, ε_{it} is a random disturbance which is assumed to be independent and identically distributed (i.i.d. normal).

Second, some independent variables in the model are endogenous, which might create an endogeneity problem. For example, firm size and R&D investment causality might run in both directions – from firm size to R&D investment and vice versa. Therefore, the models

were estimated using instruments. Lagged levels were used for both difference equations and levels of equation in combination with system GMM. System GMM was used because it has been found to be more efficient than difference GMM (Blundell and Bond, 1998). Moreover, difference GMM estimation suffers from the problem of weak instruments (Alonso-Borrego and Arellano, 1999). A two-step estimation was performed on the grounds that it produces more efficient estimates than one-step estimation. In two-step estimation, the standard covariance matrix is robust to panel-specific heteroscedasticity and serial correlation, but the standard errors are downward biased. To fix possible downward bias, the Windmeijer (2005) finite-sample corrected covariance matrix was used.

Third, the lagged value of dependent variables was included on the right-hand side as a regressor. The presence of a lagged dependent variable may give rise to an auto-correlation problem. Thus, the estimation of the model using OLS in levels will be inconsistent, even if the errors are not auto-correlated.

Finally, the model was tested for potential misspecification. First, the Hansen J statistic of over-identifying restrictions was used to test whether the instruments were valid, i.e. they were uncorrelated with the error term. The results showed that the instruments were valid in the models. The hypothesis that the error term was not second-order serially correlated was then tested, denoted by AR(2). The results showed that there were no second-order serial correlations in the models. As a result of the first difference transformation, there might be first-order serial correlation AR(1), but this would not create a specification problem with the models. However, the results also showed that first-order serial correlations AR(1) were not present. Finally, two Wald tests were used: $z_1$was a test of the joint significance of the regressors, and z_2 was a test of the joint significance of the time dummy, suggesting that aggregate factors exert a significant influence on the relationship

between R&D investment and the explanatory variables. The results showed that the two Wald tests provided satisfactory results for the models.

5.5 Empirical results

5.5.1 Financial crisis and R&D

Table5.10 reports the results for local firms and MNEs. The financial crisis had negative effects on both local firms and MNEs. However, MNEs tended to be more affected than local firms. Empirical studies, such as those by Flamm (1984), Gao and Eshaghoff (2004) and Lee and Makhija (2009), have also supported this notion. With a one-unit change in financial crisis, the probability of R&D investment decreases by 94.32 per cent for local firms and 153.27 percent for MNEs. This means that the effect of the recent financial crisis on MNEs was 1.63 times higher than on local firms. This is because MNEs have more foreign exposure and greater export orientation than local firms.

Table 5.10: Summary of Results for Local Firms and MNEs

	Local Firms		**MNEs**	
Variable Name	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
$R\&D_{t-1}$	0.88118***	0.04113	0.62874***	0.09096
Age	-0.00219**	0.00103	-0.00138	0.00178
Size	0.21002***	0.07162	0.34640***	0.11900
Exportorientation	0.26796*	0.14737	0.30205*	0.17776
Diversification	-0.00953	0.06030	0.27874*	0.15011
Sales growth	0.03775***	0.01279	-0.00384***	0.00131
Profitability	0.11225	0.16003	0.07721	0.09835
Debt ratio	-0.03591	0.19837	0.28668	0.29377
Foreign ownership	0.00166*	0.00089	0.00270**	0.00122
Institutional ownership	-0.00231	0.00255	0.00563**	0.00276
Financial crisis	-0.94323***	0.38720	-1.53277***	0.63909
Industry dummy	Yes		Yes	
Country dummy	Yes		Yes	
Year dummy	Yes		Yes	
Total Observations	**1177**		**1562**	
AR(1), *p*-value	-4.18	0.000	-2.59	0.010
AR(2), *p*-value	-0.51	0.610	0.99	0.320
z_1, *p*-value	728.20(13)	0.000	769.42(13)	0.000
z_2, *p*-value	2.48(8)	0.015	1.81(8)	0.078
Hansen, *p*-value	119.21(175)	0.999	157.87(155)	0.421

Significance level: * <0.10, ** <0.05, ***<0.01

Moreover, international production facilities and the need to cut operational costs forced them to react more abruptly than local firms (Flamm, 1984; Gao and Eshaghoff, 2004; Lee and Makhija, 2009; Varum and Rocha, 2011). Thus, the results support the cyclical view of R&D investment and Hypotheses 1 and 2.

Firm size, export orientation, sales growth and foreign ownership had a significant impact on the R&D investments of both local firms and MNEs in emerging markets. Sales growth had a positive impact on the R&D investments of local firms but a negative impact on those of MNEs. This is because the recession affected MNEs more than local firms. Varum and Rocha (2011) found that MNEs showed 10 to 15 per cent lower sales growth than local firms during the crisis. Moreover, MNEs' R&D investments depended on their diversification and institutional ownership. Firm age had a significant negative impact on the R&D investment of local firms. Older local firms had fewer technological opportunities than younger local ones. In addition, newcomer or younger firms might invest more in R&D to compete with both local firms and MNEs.

Table 5.11 reports the results for innovative versus non-innovative firms. The financial crisis had a significant positive impact on innovative firms but a significant negative impact on non-innovative firms. Supporting the anti-cyclical view of R&D investment, the results show that a one-unit change in the financial crisis led to a 6.98 per cent increase in innovative firms' R&D investment. This suggests that innovative firms followed a strong R&D policy which worked as a safeguard against the crisis. Similar results were obtained in a study by Kanever and Hollanders (2009). In contrast, supporting the cyclical view of R&D investment, non-innovative firms decreased their R&D investment by 92.10 percent per one-unit change in the recession. Thus, the results support Hypotheses 3 and 4. Although innovative firms' R&D investment increased during the crisis period, the increase rate was very low compared with the decrease rate in non-innovative firms. Firm size, export orientation and profitability had a significant positive impact on both

innovative and non-innovative firms. Firm age and debt ratio had a significant negative influence on the R&D investments of innovative firms. This implies that innovative firms' investments were not influenced by age because of the nature of the firms. From the inception of their business, they had had to invest in R&D. Due to the credit crunch during the recession, firms' access to external funding reduced; therefore, the debt ratio affected R&D investments negatively. Foreign ownership had a significant positive influence on the R&D investments of non-innovative firms.

Table 5.11: Summary of Results for Innovative and Non-Innovative Firms

	Innovative		**Non Innovative**	
Variable Name	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
$R\&D_{t-1}$	0.68382***	0.10197	0.87058***	0.04560
Age	-0.00460**	0.00187	0.00108	0.00088
Size	0.31629***	0.09750	0.17403**	0.06827
Export orientation	0.12322*	0.06989	0.30170*	0.17688
Diversification	-0.08197	0.10831	0.05794	0.08087
Sales growth	-0.00157	0.00413	-0.02001	0.03106
Profitability	0.19754*	0.10959	0.20408*	0.10431
Debt ratio	-0.38174***	0.14234	0.15239	0.21944
Foreign ownership	-0.00159	0.00098	0.00296**	0.00116
Institutional ownership	0.00115	0.00222	-0.00177	0.00242
Financial crisis	0.06978*	0.04069	-0.92098**	0.36452
Market dummy	Yes		Yes	
Country dummy	Yes		Yes	
Year dummy	Yes		Yes	
Total Observations	**1571**		**1168**	
AR(1), *p*-value	-2.35	0.019	-4.33	0.000
AR(2), *p*-value	0.96	0.339	-0.02	0.981
z_1, *p*-value	74.12(13)	0.000	618.35(13)	0.000
z_2, *p*-value	1.72(8)	0.096	2.26(8)	0.027
Hansen, *p*-value	84.27(73)	0.173	104.66(103)	0.439

Significance level: * <0.10, ** <0.05, ***<0.01

5.5.2 Determinants of R&D

Table 5.12 reports the results of baseline estimations, the interest of which was to establish the common determinants of R&D investments in emerging markets. The lagged value of the dependent variable is significantly different from zero, showing the persistency of R&D investment. A persistence rate of 72.16 percent suggests that firms follow a stable

R&D policy. The main determinants of R&D investment in emerging markets are age, size, export orientation, debt ratio and foreign ownership. This implies that firms held the assumption of RBV even during the financial crisis. Age has a significant negative impact on R&D investment, indicating that, in order to stay in competitive markets and meet growing customer demand, new firms invested more than old firms in R&D. Moreover, emerging markets were less dependent on high-tech sectors; older firms in low-tech sectors invested less in R&D than those in high-tech-sectors. With a one-unit change in age, the likelihood of R&D investment decreased by 0.31 percent in emerging markets. Studies such as those by Klepper (1996), Lynskey (2004) and Murro (2013) have supported this finding. Larger firms, more export-oriented firms and firms with higher foreign ownership invested more in R&D than small, less export-oriented and domestically-owned firms. Larger firms had more resources to invest in R&D activities and the ability to benefit from returns on their innovative activities. Moreover, Lall (1983), Katrak (1985), Kumar and Saqib (1996), Tan and Hwang (2002), Galende and Fluente (2003), Liu (2011) and Murro (2013) found a positive relationship between firm size and R&D investment.

Exports allow firms to produce on a large scale and thereby exploit increasing returns on scale, made possible by fixed investments like R&D. Thus, exporter firms invest more in R&D than non-exporter firms. With a one-unit change in exports, the probability of investment in R&D increases by about 60 per cent. Braga and Willmore (1991), Kumar and Saqib (1996), Tan and Hwang (2002), Galende and Fluente (2003) and Zemplinerova and Hromadkova (2012) reached the same conclusion. High growth opportunities in emerging markets influence foreign owners to invest in R&D. Moreover, in order to make more profits and gain market share, foreign ownership firms invest more in R&D than domestically-owned firms. The results show that with a one-unit change in foreign ownership, R&D investment increases by 0.13 percent. Gannicott (1984), Becker and Pain (2008), Parameswaran (2008), Kriaa and Karray (2010) and Lee (2012) obtained similar

results. Due to the lower collateralisable value of R&D investments, R&D is significantly negatively affected by the debt ratio in emerging markets. Moreover, the presence of agency costs and information asymmetry problems are likely to exert a negative influence.

Table 5.12: Summary of Results for All, Affected and Less-/Unaffected Countries

Variable Name	All Countries	Affected Countries	Less-/Unaffected Countries
$R\&D_{t-1}$	0.72155***	0.66717***	0.84628***
	(0.06410)	(0.11188)	(0.05542)
Age	-0.00310**	-0.00005	-0.00072
	(0.00149)	(0.00408)	(0.00101)
Size	0.38907***	0.29540***	0.17209**
	(0.10619)	(0.10411)	(0.07683)
Export orientation	0.59557**	0.40151**	0.04960
	(0.25989)	(0.20427)	(0.04357)
Diversification	-0.00269	0.20095	0.02122
	(0.09833)	(0.15242)	(0.06761)
Sales growth	0.00218	0.00288	0.03340***
	(0.00511)	(0.00666)	(0.00827)
Profitability	-0.03938	0.30490*	0.19743*
	(0.08303)	(0.16698)	(0.11667)
Debt ratio	-0.28508**	0.27846	0.03327
	(0.16541)	(0.29606)	(0.17585)
Foreign ownership	0.00137*	0.00272*	-0.00027
	(0.00073)	(0.00138)	(0.00107)
Institutional ownership	-0.00081	-0.00157	-0.00038
	(0.00196)	(0.00377)	(0.00147)
Financial crisis	-1.62602***	-1.29717**	-0.69653*
	(0.51825)	(0.54475)	(0.36338)
Industry dummy	Yes	Yes	Yes
Market dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
Country dummy	Yes		
Total Observations	**2739**	**1407**	**1332**
AR(1)	-3.43	-2.2	-3.9
p-value	0.001	0.028	0
AR(2)	0.92	0.98	-0.1
p-value	0.359	0.328	0.922
z_1	960.43(14)	395.57(13)	879.61(13)
p-value	0.0061	0	0
z_2	2.50(8)	2.03(8)	1.93(8)
p-value	0.0122	0.0465	0.06
Hansen J	123.81(119)	136.35(121)	133.42(119)
p-value	0.363	0.161	0.173

Significance levels: * <0.10, ** <0.05, ***<0.01. Standard errors in parenthesis.

With a one-unit change in debt, the probability of R&D investment decreases by 28.51 per cent. This result is consistent with studies by Hall (1990), Cumming and Macintosh (2000) and Cheng and Chen (2006). Moreover, the adverse environment created by the financial crisis also affected R&D investment negatively in emerging markets in general.

When the sample was separated between crisis-affected countries and less-/unaffected countries, some interesting results were produced for R&D determinants. Consistent with Cincera at al. (2012), the results show that R&D investments in both types of country were reduced to a greater or lesser extent by the financial crisis. Affected countries' R&D investments were negatively influenced 1.86 times more than less-/unaffected countries. In other words, the crisis decreased the chances of R&D investment by 60 per cent more for crisis-affected than for less-/unaffected countries. The results show that, during the financial crisis, the R&D determinants for affected countries were firm size, exports, profitability and foreign ownership, while for less-/unaffected countries, the R&D determinants were firm size, sales growth and profitability. This suggests that firms' R&D determinants behave differently in a financial crisis for affected and less-/unaffected countries. The results also imply that, whether a country is affected or not, firm size and profitability play an important role in R&D spending. This also confirms RBV, indicating that firm resources and capabilities are important determinants of R&D investment, even in a financial crisis.

Firm size is positively related to R&D investment for both affected and less-/unaffected countries. This is because larger firms had more organisational slack, so they could invest in innovation even during the crisis period. Profitability impacted positively on R&D investment for both affected and less-/unaffected countries. This is due to that fact that high-profit firms remained in a more advantageous position to grow more quickly than other firms during the crisis period. Interestingly, the results show that the scale of the impact of firm size and profitability in affected countries was greater than in less-

/unaffected countries, implying that affected countries devoted more resources and profits to innovative activities to alleviate the crisis. The results also show that sales growth does not explain R&D investment in financial crisis-affected countries. However, as expected, sales growth positively impacts on R&D expenditure in less-/unaffected countries more than in affected countries. With a one-unit change in sales growth, the probability of R&D spending increases by 3.33 per cent in less-/unaffected countries. This is because, during a crisis period, demand in affected countries is significantly reduced (Stiglitz, 1993; Hud and Hussinger, 2015). Exports significantly impacted on R&D during the crisis. With a one-unit change in exports, there was a likelihood of increasing R&D investment by 40.15 per cent in affected countries. An explanation for this is that, before the beginning of the actual recession, some firms may have stocked up on products, and then sold them overseas during the recession to meet customer demand, earn greater profits and retain market power.

The presence of foreign ownership had a significant positive impact on R&D spending in during the financial crisis for affected countries. This is because, owing to the credit crunch, affected countries tended to finance R&D investments from foreign investors. This result is similar to that obtained by Mangena et al. (2012), who also found that, during the political and economic crisis, ownership structures changed.

5.6 Conclusion

This chapter has empirically examined the firm-level determinants of R&D investment, focusing on the recent financial crisis in emerging markets. 3,100 firm-year observations were analysed for the period 2003-2012 using a Granger causality test and system GMM estimation. The Granger causality test was used to identify countries affected and less-/unaffected by the recession. The results show that Greece, Hong Kong, Indonesia, Israel, Malaysia, Mexico, the Philippines and South Africa were affected by the financial crisis of

2007-2008. However, Bangladesh, Brazil, India, Chile, China, Pakistan, Peru, Poland, Russia, Sri Lanka, Thailand and Turkey were less-/unaffected.

In order to examine the impact of the financial crisis, the firms in emerging markets were divided into local firms and MNEs, and innovative and non-innovative firms. It has been found that both local firms and MNEs were negatively affected by the recent financial crisis. Moreover, MNEs' R&D spending was more greatly affected by the financial crisis than that of local firms. The results show that MNEs were 1.63 times more affected by the recent financial crisis than local firms. Similarly, following cyclical theory, non-innovative firms' R&D expenditure was negatively affected by the financial crisis. In contrast, innovative firms were positively affected. The results indicate that innovative firms continued to invest in R&D during the crisis, expecting to gain competitive advantage when a market up-turn arrived. Moreover, the results suggest that the degree to which firms' R&D was affected by the financial crisis depended on their R&D policy. In other words, a strong R&D policy worked as a safeguard against recession. These empirical results support the cyclical and countercyclical views of R&D investment. Overall, the recent financial crisis adversely affected the R&D investment of emerging market firms.

Furthermore, the results indicate that firm age, firm size, export orientation, debt ratio and foreign ownership were the main determinants of R&D investment in emerging markets during the financial crisis. In addition, it has been found that firms' R&D determinants behave differently between affected and less-/unaffected countries. The results show that the R&D determinants in affected countries were firm size, exports, profitability and foreign ownership, while in less-/unaffected countries the determinants were firm size, sales growth and profitability. Firm size and profitability were the main R&D determinants, irrespective of whether or not a country was affected by the financial crisis. Following RBV, the results confirm that a firm's resources and capabilities are the main determinants of R&D investment, even during a financial crisis. Furthermore, affected

countries' R&D investments were negatively influenced1.86 times more than less-/unaffected countries. In other words, the probability of a decrease in R&D investment in crisis-affected countries is 60 per cent higher than in less-/unaffected countries.

The work presented here has profound implications for future studies of R&D investment in emerging markets, and may help policy makers, investors, managers and senior executives in emerging markets to make decisions on R&D investments. Due to missing values, some emerging markets were not included in the analysis, which is a limitation of this study. Further research is needed on other emerging markets to observe the impact of the financial crisis and identify the precise and correct determinants of R&D investment in emerging markets. Future research might be based on regions, because entire regions were affected equally by the financial crisis. For example, Asian emerging markets were less affected than European emerging markets by the recent financial crisis.

Chapter 6: Behaviour of Macroeconomic Determinants of R&D Investments in Advanced and Emerging Markets

6.1 Introduction

In this knowledge-based era, only technologically-advanced countries such as the USA, South Korea and Japan are dominant in world competition. At the core of this technological advancement is innovativeness. Innovation helps to transform the economic development of a country. Thus, the higher the innovativeness, the more advanced and knowledge-based the economy. Moreover, a country's standard of living (Bernstein, 1996), and economic and productivity growth (Griliches, 1988) depend on its investment in R&D. The argument is that R&D investment provides a higher rate of return than investment in structures, machines and equipment (Coe et al., 1997). Moreover, the social rate of return on private R&D is seven times as large as on fixed investments (Lichtenberg, 1992). However, returns from R&D investments depend on other external factors (OECD, 2006). Oliver (1997) pointed out that the external environment, particularly institutions, have an influence on firm strategies such as R&D that create sustainable competitive advantage. In an empirical study, Hillier et al. (2011) found that institutional settings facilitate investment in R&D activities. Firms are most likely to respond positively to institutional pressure for R&D investment when they possess idiosyncratic resources and capabilities. This implies that firms tend to be more innovative in the presence of strong economic, social, legal and political institutions. Economic institutions have a particularly large impact on investment, financial development and economic growth (Acemoglu and Johnson, 2005). Furthermore, the economic institutions of a country attract MNEs to set up business operations there (Du et al., 2008), and economic institutions support managers and investors in accessing external finance for R&D activities in a timely manner. Macroeconomic factors form part of the effect of economic institutions. For example, strong economic institutions set lower interest rates, which creates a favourable environment for business investment, while adverse macroeconomic conditions, such as a

financial crisis, may be avoided or mitigated by strong economic institutions. Therefore, the combined framework of institutional context and firm strategy allow an examination of the macroeconomic determinants of aggregate R&D investment.

There are several reasons why the macroeconomic environment is considered to be the most important driver of aggregate R&D expenditure. First, favourable macroeconomic conditions are essential for a country's overall R&D performance (OECD, 2014). It is argued that macroeconomic factors determine budgets, policies and strategies for R&D expenditure. For example, a trade liberalisation policy has an impact on R&D investment (OECD, 2006). Clarke (2001) stated that trade openness, either to imports or foreign investment, increases market competition, which may affect domestic R&D spending. Similarly, it is highly likely that restricted trade liberalisation discourages technological change as it raises the price of incentives to innovate. Second, stability of macroeconomic factors helps to maintain a country's investment in R&D (OECD, 2014). Moreover, in order to maintain economic growth and development and grow more robustly, a country will increase R&D expenditure, which is considered as the foundation for new businesses, new jobs and productivity growth (Braconier et al., 2014; OECD, 2015b). Therefore, identifying appropriate macroeconomic factors for R&D expenditure will help policy makers devise long-term plans for national economic growth. Most earlier papers that have dealt with macroeconomic determinants have been based on developed countries (e.g. Becker and Pain, 2008; Wang, 2010; Sameti et al., 2010; Guloglu, 2012; Hammadou et al., 2014) and have covered the pre-crisis period. Thus, this study seeks to close this gap and observe the macroeconomic determinants of R&D investment for both advanced and emerging countries, covering the pre- and post-crisis periods.

The existing literature has shown that GDP growth (Sameti et al., 2010), patents (Varsakelis, 2001), trade openness (Wu et al., 2007) and FDI (Guloglu et al., 2012) are the main macroeconomic determinants of a country's R&D investments. Economic growth

creates employment opportunities, increasing the number of R&D researchers. Countries use patents to encourage, protect and reward innovation (Allred and Park, 2007a). Moreover, patents encourage individuals or firms to take first-mover advantage. Trade openness helps traders or partners to pool research, and this pooled research facilitates investment in large projects such as R&D. Furthermore, trade openness intensifies global market competition, and market competition boosts R&D investment (Barker, 2010; Kilic, 2014). FDI may benefit R&D activity in the host country via spill-over channels such as reverse engineering, skilled labour turnover, demonstration effects and supplier–customer relationships (Cheung and Lin, 2004). In addition, FDI facilitates the use of upgraded technologies that help to increase productivity, fostering R&D investment (Rowthorn and Wells, 1987; Robert and Romana, 1997, cited in Lin and Yeh, 2005).

Consistent with the existing literature, by applying a fixed and random-effect regression model with an IV approach for 36 countries during the period 2002-2011, this study finds that GDP growth, exports, trade openness, patents and financial crisis are the main macroeconomic determinants of a country's R&D investment. Interesting results emerge when the sample countries are separated into sub-samples of advanced and emerging countries. It is found that GDP growth, exports, trade openness, patents and financial crisis are the macroeconomic determinants for advanced countries, while exports, trade openness, FDI, patents and market size are the macroeconomic determinants for emerging countries. Among the common determinants, only patents have a positive impact on R&D investments for both advanced and emerging countries. This implies that both types of country encourage the protection of property rights. Export intensity positively affects emerging countries' R&D intensity while negatively affecting advanced countries. On the other hand, trade openness is negatively related to R&D intensity in emerging countries while positively related in advanced countries. In general, the results of the analysis suggest that macroeconomic determinants behave differently for R&D investment between

advanced and emerging countries, owing to their different nature and purpose and their level of economic development.

The contribution of this chapter is threefold. First, although numerous researchers have examined the firm- and industry-level determinants of R&D investment, few have emphasised its macroeconomic determinants (e.g. Varsakelis, 2001; Becker and Pain, 2008; Wang, 2010; Sameti et al., 2010; Guloglu, 2012; Hammadou et al., 2014). Therefore, the latter are examined in this study. Moreover, this is the first work to consider the financial crisis as a determinant of a country's R&D policy. The main reason for doing so is that the recent financial crisis adversely affected most countries worldwide, and during the recession, the role of other economic variables may have changed.

Second, this is thought to be among the first efforts to test variation across the macroeconomic determinants of R&D investment for advanced and emerging countries. Macroeconomic policies determine a country's growth and development path, which affects the aggregate economy (Ames et al., 2001). Moreover, macroeconomic policies create networks with the rest of the world. For example, a country's export intensity depends on international relations with other countries which can be achieved through an open trade policy or a flexible tax policy. However, these macroeconomic policies differ between emerging and advanced countries (Monteil, 2011). It is widely accepted that developed countries' macroeconomic policies are stable, while the sensitivity of emerging market policies is highly likely to depend on policy changes and shocks. As a result, macroeconomic policies are made in the context of emerging economies (Montiel, 2011). Moreover, Montiel (2011) has pointed out that distinguishing emerging markets from developed markets helps provide an understanding of how economies work at the macroeconomic level. Thus, this study will be of particular interest to policy makers in emerging markets, who need constantly to make decisions on macroeconomic policies.

Third, in relation to the methodological contribution, this study is among the first to investigate the macroeconomic drivers of R&D investment by addressing causality. Most of the existing literature has shown causality between GDP growth and R&D investment, and between patents and R&D investment (see Section 6.2)[2]. Moreover, unobserved heterogeneity is taken into account, as the results described in this chapter are based on panel data estimation.

This chapter is organised as follows. Section 6.2 presents the hypotheses of the study, Section 6.3 introduces the data and research methods, Section 6.4 presents and discusses the results, and Section 6.5 draws conclusions from this study.

6.2 Hypotheses to be tested

There is a strong relationship between GDP growth and R&D investment (OECD, 2015b). According to the acceleration principle, changes in economic growth have an effect on R&D investment. Rising economic growth indicates rising profits and sales and greater use of existing capacity. In order to maintain and improve firm performance, firms ultimately invest in R&D (Pindado et al., 2015). In a similar vein, in order to maintain economic growth and grow more robustly, countries increase their R&D expenditure. Furthermore, economic growth that results in the creation of employment opportunities increases the number of R&D researchers. Markusen (1986) stated that richer consumers tend to allocate a greater share of income to differentiated products, which are more R&D intensive. Thus, increased GDP growth seems to lead to increased investment in R&D. As a result, Wang (2010) argued that GDP growth creates stronger incentives for R&D investment. Sameti et al.'s (2010) study, based on 30 OECD countries, revealed that GDP growth has a positive impact on R&D investment. On the other hand, Wang (2010) found a fragile relationship between GDP growth and R&D investment, arguing that R&D investment policies and

[2] There may be causality between exports and R&D investment, FDI and R&D investment and market size and R&D investment, but the existing literature does not provide sufficient evidence for these.

targets are determined by governments and other international organisations, not by GDP growth. Santos and Catalão-Lopes (2014) examined the causality between GDP growth and R&D in European countries, with an emphasis on Portugal, and found that causality may exist but varies across countries. Thus, the existing literature has provided inconclusive results. On the grounds of the acceleration principle, the following hypothesis is postulated:

> **Hypothesis 1***: The higher the GDP growth, the higher the R&D investment intensity.*

A larger export market increases the probability of investment in R&D (Kumar and Saqib, 1996; Tan and Hwang, 2002). Foreign exposure induces increases in productivity growth that ultimately foster investment in R&D. As a result of international linkages, exporters are constantly updated on recent technological developments. Moreover, in order to maintain competitive strength and produce international-standard, diversified products, exporters need to invest in R&D. Damijan et al. (2010) stated that exporters are two to five times more likely to be innovative than non-exporters, while Aw et al. (2007) revealed that exporters that invest in R&D and staff training are 10 to 17 percent more efficient than non-exporters. Furthermore, in a study based on Canadian manufacturing firms, Baldwin and Gu (2004) observed that new exporters are likely to invest in advanced technology in order to enhance absorptive capacity. This concept supports the "learning by exporting" hypothesis, implying that previous exporting experience increases the probability of firms' R&D investment (Salomon and Shaver, 2005). Damijan et al. (2010) found that exporting activity helps firms to become more process-innovative. Moreover, Aw et al. (2007) found a positive relationship between exports and R&D investment based on micro-data. However, according to Abdelmoula and Etienne (2010), exports generally involve standard, non-innovative products. Earlier studies have failed to reach a consensus on the relationship between exports and R&D investment. Although earlier results have been inconclusive, on the basis of foreign exposure, the following hypothesis is postulated:

Hypothesis 2: *Exports have a positive impact on R&D expenditure.*

Trade openness has an impact on R&D investment (Wu et al., 2007) and facilitates traders or partners in pooled research, which aids investments in large projects such as R&D. Trade openness intensifies global market competition, and market competition boosts R&D investment. The greater the competitiveness of a country, the higher its R&D investment (Varsakellis, 2001). Lower trade barriers encourage foreign presence, which has a positive impact on R&D activity (Anwar and Sun, 2013). Moreover, trade openness increases stock market efficiency (Lim and Kim, 2011), which ensures that investors create wealth by investing in R&D. According to Matsushima et al. (2008, cited in Sameti et al., 2010), high innovation and fixed trade costs cause a positive relationship between trade openness and the R&D activities of a firm, while low innovation and fixed trade costs cause a negative relationship between the two. However, based on a cross-country study, Varsakellis (2001) explained that, due to the cross-industry effect, there is no relationship between economy openness and R&D intensity. Trade openness increases competition, and on these grounds the following hypothesis is postulated:

Hypothesis 3: *Trade openness has a positive impact on R&D expenditure.*

In general, expansion of FDI increases R&D investment by MNEs and foreign firms in local markets. FDI may benefit R&D activity in the host country through spill-over channels such as reverse engineering, skilled labour turnover, demonstration effects and supplier-customer relationships (Cheung and Lin, 2004). Sasidharan and Kathuria's (2011) examination of the relationship between FDI and R&D investment in Indian manufacturing firms for the period 1994-2005 found, when their sample was divided according to equity ownership, that FDI and R&D are complements not substitutes. They also found that FDI induces foreign-owned firms to increase R&D investment in high-tech industries and firms with minority ownership. However, Beladi and Firoozi (2008) have stated that the existing literature has not shown an inconclusive relationship between FDI and R&D investment.

There is a negative relationship if MNEs avoid entry because domestic firms face technological challenges, and a positive relationship when MNEs are motivated partly by technological spill-over into domestic markets. From the macroeconomic perspective, increased FDI leads to de-industrialisation (Lin and Yeh, 2005), which reduces R&D investment. This is because increased FDI decreases domestic investment, employment and exports (Singh, 1977; Thirlwall, 1982, both cited in Lin and Yeh, 2005). On the other hand, FDI facilitates the use of upgraded technologies, which helps to increase productivity (Rowthorn and Wells, 1987; Robert and Romana, 1997, cited in Lin and Yeh, 2005) and fosters R&D investment. However, Potterie and Lichtenberg (2001) argued that FDI contributes to neither improvement nor reduction of the technological base of host countries. On the grounds of the spill-over effects of FDI, the following hypothesis is proposed:

Hypothesis 4: *The greater the FDI, the higher the R&D investment.*

Invention motivation theory explains that anticipation of patents provides motivation for useful inventions. Moreover, inducing commercialisation theory views patents on inventions as inducing the investment needed to develop and commercialise those inventions. Patents allow innovators to produce particular products and ensure monopoly power in the market, thus increasing profits and creating additional incentives for investment in R&D (Mukherjee, 2005). In this regard, Allred and Park (2007a) stated that countries use patents to encourage, protect and reward innovation. Wang (2010) argued that strong patents increase the market share of owners of new goods or processes, and prohibit the entrance of imitators; hence, producers invest in R&D in order to cover a larger market. As a result, Grabowski's (1968) study found a significant positive influence of patents on R&D investment. Klemperer's (1990) study also came to the same conclusion. On the other hand, Almedia and Teixiera (2007) provided mixed results. They argued that making patents easier to obtain may actually cause R&D expenditure to

decline. In this sense, raising patent costs and increasing standards will stimulate R&D. Although the existing literature has shown inconclusive results, on the basis of invention motivation theory, the following hypothesis is postulated:

Hypothesis 5: *Patents have a positive impact on R&D expenditure.*

Financial crisis is never welcome. Following cyclical theory, during a financial crisis, firms reduce their R&D investment due to financial constraints. Financial constraints, lower customer demand for products and services, low profit margins and a generally "pessimistic mood" (Freeman et al., 1982) make R&D cyclical. Moreover, Stiglitz (1993) and Hall (2002) argued that firms will decrease their R&D investments during a financial crisis due to credit rationing and limited internal funding. In light of the recent financial crisis, the OECD (2009, 2012) and Archibugi et al. (2013) found that firms reduced their investment in innovation and R&D. The anti-cyclical view states that financial crises induce R&D investment in order to replace old and inefficient production techniques with newer ones. Opportunity costs, availability of internal funding, high adjustment costs and large firm size make R&D investment counter-cyclical. Consistent with the anti-cyclical view, Archibugi et al. (2013b) found that fast-growing new firms and those already highly innovative before a crisis invest in innovation during the crisis. Thus, whether or not R&D investment is cyclical remains an open question. According to Cincera et al. (2012), it depends on how a company reacts to a financial crisis and the way it manages the R&D process and collaboration or outsourcing with others. At a country level, a financial crisis may have different effects because of pre-crisis preparation, previous experience, stock market strength, and the law and regulations of a country (Graham et al., 2012; Wenn, 2013). Following cyclical theory, the following hypothesis is postulated:

Hypothesis 6: *Financial crisis has a negative impact on R&D expenditure.*

Increase in market size has an impact on R&D investment (Acemoglu and Linn, 2004). Market size influences R&D decisions in the following ways. First, larger markets have a

larger number of producers, which ensures market competition, and greater market competition boosts firms to invest in R&D. Second, larger market share indicates higher internal funding and more profits that can be used to finance R&D activity. Third, larger market share ensures an ability to recoup returns on R&D investment. Acemoglu and Linn (2004) tested the effects of market size on innovation in the US pharmaceutical industry for the period 1965-2000, and found that a one per cent increase in market size led to an approximately four per cent increase in the introduction of new drugs and new molecular entities, and that R&D and technological change was directed toward more profitable areas. Moreover, Berry and Waldfogel (2010) examined the relationship between market size and product quality, finding that with variable-cost products, such as restaurants, the range on offer increases with market size, and with fixed-cost products, such as newspapers, the quality of products increases with market size. On the grounds of the above discussion, the following hypothesis is postulated:

Hypothesis 7: *Larger market size ensures greater R&D investment.*

6.3 Data, model and method

6.3.1 Data

Annual data were drawn from the World Bank's Development Indicators and Worldwide Governance Indicators. After removing data with missing values, the World Bank provided data on 36 countries (see Appendix 1). To be included in the sample, a country must have 10 consecutive years of data. The 10-year sample period of the study was from 2002 to 2011. This period was selected because of data availability on the variables from the World Bank's database. Gaps in the latest data were minimised where possible. Balanced panel data were used for the sample countries. Panel data were used because they enable control for firm heterogeneity, provide more information, greater variability and more degrees of freedom, avoid multicollinearity problems, provide more efficient results and are more

suitable for identifying and measuring effects that are not detectable in pure cross-sectional or pure time series data (Baltagi, 2013).

Table 6.1: Summary of Variables

Variable	Description
R&D intensity	R&D expenditure by percentage of GDP
GDP growth	Annual GDP growth
Exports	Exports of goods and services by percentage of GDP
Trade openness	Ratio of exports and imports to GDP
FDI	FDI received (In log)
Patents	Number of patent applications (In log)
Financial crisis dummy	Takes a value of 1 during crisis years 2007-2009
Market size	Market value of shares by percentage of GDP
Regulatory quality	Mean value from -2.5 to 2.5 capturing the ability of the government
Government effectiveness	Mean value from -2.5 to 2.5 capturing quality of policy formulation and implementation
Savings	Gross savings by percentage of GDP
Inflation	Annual percentage change in consumer price index
Country dummy	Takes a value of 1 if the country is advanced, and 0 otherwise

Table 6.1 provides definitions of the variables. From the existing literature, the above-listed variables have been found to have significant effects on countries' R&D expenditure. In this study, R&D intensity is considered as a dependent variable, being the ratio of annual R&D expenditure to GDP. The main independent variables are GDP growth, exports, trade openness, FDI, patents, financial crisis and size of the market. The control variables are regulatory quality and government effectiveness, and the instrumental variables are savings and inflation. All variables are standardised to a common USD exchange rate. Some of the explanatory variables have higher scales than other, and the absolute value of the variables increases the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, natural logarithm, ratio and percentage variables are adopted.

6.3.1.1 Control Variables

R&D investment is highly related to country-specific factors such as the political, legal and social environment. In order to isolate the effect of specificity, institutional factors are used as a control variable. The control variables are the quality of regulation and government

effectiveness of a country. Regulatory quality measures the ability of a government to formulate and implement sound policies and regulations that promote private-sector development (World Bank, 2014). Issues for consideration include market competition policy, protection of intellectual property, reliability of financial statements, tax codes and investment incentives (The Economist, 2014). Regulatory quality ranges from approximately -2.5 (weak) to 2.5 (strong) for scores of governance performance. The government effectiveness of a country measures its quality of policy formulation and implementation, the sincerity of its commitment to such policies, and its degree of independence from political pressure (World Bank, 2014).

6.3.1.2 Instrumental variables

From the existing literature, it can be said that there is causality between R&D investment and GDP growth and between R&D investment and patents, which create an endogeneity bias problem. In order to avoid endogeneity bias and obtain estimates of the simultaneity of R&D investment and GDP growth and patents, three instrumental variables are used: the gross savings and inflation of a country, and the lag of the dependent variable. Using these instrumental variables adds variation to GDP growth and patents, making them exogenous to R&D intensity.

There is no doubt about the relationship between a country's savings and economic growth. Higher savings indicate lower consumption, enhancing investment opportunities, employment and production, and leading to higher economic growth. On the other hand, higher economic growth may increase a country's savings rate. According to the Harrod-Domar growth model, two important factors for economic growth are a country's savings and its capital-output ratio.

Inflation is a strong predictor of GDP growth. Higher inflation decreases economic growth while lower inflation increases economic growth. Lower inflation indicates stability and assurance, which lead to higher investment, and higher investment may lead to stronger

economic growth. On the other hand, economic growth also influences inflation. For example, in the period of the Lawson boom of the 1980s, the UK's annual economic growth reached five per cent, causing an 11 per cent increase in inflation.

R&D investment encourages innovation (Prodan, 2005). Innovation helps to increase national productivity and employment which, in turn, spurs GDP growth. Moreover, innovation ensures a country's long-term growth. R&D investments with a time lag also use a country's patent applications as an input. According to Grief (1985, cited in Prodan, 2005), it takes one to two years from R&D investment to patent application, although Hall et al. (1986) denied the existence of this time lag. In this study, a one-year lag is considered for R&D intensity with regard to patent applications.

Tables 6.2 and 6.3 present descriptive statistics for the dependent, independent, control and instrumental variables.

Table 6.2: Summary Statistics for All Countries

Variable	Mean	Standard Deviation	Minimum	Maximum
R&D intensity	1.56845	1.00826	0.11597	4.52323
GDP growth	3.22602	4.25394	-17.95499	15.24038
Exports	47.55467	34.45117	9.06343	230.26900
Trade openness	94.40744	64.75060	21.16393	439.65670
FDI	9.68017	1.99117	0.00000	11.53156
Patents	3.32678	0.97004	1.25527	5.61892
Financial crisis	0.30000	0.45890	0.00000	1.00000
Market size	56.69986	42.25633	3.77917	248.51920
Regulatory quality	0.95831	0.67498	-0.61000	1.94000
Government effectiveness	0.96072	0.81427	-0.81000	2.43000
Savings	23.24385	8.10167	9.03011	53.34713
Inflation	3.99289	4.29327	-4.47994	44.96412
Country dummy	0.61111	0.48818	0.00000	1.00000

Source: Author's calculations

Table 6.3: Summary Statistics for Advanced and Emerging Markets

	Advanced countries				Emerging countries			
Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
R&D intensity	2.07424	0.96462	0.37808	4.52323	0.77362	0.34400	0.11597	1.83617
GDP growth	2.36238	3.81298	-17.95499	15.24038	4.58318	4.56015	-14.80000	14.16239
Exports	54.26905	40.34749	9.06343	230.26900	37.00351	17.80641	10.87158	93.99816
Trade openness	106.07120	75.26125	21.16393	439.65670	76.07869	36.74961	22.11830	180.50120
FDI	9.59976	2.30682	0.00000	11.53156	9.80653	1.35259	0.00000	11.52060
Patents	3.42711	1.01875	1.25527	5.56634	3.16912	0.86841	1.73239	5.61892
Financial crisis	0.30000	0.45930	0.00000	1.00000	0.30000	0.45990	0.00000	1.00000
Market size	68.54734	45.36044	3.77917	248.51920	38.08239	28.26092	4.58916	178.19710
Regulatory quality	1.38927	0.32055	0.48000	1.94000	0.28107	0.50881	-0.61000	1.31000
Government effectiveness	1.50368	0.46456	0.49000	2.43000	0.10750	0.41544	-0.81000	1.02000
Savings	23.82910	7.19826	10.00310	51.53243	22.32418	9.30014	9.03011	53.34713
Inflation	2.39881	2.01980	-4.47994	15.40320	6.49787	5.55302	-1.14575	44.96412

Source: Author's calculations

R&D intensity in advanced countries is almost double that of emerging countries, although GDP growth is completely the opposite, being almost double in emerging countries compared with advanced countries. Consumer spending power and structural development increase GDP growth in emerging markets. Owing to the risk of intellectual property theft and management issues, R&D investment in emerging markets is far below that of advanced ones (The Economist, 2014), although emerging-market R&D investment has recently increased considerably. Investments in technology are established and fixed in advanced countries (Logue, 2011). There are significant disparities in exports, trade openness and market size between advanced and emerging countries. However, higher standard deviations for these factors indicate variations across advanced countries. Institutional factors such as regulatory quality and government effectiveness are better in advanced countries than in emerging countries. Regulatory quality is weak and often uncertain, and governments are typically more intrusive and less transparent in emerging markets (The Economist, 2014). Emerging countries' inflation rates vary, but are commonly higher than in advanced countries.

6.3.2 Model

In order to examine the macroeconomic determinants of R&D expenditure, the following model was devised. A semi-logarithmic model is used for the analysis, firstly because financial crisis is a dummy variable which takes values of 0 and 1, so the logarithm cannot be used for this variable as the logarithm of 0 does not exist. Secondly, GDP growth, regulatory quality and government effectiveness may be negative; thus, the logarithms of these values cannot be used.

$$RD\ Intensity_{it} = \alpha_i + \beta_1(GDP\ growth_{it}) + \beta_2(Export_{it}) + \beta_3(Trade\ Openness_{it}) + \beta_4 ln(FDI_{it}) + \beta_5 ln(Patent_{it}) + \beta_6(Financial\ crisis_{it}) + \beta_7(Market\ Size_{it}) + \beta_8(Regularity\ Quality_{it}) + \beta_9(Government\ Effectiveness_{it}) + c_i + v_{it} \quad \textbf{(1)}$$

where subscript *i* represents the country and *t* represents the year. Here α_i, and β_1 to $\beta_9$represent the relationships between R&D investment and GDP growth, exports, trade

openness, FDI, patents, financial crisis, market size, regulatory quality and government effectiveness. The error component ε_{it} is separated into two components $\varepsilon_{it} = c_i + v_{it}$. As the countries are split between advanced and emerging, a country dummy, c_i is included. The country dummy captures country-specific effects. Moreover, v_{it} is considered as a random disturbance term which is assumed to be i.i.d. normal.

6.3.3 Method

A fixed- and random-effect model with an IV approach was used to examine the macroeconomic determinants of a country's R&D investment.

An IV approach was adopted for the following reasons. First, the existing literature has shown causality between R&D investment and GDP growth and between R&D investment and patents. These simultaneously create a problem of endogeneity bias. In the presence of endogeneity, OLS estimation will be biased and inconsistent, and standard errors will be unreliable. According to Worrall (2010), an IV approach provides a potential solution to endogeneity bias in the context of panel data. Second, the IV approach provides consistent estimation under the assumption that valid instruments exist (Cameron and Trivedi, 2010).

Finally, the model was tested for potential misspecification. First, the hypothesis that the instruments are weak was tested. An Anderson-Rubin Wald test rejected the null hypothesis at the statistically significant one per cent level. Moreover, the Cragg-Donald Wald F statistic exceeded the 10 per cent maximum bias critical value. Second, the Kleibergen-Paap rk LM test indicated that the excluded instruments predict the endogenous variable at the five per cent significance level. Third, the Hansen J statistic of over-identifying restrictions was used to test whether the instruments are valid, i.e. uncorrelated with the error terms. The results show that the instruments in the model are valid. Fourth, the hypothesis that the regressors are exogenous was tested. An endogeneity test rejected the null hypothesis at the one per cent significance level.

Although the Hausman test shows a preference for a fixed-effects model, due to their distinct advantages, both fixed-effects and random-effects models were used. A fixed-effects model adjusts data changes within individuals, while a random-effects model is efficient in adjusting changes across individuals. A fixed-effects model assumes that individual-level residuals are correlated with predictors, while a random-effects model assumes no correlation.

A fixed-effects model was devised using two-step GMM with robust standard errors, and a random-effects model using generalised least squares (GLS) without robust standard errors. GMM was used rather than 2SLS or limited information maximum likelihood (LIML) for the following reasons. First, GMM is robust to autocorrelation and heteroscedasticity, and Wooldridge and Modified Wald tests confirmed the presence of autocorrelation and heteroscedasticity problems in the data. Second, GMM nests several estimations within a single framework, including OLS, 2SLS and IV (Worrall, 2008). Moreover, GMM provides more efficient estimation when there are two endogenous variables. Due to software limitations, the specification test and robust standard errors are not reported for the random-effects model, although the fixed- and random-effects models provided almost the same results.

6.4 Results

Table 6.4 presents the empirical results of analysis based on the IV approach. The results show that GDP growth, exports, trade openness, patents and financial crisis are the main macroeconomic determinants of a country's R&D investment. GDP growth, exports, and financial crisis have a significant negative impact on R&D investment, while patents and trade openness have a significant positive impact.

A one-unit rise in GDP growth is associated with a 3.2 per cent reduction in R&D intensity. This reversely supports Hypothesis 1, showing that lower GDP growth induces a country to be more innovative. Moreover, during the recent financial crisis, countries

employed capital for real investments or projects that would provide quick returns, rather than long-term R&D investments. In addition, the negative relationship between GDP growth and R&D investment may be due to the selected sample period. Wang (2010) also found that GDP growth is a fragile determinant of R&D intensity, based on 26 OECD countries. R&D investment changes with variations in a country's export performance. With a one-unit change in exports, the probability of R&D investment decreases by four percent. This means that the adverse effect of the recent financial crisis reduced the exit probability of exporter firms. Moreover, Paunov (2012) pointed out that losses on export market sales are more likely to lead to discontinuation of innovation. In contrast, Domijan et al. (2010) found that the learning effect of exporting does not contribute to R&D investment. This reversely supports Hypothesis 2. A one percent change in trade openness produces a three per cent change in R&D investment. Higher trade openness opens the door to global market competition, which influences firms to invest in R&D. Sameti et al. (2010) also identified trade openness as a determinant of R&D intensity. The results support Hypothesis 3. With a one-unit change in patenting, there is a probability of a 246 per cent increase in R&D investment. This is because patents motivate greater investment in R&D to obtain first-mover advantage. This is supported by invention motivation theory. Similar results were obtained by Varsakelis (2001), based on a study of 50 countries. Thus, Hypothesis 5 is supported. According to cyclical theory, financial crisis causes firms to cut down on R&D investment in order to cope with difficult times. With a one-unit rise in financial crisis, the likelihood of R&D investment reduces by around 16 percent. This implies that recession adversely affects a country's productivity, investment and employment. An OECD (2012) study found similar results. Thus, Hypothesis 6 is supported.

Table 6.4: Results Summary – IV Approach

	Fixed Effects Estimation			Random Effects Estimation		
	All	Advanced	Emerging	All	Advanced	Emerging
GDP growth	-0.03260**	-0.05068*	0.00557	-0.03734**	-0.04721**	-0.00051
	(0.01627)	(0.02757)	(0.00761)	(0.01217)	(0.02202)	(0.00513)
Exports	-0.04080*	-0.09382**	0.01897*	-0.04688**	-0.09279**	0.00667
	(0.02413)	(0.03945)	(0.01120)	(0.01637)	(0.03012)	(0.00751)
Trade openness	0.03033**	0.06420**	-0.01074*	0.03469***	0.06362***	-0.00209
	(0.01411)	(0.02357)	(0.00632)	(0.00940)	(0.01707)	(0.00429)
FDI	0.00176	0.00970	-0.01059**	0.00196	0.00617	-0.01604*
	(0.00879)	(0.01311)	(0.00483)	(0.00851)	(0.0116)	(0.0081)
Patents	2.46312***	3.74313***	1.01426***	2.30475***	2.80906***	0.85662***
	(0.50563)	(0.81999)	(0.10811)	(0.24517)	(0.35973)	(0.08906)
Financial crisis	-0.15662**	-0.22506**	0.02831	-0.16762**	-0.19625**	0.00533
	(0.07226)	(0.10716)	(0.03858)	(0.05758)	(0.08736)	(0.03122)
Market size	0.00025	0.00266	-0.00115*	0.00029	0.00112	-0.00094*
	(0.00094)	(0.00164)	(0.00067)	(0.00091)	(0.00146)	(0.00055)
Regulatory quality	-0.07618	0.51016	-0.02543	-0.01028	0.23307	0.09429
	(0.21555)	(0.36371)	(0.10541)	(0.15731)	(0.26352)	(0.08794)
Government effectiveness	-0.14861	0.11174	-0.44189***	-0.07868	0.05817	-0.16104
	(0.12922)	(0.18425)	(0.12201)	(0.14851)	(0.20125)	(0.11978)
Country Dummy				0.53835		
				(0.57824)		
Kleibergen-Paap rk LM test	22.729***	8.872**	7.699**			
Anderson-Rubin Wald test	99.64***	80.32***	41.68***			
Cragg-Donald Wald F stat	19.499	11.833	14.202			
Endogeneity test	27.264***	16.477***	17.268***			
Hansen J statistics *P*-value	0.8451	0.2602	0.9946	0.5015	0.1729	0.3817
Number of observations	324	198	126	324	198	126

Note: Standard errors in parenthesis; significance levels: *< 0.10, **< 0.05, ***< 0.01.

Comparison of the behaviour of macroeconomic determinants between advanced and emerging markets reveals some interesting results. The results show that patents, exports and trade openness, with different signs, are common determinants of R&D investment. Numbers of patent applications have a significant positive relationship with R&D investment in both advanced and emerging markets. This implies that both types of country encourage protection of property rights. Moreover, people or firms in both types seek to take early opportunities for new inventions or creations. Varsakelis (2001) reached the same conclusion based on 50 countries. Exports have a positive impact on R&D investment in emerging markets and a negative impact in advanced countries. This is

because emerging markets can make products more cheaply than developed countries, which attracts international attention and earns higher profits. Moreover, emerging markets may adopt an export-led growth strategy. Empirical evidence from emerging markets has shown a positive relationship between exports and R&D investment. Kumar and Saqib's (1994) study of India and Braga and Wilmore's (1991) study of Brazilian firms found a positive relationship between the two.

On the other hand, trade openness is positively associated with R&D investment in advanced countries but negatively associated in emerging countries. This result implies that, due to discrimination in trade restrictions, tax competition and exchange rates, trade openness has a positive effect in advanced countries and a negative effect in emerging markets. The empirical evidence has supported both directions: Sameti et al. (2010) supported a positive relationship, while Eaton and Kortum (2001) supported a negative relationship. In this regard, Gupta (2009) suggested that neither trade openness nor a closed economy, but controlled, regulated and selective trade are appropriate for emerging markets. The GDP growth index exhibits a significant negative relationship with R&D investment in advanced countries. This means that, as a result of the recent financial crisis, GDP growth in advanced countries slowed down and was not used as a tool for innovation. Moreover, advanced countries had already gained benefits from past technological advancements and innovation. Akinwale et al. (2012) observed a negative relationship between R&D and economic growth. It is assumed that emerging markets grew more than twice as much as advanced countries. As a result, GDP growth shows a positive sign, but is not significant for emerging countries. This is because emerging countries spent their income on infrastructural development.

Consistent with cyclical theory, there is no doubt that the recent financial crisis adversely affected advanced countries, creating a credit crunch in these countries. Emerging markets were more resilient during the financial crisis and are considered to be crisis-resistant

countries. With a one-unit change in FDI, the probability of R&D investment decreases by one percent in emerging countries. This may be because FDI in emerging markets does not contribute to R&D investment, or may help production and exports rather than R&D intensity. Moreover, FDI is comparatively low in emerging markets. A similar result was revealed by Kathuria's (2008) study of the emerging market of India. Market size has a negative impact on R&D investment in emerging markets. Emerging markets have small market size due to lower per capita income and consequently lower purchasing power (Gupta, 2009). Small market size provides weak incentives for R&D investment. Moreover, government effectiveness and R&D investment have a negative relationship in emerging countries. This implies that emerging markets have a lack of good governance. The results suggest that macroeconomic determinants behave differently for R&D investment between advanced and emerging countries due to their different nature and purpose.

Table 6.5: Comparison of Results

Determinants	Hypothesis	All	Advanced	Emerging
GDP growth	Positive	Reversely Supported	Reversely Supported	
Exports	Positive	Reversely Supported	Reversely Supported	Supported
Trade openness	Positive	Supported	Supported	Reversely Supported
FDI	Positive			Reversely Supported
Patent	Positive	Supported	Supported	Supported
Financial crisis	Negative	Supported	Supported	
Market size	Positive			Reversely Supported

Table 6.5 compares the results with the hypotheses. All hypotheses based on the literature are either supported or reversely supported by IV estimation. It was hypothesised that higher GDP growth contributes to higher R&D investment in a country. This is reversely supported for advanced countries. This suggests that lower GDP growth may contribute to higher R&D investment for sustainable or long-term growth. The export hypothesis is supported for emerging countries; that is, higher export performance has a positive relationship with R&D intensity. However, export intensity negatively affects R&D investment for advanced countries. The trade openness hypothesis is supported for

advanced countries, while reversely supported for emerging countries. FDI and R&D investment are negatively related for emerging markets. This is because FDI is still weak in emerging markets. Only the patent hypothesis provides the same results for all categories, supporting the hypothesis. Financial crisis negatively affects advanced countries but does not affect emerging countries. Market size is reversely supported for emerging markets. This suggests that lower market size may result in greater R&D investment in order to grow faster and compete with global markets. All results are the same for all countries and for advanced countries because about 60 per cent of the sample consisted of advanced countries.

6.5 Conclusion

This chapter has examined the macroeconomic determinants of R&D investment. Macroeconomic behavioural differences between advanced and emerging countries have been investigated. Panel data fixed-effects and random-effects regression models with an IV approach were used for36 countries for the period 2002-2011.

GDP growth, exports, trade openness, patents and financial crisis are found to be the main macroeconomic determinants of a country's R&D investment.GDP growth negatively affects R&D investment, showing that lower GDP growth induce sa country to be more innovative. Moreover, as a result of the recent financial crisis, countries employed capital for real investments or projects that would provide quick returns, rather than long-term R&D investment. Export intensity and R&D intensity are negatively associated. This means that the adverse effects of the recent financial crisis reduced the exit probability of exporter firms. There is a positive relationship between trade openness and R&D intensity. Higher trade openness opens the door to global market competition, which influences firms to invest in R&D. Patents have a positive impact on a country's R&D investment. This is because patents motivate greater investment in R&D in order to obtain first-mover

advantage. Financial crisis negatively affects countries' R&D investment. This implies that recession adversely affects a country's productivity, investment and employment.

When the sample countries were separated into advanced and emerging, the estimation provided surprising results. The results suggest that macroeconomic determinants behave differently for R&D investment between advanced and emerging countries, owing to their different nature and purpose.GDP growth, exports, trade openness, patents and financial crisis are found to be the macroeconomic determinants for advanced countries, while exports, trade openness, FDI, patents and market size are the macroeconomic determinants for emerging countries. Among the common determinants, only patents have a positive impact on R&D investment for both advanced and emerging countries. This implies that both types of country encourage protection of property rights. Moreover, people and firms in both types seek to take early opportunities for new inventions or creations. Export intensity positively affects emerging countries while negatively affecting advanced countries. This is because emerging markets can make products more cheaply than developed countries, which attracts international attention and earns higher profits. On the other hand, trade openness is negatively related to R&D investment in emerging countries while positively related in advanced countries. The result simply that discrimination in trade restrictions, tax competition and trade openness has a positive effect in advanced countries and a negative effect in emerging markets. GDP growth and financial crisis negatively impact on R&D intensity. Due to the recent financial crisis, investment reduced dramatically in advanced countries, which also affected their GDP growth. FDI and market size negatively affect R&D intensity in emerging markets. FDI is still weak and market size small in emerging countries.

It is hoped that this study will serve as new evidence for investors and policy makers when considering R&D investment in advanced and emerging countries. Due to missing values, not all advanced and emerging markets were included in the analysis, which is a limitation

of this study. In addition, also due to missing values, some economic factors that may have an impact on country-level R&D investment were not included. Due to data availability, interest rates, savings and the lag of the dependent variable were considered as instrumental variables, which is another limitation of the study. However, the empirical results of this study may provide lessons for other advanced and emerging markets. Further investigation is needed on other advanced and emerging markets to identify specific macroeconomic determinants of R&D investment.

Chapter 7: Institutional Determinants of R&D Investment: Evidence from Emerging Countries

7.1 Introduction

R&D investment is considered to be one of the most essential elements in promoting economic growth and development (OECD, 2015b). Wang (2010) observed that countries with a sufficient level of R&D investment can achieve target economic growth by promoting productivity and advancing their knowledge base. A central focus of innovation research is analysis of R&D determinants (Barge-Gil and López, 2014). Previous research has used the Schumpeterian hypothesis and inter-industry effects to explain the determinants of R&D investment (Barge-Gil and López, 2014). RBV (Lai et al., 2015) and the behavioural view (Lewellyn and Bao, 2015) have also been used to explain the determinants. However, Wang (2010) stated that institutional factors may also help to explain R&D investment. Following an observation by Barge-Gil and López (2014), who pointed out the omission of important R&D determinants from the literature, this paper examines the institutional determinants of R&D investment.

Scott (1995) and Oliver (1997) stated that strategic choices such as R&D are driven by the institutional framework. Wang et al. (2015) supported this notion, indicating that R&D investment strategy, structure and process must be compatible with institutional demands. There are several reasons why the institutional environment is considered to be the most important driver of innovative activities. First, good institutional quality may attract foreign investors (Bénassy-Quéré, 2007), help firms to access external finance (La Porta et al., 1997), mitigate opaque information (Hillier et al, 2011), and provide incentives (Edquist and Johnson, 1997);it therefore promotes R&D investment. Second, institutions influence the cost of innovation (Wang et al., 2015). Poor or corrupt institutions may increase the cost of R&D investment. Third, good governance, with strong intellectual property rights (IPR), provides investor protection, thereby facilitating investment in R&D. In this regard, Ghosh and He (2015) stated that stronger investor protection reduces

managers' opportunistic behaviour of diverting cash flow to themselves; therefore, more resources are deployed to value-enhancing capital projects such as R&D. Fourth, strong institutions ensure returns from uncertain investments such as R&D by managing risk (Edquist and Johnson, 1997) and fostering an innovation-friendly environment.

However, this relationship between institutions and R&D investment may not be true all the time (Edquist and Johnson, 1997). Institutional settings introduce stability, and even rigidity, into the economy, and may act as a brake on innovation rather than an accelerator (Edquist and Johnson, 1997). Moreover, all parts of institutions may not contribute equally to R&D activities. Different structures may exist simultaneously, and may even contradict explanations of investment in R&D. For instance, economic policies such as government subsidies may impact positively on R&D investment, while social factors such as corruption and politics may be negatively related. Moreover, aligning institutional settings with corporate governance and strategic decision making also depends on corporate politics.

Although the institutional framework shapes strategic investment decisions around the world, this issue is even more critical for emerging economies. Peng et al. (2008) pointed out that the institutional framework is more sensitive to firms' investment decisions and performance in emerging economies. Furthermore, firm strategies depend mainly on institutional settings in emerging markets (Meyer et al., 2009). Nowadays, emerging countries are considered as lands of opportunity for foreign investors. Therefore, investment growth, and sustainability in emerging markets depends on foreign investment, debt and aid, which are guided by institutional development. Accordingly, emerging economies are markedly improving their institutional quality (OECD, 2011). In addition, evidence shows that in recent years emerging markets have considerably increased their R&D investment. For example, according to Booz & Company (2012), in 2011 only India and China increased their R&D spending, by about 28 per cent. Therefore, considering the

importance of institutional factors in emerging economies, this chapter examines the institutional determinants of R&D investment for firms in emerging economies.

This study contributes to the literature in several ways. First, it investigates the institutional determinants of R&D spending for 3,973 firm-year observations from 20 selected emerging markets during the period 2006-2013. Earlier researchers have emphasised single factors, such as legal institutions (Anderlini et al., (2013), political instability, education systems (Varsakelis, 2006), government effectiveness (Dolfsma and Seo, 2013) and regulation (Blind, 2012). This is thought to be the first study to consider all aspects of institutions and attempt to identify the social, legal and political institutional determinants of R&D investment in the emerging market context. Thus, this study provides significant insights into the importance of the external environment for R&D investment in emerging markets. Second, advanced econometric techniques are used, which take into account the problems of unobserved heterogeneity and endogeneity by applying GMM estimation to panel data. Finally, exploring the institutional determinants of R&D investment by emerging market firms is also more important to policy makers, as returns on R&D investment in emerging countries are higher than in advanced countries (Lederman and Maloney, 2003).

This chapter is organised as follows. Section 7.2 presents the theory and hypotheses of the study. Section 7.3 introduces the data and research method. Results and discussion are presented in Section 7.4, and Section 7.5 draws conclusions from the study.

7.2 Theory and hypotheses

Jorde and Teece (1990) pointed out that innovation activities, as a form of investment, are sensitive to institutional quality. Similarly, Daude and Stein (2007) reported that investment decisions may depend on various dimensions of the institutional environment. The investment decisions of individual firms are also influenced by the institutional framework (North, 1990). In terms of R&D investment, Pattit et al. (2012) found that

institutions have an influence on technological innovation and emerging technological opportunities. Furthermore, Cincera and Veugelers (2013) investigated the R&D investment gap between the US and the EU and observed that the gap relates mostly to structural differences between the countries. Therefore, it is highly likely that stronger institutional settings help to boost R&D investment and improve a country's knowledge accumulation and knowledge spill-over. On the other hand, weak institutional settings hinder R&D activities (OECD, 2005, p. 113). This tends to confirm the notion of contingent RBV, that firm capabilities depend on institutional settings (Priem and Butler, 2001; Yi et al., 2013).

There may be huge disparities in features of institutions. In this regard, Mahendra et al. (2015) stated that it is difficult to measure institutional variables, as each country and region may have different understandings and perceptions of what institutions are. Moreover, firm- and country-level institutional variables differ (Dunning, 2006). Firm-level institutional factors are beyond the scope of this analysis. Country-level institutions have an impact on firm strategy (Wan and Hoskisson, 2003). Similarly, Pindado et al. (2015) found that country-level institutions strongly affect the market valuation of firms' R&D investment. Among country-level factors, financial systems, education systems, public policy and training systems are important institutional factors for national innovation systems (Freeman, 1987; Dosi et al., 1990; Lundvall, 1992). In contrast, as suggested by Kaufmann et al. (2009), institutional variables have been used, including government effectiveness, rule of law, corruption, political instability and regulatory quality. An institutional setting is a set of social, political and legal factors that establishes the basis for production, exchange and distribution (Davis and North, 1971). By and large, these factors are more tangible than other factors.

Government effectiveness has an impact on firm performance through its effect on managerial assumptions and actions (Pearce et al., 2011); therefore, it reduces agency

costs. Lower agency costs increase the likelihood of efficient investments. Moreover, an effective government gives investors' confidence in their investments and safeguards future returns from investments. In addition, effective government encourages private and public firms to engage in R&D investment and accelerates technological innovation. In an empirical study, Mahmood and Rufin (2005) stated that an active role of government accelerates technological innovation through spill-overs creating networks between firms and individuals. Moreover, greater government capacity may promote R&D investment, providing greater support, budgets and subsidies for creative and innovative activities. As the role of government tends to be much more influential in emerging markets (Hong et al., 2015), this leads to the following hypothesis:

Hypothesis 1: *Government effectiveness positively impacts on R&D investment.*

Rule of law or a strong legal system seem to be important in encouraging R&D investments. La Porta et al. (1997) found that a strong legal system helps firms to access external finance to support strategic investments such as R&D. Moreover, the legal system enhances investors' protection and confidence. The Sarbanes-Oxley (SOX) Act 2002 is seen as an example of good investor protection. Therefore, following institutional theory, Furukawa (2007) stated that a stronger rule of law provides strong protection of patent rights and investment incentives, which motivate investors to engage in R&D activity. However, sometimes tight laws may discourage new entrants, who are more likely to be drivers of technological progress. In light of the above arguments, this study proposes the following hypothesis:

Hypothesis2: *Strong rule of law and R&D investment are positively correlated.*

According to Bardhan (1997), corruption adversely impacts on investment and growth. As investors must pay bribes to officials for permits and licences, corruption increases the cost of investment (Daude and Stein, 2007). Romer (1994) added that, by increasing the cost of fixed investments, corruption reduces the entry of new goods and technologies. However,

advocates of corruption have argued that it speeds up the work of officials, and therefore may improve efficiency in emerging countries (Bardhan, 1997). Corruption makes projects uncertain and less profitable. Consequently, both local and foreign investors become demotivated from engaging in long-term and costly investments such as R&D. Moreover, corruption remains a major problem of doing business and innovating in most emerging countries (IFC, 2002). Thus, the following hypothesis is postulated:

Hypothesis3: *Corruption negatively impacts on R&D investment.*

Political theory posits that political stability creates a favourable environment for doing business, which affects firm performance in important ways (Mangena et al., 2012). A favourable political environment is crucial to financial and technical progress and conducive to infrastructural development, particularly in R&D activities (Henisz, 2002). In addition, R&D subsidies depend on the political decisions of a country. For instance, the German government increased its R&D budget by nine per cent during the crisis between 2008 and 2009 (Hud and Hussinger, 2015). On the other hand, political instability increases the propensity for policy changes that adversely affect investment and economic growth. Thus, Alesina and Perotti (1996) found that political turmoil reduces investment. Allard et al. (2012) also concluded that political instability creates barriers to firm-level R&D spending. The Economist (2014) stated that political conditions vary among emerging countries, and thus firms face greater risks and challenges than in advanced countries. Hence, the following hypothesis is postulated:

Hypothesis 4: *Political instability is negatively related to R&D investment.*

Jalilian et al. (2007) pointed out that effective regulations help to achieve social objectives set by governments for regulatory authorities, enabling social goals to be achieved at minimum cost. On the other hand, inefficient and inconsistent government regulations lead to uncertainty for investors as they raise investment costs (Parker, 1999). Good quality regulations help firms with market entry and keeping up to date with developments. They

also increase a country's investment opportunities. In this regard, Kirkpatrick et al. (2006) concluded that the quality of the regulatory framework and foreign investment are closely related. They also observed that, with weak government regulations, foreign investors may be reluctant to invest in large investment projects such as R&D. As emerging markets are improving the quality of their government regulations, the following hypothesis is postulated:

Hypothesis 5: *Regulatory quality is positively correlated with R&D investment.*

In addition to the above, other factors also impact on firms' R&D investment. Scott (1995) and Oliver (1997) stated that strategic choices such as R&D spending are driven by institutional frameworks, along with industry conditions and firm-specific resources. Firm size (Lall, 1983), cash flow (Bhagat and Welch, 1995), debt ratio (Hall, 1992) and GDP growth (Wang, 2010) have an impact on R&D investment decisions. Larger firms tend to be more diversified, more technologically complex and better aware of technological opportunities (Lall, 1983). Pecking order theory and internal fund theory argue that financial status, measured by the cash flow of a firm, determines the level of investment. Bhagat and Welch (1995) noted that R&D occurs mostly when firms have more operating cash flows on hand and are thus able to avoid the costs of external capital markets. According to Hall (1992), external finance, and specifically debt, is not favoured as a form of finance for R&D investment, as debt servicing usually requires a stable source of cash flow, which makes it more difficult to find funds for R&D investment. Increased GDP growth seems to be allocated to increased investment in R&D. Wang (2010) pointed out that GDP growth creates stronger incentives for R&D investment.

7.3 Methodology

7.3.1 Data

To test the hypotheses, data were collected from several sources, including DataStream, and the World Bank's Development Indicators and Worldwide Governance Indicators.

Firm-level data, such as R&D expenditure, sales, total assets, total debt, cash flow and industry type, were drawn from DataStream.GDP growth data were obtained from the World Bank's Development Indicators. Data on institutional factors, measuring government effectiveness, regulatory quality, rule of law, corruption and political stability, were collected from the World Bank's Worldwide Governance Indicators.

In order to be included in the sample, countries must have five consecutive years of data. The eight-year sample period of the study was from 2006 to 2013. The post-reform period of R&D reporting was considered so that the sample firms would treat R&D expenditure homogeneously. Moreover, gaps in the latest data were minimised where possible. Hong Kong, Singapore, South Korea and Taiwan were excluded, as these countries are now considered as emerged economies.

Table 7.1: Sample by Country

Country	Frequency	Composition	Country	Frequency	Composition
Bangladesh	2	0.300	Malaysia	35	5.255
Brazil	8	1.201	Pakistan	12	1.802
Chile	2	0.300	Philippines	11	1.652
China	60	9.009	Poland	4	0.601
Egypt	2	0.300	Romania	1	0.150
Greece	37	5.556	Russia	12	1.802
India	277	41.59	Saudi Arabia	2	0.300
Indonesia	17	2.553	South Africa	28	4.204
Israel	59	8.859	Sri Lanka	6	0.901
Jordan	4	0.601	Turkey	87	13.063

Source: Author's calculations

Following Pindado et al. (2015), financial firms were also excluded due to their different corporate structure and strategy. After dropping missing values and unrealistic figures (such as negative values of R&D expenditure), the sample consisted of 666 firms from 20 emerging countries (see Table 7.1).

Panel data are a combination of cross-sectional and time series data. Panel data were used for this analysis because they enable control for firm heterogeneity, give more information, more variability and greater degrees of freedom, avoid multicollinearity problems, provide more efficient results, and are more suitable for identifying and measuring effects that are not detectable in pure cross-sectional or pure time series data (Baltagi, 2013). There are two types of panel data: balanced and unbalanced. If each cross-sectional unit has the same number of time-period observations, the panel data are balanced; otherwise, they are unbalanced. Unbalanced panel data were used for the sample countries, as this might mitigate the survivorship bias problem (Hillier et al., 2011).

Table 7.2: Definitions of Variables

R&D intensity	R&D expenditure over sales
Government effectiveness	Measures competency or capacity of the government
Rule of law	Measures judicial strength
Corruption	Measures misuse of power
Political instability	Measures likelihood of political instability
Regulatory quality	Captures the ability of the government to promote development
Firm size	Measured by total assets
Cash flow	Ratio of cash flows to sales
Debt ratio	Ratio of total debt over total assets
GDP growth	Annual GDP growth of a country
Industry Type	Takes a value of 1 if the industry is innovative, and 0 if it is non-innovative[3]

Table 7.2 gives definitions of the variables. All variables are standardised to a common USD exchange rate. Some of the explanatory variables have higher scales than others, and the high absolute values of variables increase the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, the natural logarithms, ratios and percentages of the variables were adopted.

Table 7.3 presents descriptive statistics for the variables. These show that governance indicators such as government effectiveness, rule of law, corruption, political stability and

[3] Innovative and non-innovative firms were split following Kallunki et al. (2009).

regulatory quality vary among emerging markets. This implies that some emerging countries have stronger governance than others. For example, Pakistan and Bangladesh have greater political instability than any other emerging countries. Cash flows and GDP growth also vary among emerging markets. This is because the impact of the recent global financial crisis was not the same for all firms. Firm size also varies among emerging countries because some, such as China and India, have more MNEs than others. However, R&D investment is relatively similar among emerging markets.

Table 7.3: Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
R&D intensity	0.007801	0.020360	0.000000	0.252287
Government effectiveness	0.232742	0.477687	-0.893061	1.367924
Rule of law	0.067994	0.418766	-0.976797	1.366790
Corruption	-0.211879	0.459603	-1.42297	1.562048
Political instability	-0.912160	0.565566	-2.812080	1.056947
Regulatory quality	0.053516	0.525419	-0.963199	1.540422
Size	5.383533	0.859591	3.265525	8.643295
Cash flow	9.942318	19.25407	-685.430	122.1800
Debt ratio	0.250561	0.181732	0.000000	0.882208
GDP growth	5.554006	3.970243	-8.870000	14.16000
Industry dummy	0.631545	0.482438	0.000000	1.000000

Source: Author's Calculations

7.3.2 Model

In order to examine the institutional determinants of R&D expenditure, the following model was devised. A semi-logarithmic model was used for the analysis because government effectiveness, rule of law, corruption, political instability and GDP growth contain negative values, preventing use of the logarithm for these values. Industry type is a dummy variable, taking values of 0 and 1, for which a logarithm could not be used as the logarithm of 0 does not exist.

$$ln(R\&DIntensity_{it}) = \alpha_i + \beta_1(GovernmentEffectiveness_{it}) + \beta_2(RuleofLaw_{it}) + \beta_3(Corruption_{it}) + \beta_4(PoliticalInstability_{it}) + \beta_5(RegulatoryQuality_{it}) + \beta_*(ControlVariables_{it}) + \eta_i + d_t + I_i + \nu_{it} \quad \textbf{(1)}$$

where subscript *i* represents the firm and *t* represents the year. R&D intensity is considered as a dependent variable which, following Xiao (2013), takes the logarithm of annual R&D expenditure over sales. The main independent variables are government effectiveness, rule of law, corruption, political instability and regulatory quality. Firm, industry and macroeconomic variables are controlled, such as firm size, cash flow, debt ratio, industry dummy and GDP growth. The error component ε_{it} is separated into four sub-components: $\varepsilon_{it} = \eta_i + d_t + I_i + \nu_{it}$. η_i is considered as an individual effect to control for individual heterogeneity, which is then eliminated by taking first differences. In addition, the time dummy, denoted by d_t, captures the time-specific effect to control for macroeconomic variables. As the industries are separated into innovative and non-innovative, industry dummy I_i is included to capture industry-specific effects. Moreover, ν_{it} is considered as a random disturbance term, which is assumed to be i.i.d normal.

7.3.3 Method

In order to examine the institutional determinants of R&D spending in emerging countries, a GMM estimation was performed, following Hiller et al. (2011).

7.3.3.1 Endogeneity problem

This study faced the challenge of endogenous variables. Some explanatory variables in the model are endogenous, which may create a problem of endogeneity. For example, firm size may also impact on R&D investment, as greater availability of resources may encourage managers to commence new R&D activities (Pindado et al., 2015). This endogeneity problem can be addressed by an IV approach, such as 2SLS or GMM estimation. In general, external instruments are used for IV estimation, while internal instruments (lag of explanatory variables) are used for GMM estimation. The IV approach provides consistent estimation under the assumption that valid instruments exist (Cameron and Trivedi, 2010).

However, it is very complex, if not impossible, to find valid external instruments (Pindado et al., 2014). In addition, GMM embeds all other instrumental methods as special cases (Hiller et al., 2011). As a consequence, GMM estimation was used.

7.3.3.2 Problems of estimation

Panel data may suffer from heteroscedasticity and auto-correlation problems. Heteroscedasticity may arise because different countries in the sample have different characteristics, thus the residuals are unlikely to be constant across observations. Using the lag of dependent variables may create auto-correlation problems. These problems cannot be controlled by OLS. Moreover, in the presence of endogeneity, OLS estimation will be biased and inconsistent and standard errors will be unreliable. Wintoki (2012) observed that, if the explanatory variables are not strictly exogenous (the variables in this study are endogenous) and the panel's time period is small, as in this case, both OLS and fixed-effects estimation may produce biased results. However, both problems are addressed by GMM estimation.

7.3.3.3 Auto-correlation

As a result of first difference transformation, there may be first-order serial correlation, AR(1), although this will not create a specification problem with the model. However, the results show that first-order serial correlations are not present. The hypothesis that the error terms are not second-order serially correlated was tested, denoted by AR(2). The results show that there are no second-order serial correlations in the models.

7.3.3.4 Instruments

In order to apply GMM, the instruments must be valid. The Hansen J statistic of over-identifying restrictions was used to test the validity of the instruments. GMM estimation uses multiple lags, which implies that the model is over-identified. Lagged levels t-1, t-3 and t-4 were used as instruments for difference equations, and one lag as an instrument for the level equation. In order to choose the best possible instruments, the trade-off between

the exogeneity and strength of each instrument was considered, following Keasey et al. (2015). Furthermore, the Hansen J test results show that the instruments are valid in the models. The rule of thumb is that the number of instruments should not be higher than the number of observations. In this case, the test results show that the number of instruments is far lower than the number of observations. Both results provide confidence that the instruments used are strong enough for GMM estimation.

7.3.3.5 System GMM

There are two types of GMM estimation: difference GMM and system GMM. As both sets of moment conditions (first difference and level equation) were considered, system GMM was adopted. There are no stationary problems in the analysis, which is a pre-condition for system GMM. In addition, system GMM has been found to be more efficient than difference GMM (Blundell and Bond, 1998), while difference GMM estimation has a problem of weak instruments (Alonso-Borrego and Arellano, 1999).

7.3.3.6 Two-step estimation

A two-step estimation was performed on the grounds that it produces more efficient estimates than one-step estimation. In two-step estimation, the standard covariance matrix is robust to panel-specific heteroscedasticity and serial correlation, but the standard errors are downward biased. To fix the possible downward bias, the Windmeijer (2005) finite-sample corrected covariance matrix was applied.

7.3.3.7 Joint significance

Two Wald tests were used to examine whether the independent variables are jointly equal to zero: z_1 is a test of the joint significance of the regressors, and z_2 is a test of the joint significance of the time dummies, suggesting that aggregate factors exert a significant influence on the relationship between R&D investment and the explanatory variables. The two Wald tests provided good results for the models.

7.4 Results and discussion

Table 7.4 presents the empirical results of the GMM estimation. In line with expectations, government effectiveness, rule of law, corruption and political instability have a significant impact on R&D expenditure in emerging countries. Thus, the results support the institutional-based view. Moreover, the results show that firm size, debt ratio and cash flow enhance R&D performance considerably. This implies that R&D investment may result not only from financial factors but also in response to social, legal and political factors.

Table 7.4: Summary of Results for GMM Estimation

Variable	Estimation	Standard Error
R&D intensity $_{t-1}$	0.681484***	(0.091022)
Government effectiveness	0.001858*	(0.000980)
Rule of law	0.001295*	(0.000774)
Corruption	-0.002112**	(0.001005)
Political instability	-0.000844**	(0.000392)
Regulatory quality	0.001211	(0.001000)
Size	0.000795**	(0.000387)
Cash flow	-0.000127***	(0.000028)
Debt ratio	-0.003298**	(0.001282)
GDP growth	0.000022	(0.000028)
Industry dummy	Yes	
Year dummy	Yes	
Total observations	3973	
ΔAR(1)	-2.7	
AR(2)	0.31	
z_1	51.5(11)	
z_2	1.89(5)	
Hansen	191.12(169)	

Note: Standard errors in parenthesis. Levels of significance: * <0.10, ** <0.05, ***<0.01.

The lagged value of the dependent variable is significantly different from zero, showing the persistency of R&D investment. A persistence rate of 68.14 percent suggests that firms in emerging markets follow stable R&D policies. García-Quevedo et al. (2014) reached the same conclusion based on a path-dependent hypothesis. Government effectiveness has a positive influence on R&D investment in emerging countries. A change of one unit in government effectiveness is associated with a 0.18 per cent change in firms' R&D expenditure. This is because effective government creates a favourable environment for

R&D investment by facilitating access to finance and market entry, by attracting more investment, and in particular by accelerating technological investment. On this point, Jiao et al. (2015) have stated that firms perform better in innovation under effective governance than firms without such an environment. Thus, the results support Hypothesis 1.

There is a significant positive relationship between the legal system and R&D investment of a country. With a one-unit change in legal system, the likelihood of R&D investment increases by 0.13 per cent. This implies that strong legal systems attract investors and increase investor confidence in R&D. In this regard, Jiao et al. (2015) have added that a good legal environment not only increases firms' R&D investment but also improves the efficiency of technological innovation, which increases the number of patent applications. Jiao et al.'s (2015) study of an emerging market and Hillier et al.'s (2011) study of nine EU countries, Japan and the US reached the same conclusion. Therefore, this result supports Hypothesis 2.

R&D investment is discouraged by corruption. With a one-unit change in corruption, there is a probability of R&D expenditure decreasing by 0.21 per cent. This is because corruption increases investment costs and discourages foreign investors. These results support Hypothesis 3.

The political environment significantly explains R&D investment. With a one-unit deterioration in political conditions, there is a probability of R&D expenditure decreasing by 0.08 per cent. In emerging markets, political unrest discourages local and foreign investors. Allard et al. (2012) obtained similar results. These results support Hypothesis 4.

Regulatory quality has a positive but insignificant impact on R&D investment. This is because upholding rights is not directly related to R&D expenditure. Firm size has a significant positive impact on R&D investment, consistent with Lall's (1983) finding. Large firms invest more in R&D than small firms. Larger firms have more resources to invest in R&D activities and are able to benefit from returns on their innovative activities.

In line with Bhagat and Welch's (1995) study based on US firms, cash flow negatively impacts on R&D spending. This may happen when firms depend more on external than internal funding for R&D investment. The recent financial crisis restrained firms from using internal funding. Due to the less collateralisable value of R&D investment, the debt ratio significantly negatively affected R&D in emerging markets. Moreover, agency costs and information asymmetry problems are likely to influence R&D investment negatively. A one-unit change in debt decreases the probability of R&D investment by 0.32 per cent. This result is consistent with Hall's (1992) study. As cash flow and debt both negatively influence R&D investment, it is highly likely that, following pecking order theory, firms will finance R&D from equity. Although GDP growth is higher in emerging markets, contrary to the accelerated principle, it is uncorrelated with R&D expenditure. This is because emerging countries spend their income on infrastructural development. Moreover, the recent financial crisis adversely affected emerging countries. Based on a study of OECD countries, Wang (2010) also found GDP to be a fragile determinant of aggregate R&D.

7.4.1 Robustness test

The robustness of the results was tested using OLS estimation (see Table 7.5).[4]In order to control for heteroscedasticity and autocorrelation, a cluster-robust standard error was used. The key results concerning institutional factors remain unchanged except for government effectiveness and regulatory quality. Regulatory quality becomes statistically significant, while government effectiveness has a positive sign but is statistically insignificant. The results also show that rule of law is positively related to R&D investment, while corruption and political instability impact negatively on R&D spending in emerging markets. The coefficients of these variables are remarkably stable with GMM (rule of law = 0.00129 – 0.00123, corruption = 0.00211 – 0.00197, political stability = 0.00084 – 0.00089). It can

[4] Regression analysis was also conducted using Tobit estimation, with similar results.

be seen that the results are robust and fully support Hypotheses 2, 3, and 4, while Hypotheses 1 and 5 are supported but not robustly. However, other variables retain the same sign.

Table 7.5: Robustness Test

Variable	Estimation	Standard Error
R&D intensity $_{t-1}$	0.83228***	(0.03570)
Government effectiveness	0.00050	(0.00098)
Rule of law	0.001237*	(0.00070)
Corruption	-0.00197**	(0.00098)
Political instability	-0.00089**	(0.00038)
Regulatory quality	0.00247**	(0.00118)
Firm size	0.00012	(0.00016)
Cash flow	-0.00009**	(0.00003)
Debt ratio	-0.00378***	(0.00092)
GDP growth	0.00005	(0.00006)
Industry dummy	Yes	
Time dummy	Yes	
R-squared	0.7888	
F test	169.2(17)	

Standard errors in parenthesis; significance levels: * <0.10, ** <0.05, ***<0.01.

7.5 Conclusion

Institutional environments function as a base or framework for investment. For example, weak institutions signal poor investor confidence and indicate investment risk. Institutional quality shapes variations across countries in firms' ability and opportunities for R&D investment. Thus, this study has examined the institutional determinants of R&D expenditure using panel data GMM estimation for 20 emerging countries for the period 2006-2013. The results are in the line with theoretical predictions. Institutional theory suggests that institutional factors play a vital role in a country's R&D investment. The results show that government effectiveness and rule of law have significant positive impacts, while corruption and political instability have significant negative impacts on R&D investment in emerging countries. Moreover, firm size, cash flow and debt ratios are important determinants of R&D investment in emerging markets.

It is hoped that this study will serve as new guidance to investors and policy makers when considering R&D investments in emerging countries. Due to missing values, some economic and cultural factors that might impact on firm-level R&D investment were not included in this study. In addition, due to missing values, not all emerging markets were included in the analysis. These are limitations of this study. However, the empirical results of this study may provide lessons for other emerging markets. Further investigation is needed on other emerging markets, as well as developed markets, to identify specific institutional determinants of R&D investment.

Chapter 8: Contribution of Systems and Safeguards to the Relationship Between R&D Investment and Firm Performance in Emerging Markets

8.1 Introduction

RBV stresses that heterogeneous internal resources and capabilities determine a firm's performance. Canto and Gonzalez's (1999) study confirmed the relevant role of resources and capabilities in R&D activities. R&D investment is used as a source of competitive advantage, long-term growth and technological advancement, which lead to better firm performance. The existing literature has also found a relationship between R&D and firm performance (Grabowski, 1968; Guellec and Potterie, 2001; Del Monte and Papagni, 2003; Yeh et al., 2010). However, the relationship between R&D investment and firm performance may be strengthened or weakened by country-level factors. In a recent paper, Pindado et al. (2015) have shown that country-level factors moderate the relationship between R&D and firm performance. Differences in a country's investor protection and institutional setting are the most important factors that moderate the R&D and firm performance relationship.

The R&D literature has so far focused on firm-level factors (Grabowski, 1968; Pindado et al., 2010; García-Quevedo et al., 2014) and corporate governance factors (Zhang et al., 2014; Honoré et al., 2015) that influence firm-level R&D investment. Recently, researchers have begun to consider country-level factors (Hiller et al., 2011; Pindado et al., 2015) as important determinants of R&D activity. The main reason is that institutional differences in emerging markets explain a large portion of the variation in innovative activities and outputs. However, this research has not separated investor protection and country-level corporate governance factors. Following Haidar (2009) and Kaufmann et al. (1999), these factors are separated in this study because of their different and distinct roles in firms' decision making. Country-level investor protection provides the "safeguards" and country-level corporate governance establishes the "systems" of a country. Investor

protection deals with ownership, rights, corporate responsibility and disclosure, while governance relates to the rules and processes that facilitate firms' operations.

It is assumed that greater investor protection reduces information asymmetry by disclosing R&D activities. Moreover, through monitoring and guidance, investor protection reduces fraud and earnings management, and improves the allocation of resources and access to external financing, which have an impact on firm performance (La Porta et al., 1998; Leuz et al., 2003; Xiao, 2013). Xiao (2013) confirmed that country-level investor protection has a significant impact on R&D investment, although such protection may vary between firms and countries. On the other hand, good country governance minimises the risks of and ensures high returns from R&D investment (Edquist and Johnson, 1997; Ngobo and Fouda, 2012). In addition, good governance creates an attractive environment for investment, assists financing decisions (La Porta et al., 1997; Bénassy-Quéré, 2007) and compensates for corporate governance weaknesses in firms. Hiller et al. (2011) found that country-level governance factors influence R&D investment. This study seeks to shed light on investor protection and country governance factors, and to identify which have a greater influence on the relationship between R&D activities and firm performance in emerging markets.

Nowadays, emerging markets are considered as lands of opportunity and low-cost innovation centres. As a result, in recent years, MNEs have established significant R&D centres in emerging markets (Patra and Krishna, 2015). Moreover, R&D-related FDI into emerging markets has recently increased significantly. These investor decisions are influenced mainly by country characteristics, such as law enforcement and patent protection. Moreover, the rate of return from the same investment is higher in emerging markets than in developed countries (Logue, 2011), which also ensures the importance of country-level factors. Therefore, Peng et al. (2008) have pointed out that country-level factors are more sensitive to firms' investment decisions and performance in emerging economies, although opponents have claimed that these factors have indirect influences in

emerging countries. Therefore, in considering the importance of country-level factors in emerging economies, this study examines their moderating effects on the relationship between R&D investment and firm performance.

Country-level factors such as investor protection and country governance influence firm-level decisions such as R&D investment (Hiller et al., 2011; Xiao, 2013). This study seeks to identify which has a greater moderating effect on the relationship between R&D and firm performance. Using GMM estimation of panel data for 2,549 firm-year observations consisting of 437 firms from 17 emerging countries, it is found that a country's safeguards tend to have a greater moderating effect than its systems. The results indicate that safeguards promote firm-level innovation in an emerging market, while systems substitute for firm-level corporate governance. In addition, for risky and uncertain investments such as R&D, investors seek protection to cover possible losses.

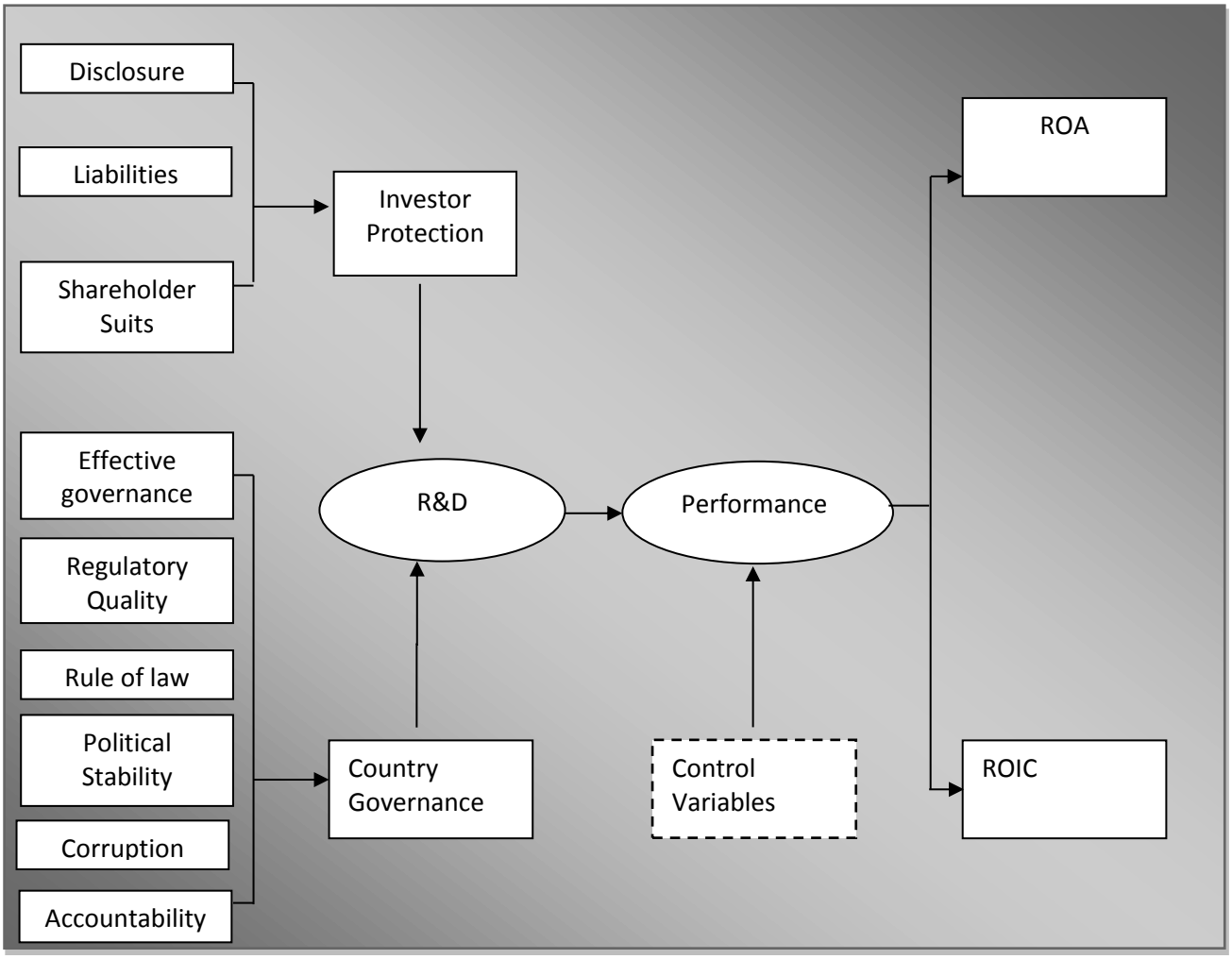
This study makes the following contributions to the R&D literature. First, it examines the non-linear relationship between R&D and firm performance based on emerging-market firms. Second, it contributes to the debate on whether safeguards or systems are more important for firm-level strategic decision making. The study considers three factors as safeguards (disclosure, directors' liabilities and shareholders' ability to sue) and six components of systems (government effectiveness, regulatory quality, rule of law, control of corruption, political stability and accountability). Third, a robust econometric technique is used that controls for unobserved behaviour of the firm.

This chapter is organised as follows. Section 8.1 presents a literature review, and Section 8.2 presents the theory and hypotheses of the study. Section 8.3 introduces the data and research method, and in Section 8.4 the results are presented and discussed. Section 8.6 draws conclusions from this study.

8.2 Theory and hypotheses

Based on the theory and empirical evidence on investor protection, country-level governance, R&D spending and firm performance, three hypotheses are developed.

Figure 8.1: Conceptual Framework



Researchers have, for a long time, been trying to measure the relationship between R&D and firm performance. However, the results have been inconsistent. Santos et al. (2014) found no significant relationship, while Knecht (2013) found a negative relationship between R&D intensity and firm performance. In contrast, Ehie and Oilbe (2010) and Gunday et al. (2011) found that R&D investment impacts positively on firm performance. R&D investment increases profitability by increasing the quality as well as the quantity of products produced and sold. These empirical results have raised debate about when R&D starts to show an impact, and whether R&D may impact on performance in the same year

as the investment. In this regard, Knecht (2013) pointed out that the current year's R&D investment reduces current year profits but may impact positively on future firm performance. Moreover, Parcharidis and Varsakelis (2007) and Natasha and Hutagaol (2009) found that R&D investment impacts negatively on profit for the year of the investment, but there may be a strong positive relationship after two years. This is because new product development, new production methods and information technology need time to show results. Thus, in line with Yeh et al. (2010), the following hypothesis is postulated:

> **Hypothesis 1:** *There is a non-linear relationship between R&D and firm performance.*

Since the seminal works of La Porta et al. (1997, 1998), researchers have found that investor protection has a significant impact on firm finance, investment and growth. Investor protection law increases investor confidence, both legally and psychologically. Anderson and Gupta (2009) argued that stronger investor protection assures investors that, besides their original investment, more of the firm's profits will get back to them as dividends and interests. This protection encourages investors and entrepreneurs to pay more for financial assets that increase the R&D investment of a firm. Moreover, investor protection ensures access to external financing, and therefore has a significant impact on investment in R&D activities (Brown et al., 2013). In addition, investor protection influences the relationship between R&D and firm performance by improving the efficiency of a firm's R&D investment. Pindado et al. (2015) found that effective investor protection leads to a positive relationship between R&D and market value, while Xiao (2013) found that stronger investor protection facilitates faster sales growth in R&D-intensive industries. From the above discussion, the following hypothesis is postulated:

> **Hypothesis 2:** *Investor protection (safeguards) positively moderates the strength of the relationship between R&D and firm performance.*

In making strategic decisions on risky and uncertain investments such as R&D, firms consider the background of institutional and country-level governance factors. Wu et al.

(2016) stated that the institutional environment may stimulate R&D activity by providing capacities or constraints beyond those of individual firms. Moreover, Peng et al. (2008) stated that strategic choices such as R&D investment are driven by the institutional framework confronting managers, along with industry conditions and firm-specific resources. In addition, Hiller et al. (2011) argued that better governance ensures greater disclosure and accountability, which in turn facilitates the availability of external financing for R&D. These result simply that, when country-level governance becomes strong, financial factors become more effective in boosting R&D investment. They found that country-level governance factors reduce the sensitivity of internal cash flows and R&D. Moreover, dimensions of country-level governance are also related to better performance (Gugler et al., 2013). In line with this result, Pindado et al. (2015) found that country-level governance factors significantly impact on the market valuation of firms' R&D investments. Following Pindado et al. (2015), the following hypothesis is postulated:

> **Hypothesis 3:** *Country-level governance (systems) positively moderates the strength of the relationship between R&D and firm performance.*

8.3 Data, model and method

8.3.1 Data

8.3.1.1 Datasources

In order to test the hypotheses, data were collected from several sources, including DataStream, the World Bank's Protecting Minority Shareholders data, and the ICRG database. Firm-level data were drawn from DataStream, including R&D expenditure, fixed assets, total assets, total debt, sales, earnings before income and tax (EBIT), and return on invested capital (ROIC).Investor protection data, measured by disclosure, liability and ability of investors to sue, were obtained from the Protecting Minority Shareholders data. Data on country-level governance factors, measured by government effectiveness, regulatory quality, rule of law, control of corruption, political stability and accountability, were also obtained from the Protecting Minority Shareholders data.

8.3.1.2 Sample selection

In order to be included in the sample, countries must have five consecutive years of data. The eight-year sample period was from 2006 to 2013. This period was considered on the basis of data availability from the World Bank's Protecting Minority Shareholders data, which provide data on most emerging countries from 2006. Moreover, gaps in the latest data were minimised where possible. Hong Kong, Singapore, South Korea and Taiwan were excluded, as these countries are now considered as emerged economies. Following Pindado et al. (2015), financial firms were also excluded due to their differing corporate structure and strategy. After dropping missing values and unrealistic figures (such as negative values of R&D expenditure), the dataset consisted of 437 firms from 17 emerging countries (see Table 8.1).

Table 8.1: Sample Selection

Description	No. of Countries	No. of firms
Initial search on DataStream	51	34,528
Firms with five consecutive years of data	39	1,657
Countries with more than one firm	21	1,639
Dropped: Countries that are already emerged	4	1,202
Final sample	**17**	**437**

Source: DataStream, Protecting Minority Shareholders database, ICRG

8.3.1.3 Structure of the data

Panel data were used for this analysis, which are a combination of cross-sectional and time series data. Panel data involve a large number of data points, offer more degrees of freedom and reduce multicollinearity among the explanatory variables; thus, they offer efficient estimation (Perera and Lee, 2013; Hsiao, 2003). There are two types of panel data: balanced and unbalanced. If each cross-sectional unit has the same number of time-period observations, the data are balanced, otherwise they are unbalanced. Unbalanced panel data were used for the sample countries, as unbalanced data mitigate the survivorship bias problem (Hillier et al., 2011).

8.3.1.4 Variable construction

Table 8.2 shows definitions of the variables. All variables are standardised to a common USD exchange rate. Some of the explanatory variables have higher scales than others, and the absolute value of variables increases the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, the natural logarithm, ratio and percentage of the variables were adopted.

Table 8.2: Summary Variables

Data Type	Variable	Description
Firm data:	Return on assets (ROA)	Earnings before interest and tax over assets
	ROIC	Earnings over invested capital
	R&D intensity	R&D expenditure of the firm in a year over sales
	R&D intensity ^{2}	Square of R&D intensity
	Firm size	Natural logarithm of firm's total assets
	Sales growth	Changes in sales over sales
	Leverage	Total debt over total assets
	Tangibility	Fixed assets over total assets
Industry data	Industry dummy	Takes a value of 1 if the firm is in an innovative industry
Investor protection:	Disclosure	Measures the transparency of transactions
	Liability	Measures directors' liabilities
	Investor suits	Measures investors' rights to sue for misconduct
Country governance:	Government effectiveness	Captures the ability of a country's government
	Regulatory quality	Captures the riskiness of investments
	Rule of law	Captures the quality of the jurisdiction
	Control of corruption	Measures the misuse of power for private gain
	Political stability	Measures the propensity for changes in government, terrorism and violence
	Accountability	Measures the responsiveness of government to its people

Dependent variable

Firm performance is a multidimensional concept (Murphy et al., 1996). It can be measured in financial terms (objective), in terms of sales, profitability and productivity growth performance, or in non-financial terms (subjective), in terms of increases in efficiency. However, it is difficult to measure the non-financial growth of a firm. Among the financial terms, profitability measures for firm performance are widespread, and ROA is a commonly-used profitability measure in R&D research (Roberts and Amit, 2003).

Therefore, following Yeh et al. (2010), in this study ROA is considered as a dependent variable for EBIT over assets. In addition to ROA, ROIC is also considered as a dependent variable to observe the impact of country-level factors.

Independent variables

R&D Intensity: A variety of measures of R&D have been used in the literature, including R&D expenditure, R&D intensity, R&D employment intensity and R&D growth. The most frequently used measure is R&D intensity. Measures of R&D intensity include ratios of R&D expenditure to sales, R&D to outputs, R&D to GDP, R&D to employees, and the proportion of scientific personnel to the total workforce. The standard measure is the R&D expenditure to sales ratio (Scherer, 1980), which shows modest year-to-year variations in R&D expenditure (Khyum et al., 2005) and normalises for differences in industry size (Jaruzelski et al., 2005), although House et al. (1994) stated that the R&D to employee ratio has less short-term variability. In this study, the R&D expenditure to sales ratio is considered as a measure of R&D intensity, following Honoré et al. (2015).

Investor Protection: A growing number of studies have used an investor protection variable for analysis. According to Gourevitch (2005), investor protection is the "sum of practices that serve to ensure that the firm is operated to maximize the value of their shareholders' stock, rather than spent or wasted on something else". La Porta et al. (2000) observed that investor protection should include rights to receive dividends on pro rata terms, to vote for directors, to participate in shareholders' meetings; to subscribe to new issues of securities on the same terms as insiders; to sue directors or the majority for suspected expropriation; and to call extraordinary shareholders' meetings. La Porta et al. (1998) used six variables as measures of investor protection: voting by mail, blocking shares before meetings, cumulative voting, oppressed minority mechanisms, pre-emptive rights to new issues, and share capital required to call an extraordinary shareholder meeting. Djankov et al. (2006) introduced a further measure of investor protection against

expropriation by corporate insiders: the anti-self-dealing index. They argued that this new measure predicts a variety of stock market outcomes and works better than the previous anti-directors index. Many researchers have subsequently used these variables to measure investor protection, including McLean et al. (2012) and Xiao (2013).

However, La Porta et al.'s (1998) measurements of investor protection have been criticised by several authors. Haidar (2009) has claimed that they are based on an adhoc collection of variables meant to capture the stance of corporate law towards investor protection. On the other hand, the World Bank's Doing Business investor protection index has focused on how regulations control the misuse of corporate assets by directors. This methodology was originally developed by Djankov et al. (2006) and adopted with minor modifications by the World Bank. Siems (2006) has argued that "the choice of variables by La Porta et al. not only suffers from a US bias but is also a poor proxy for shareholder protection in general, because their eight variables do not capture the most significant aspects of the law".

In this study, investor protection variables are measured following Haidar (2009). The three components of the Doing Business investor protection index are disclosure, liability and investor suits. Disclosure measures the transparency of transactions, and is the mean of five sub-indices ranging from 0 to 10, with higher values indicating greater disclosure. The sub-indices are: a corporate body that can provide legal approval for transactions; disclosure of transactions to the public; mandatory disclosure in annual reports; mandatory disclosure to the board of directors or supervisor; and pre-audit by an external body. Liability measures directors' liabilities, and is the mean of seven sub-indices ranging from 0 to 10, with higher values indicating higher liabilities. The sub-indices indicate that investors are able to make the approving body, directors and members of supervisory boards liable for damages due to acting negligently or being influenced by the approving body. Investor suits measures investors' rights to sue officials and directors for misconduct, and is the mean of six sub-indices ranging from 0 to 10, with higher values

indicating greater power of investors to challenge transactions. The sub-indices indicate whether investors can obtain relevant documents from a company and can recover legal expenses. Investor protection is the sum of the average of disclosure, liability and investor suits, and the shareholder governance index. The index ranges from 0 to 10, with higher values indicating stronger minority investor protection. Dummy variables are used for each component: disclosure, liability and investor suits higher than the mean are equal to 1, and otherwise 0.

Country-level governance: Following Kaufmann et al. (1999), country-level corporate governance is measured by six components comprising government effectiveness, regulatory quality, rule of law, control of corruption, political stability and accountability, and ranges from 0 to 4, with higher values indicating stronger government effectiveness. Regulatory quality measures the riskiness of investments not covered by the political, economic and financial risk components, measured by a combination of sub-components ranging from 0 to 12, with higher values indicating greater strength of regulatory quality. The sub-components are contract viability/expropriation, profit repatriation and profit delays. Rule of law measures judicial strength and is a single component with two elements, law and order, ranging from 0 to 6, with higher values indicating stronger rule of law. Control of corruption measures the misuse of power, ranging from 0 to 6, with higher values indicating less corruption. Political stability measures the propensity for changes in government, terrorism and violence, ranging from 0 to 12. The sub-components of political stability are legislative strength, government unity and popular support. Accountability measures the responsiveness of a government to its people, ranging from 0 to 6, with higher values indicating greater accountability. Dummy variables are used for each component, with a value higher than the mean taking a value of 1, and 0otherwise.

Control variables

In addition to R&D and country-level factors, firm- and industry-level characteristics influence firm performance. In order to remove the effect of confounding factors on performance, firm-level factors are considered, including firm size, sales growth, leverage and tangibility, as well as industry-level characteristics represented by an industry dummy. Following Artz et al. (2010), Ehie and Olibe (2010), García-Manjón and Romero-Merino (2012) and Pindado et al. (2015), control variables are used. Firm size is measured as the natural logarithm of total assets. Majumder (1997) found that firm size has a significant impact on firm performance. Firm growth is measured as changes in sales over sales, and not only influences R&D but also indicates whether firm strategies are working, which indirectly influences firm performance (Grant, 2001; Geroski, 2005). Moreover, Asimakopoulos et al. (2009) found that firm growth impacts positively on profitability. Leverage is measured as the ratio of total debt over total assets. Asimakopoulos et al. (2009) found that leverage impacts negatively on firm profitability, as high leverage increases the propensity for bankruptcy. Tangibility is measured as the ratio of fixed assets to total assets. High tangibility confirms that firms have no asset constraints, which encourages them to grow market share as well as exhibit consistent performance.

Industry-level differences influence both R&D investment and performance. For example, the food and clothing industry generally has insignificant R&D investment, the aircraft industry invests in R&D under government contracts, and the auto industry's R&D investment is highly related to institutional quality (Branch, 1974). Industry data were collected to control for industry effect, measured using a dummy variable. Innovative or technology-based industries take a value of 1, and non-innovative and non-technology industries take a value of 0. Innovative and non-innovative industries were separated (see Table 8.3), following Kallunki et al. (2009).

Table 8.3: Technology-Based versus Non-Technology-Based Firms

Technology-Based Industry	Non-Technology-Based Industry
Aerospace and defence	Beverages
Automobiles	Coal
Biotechnology and medical research	Containers and packaging
Construction materials	Food and tobacco
Communications and networks	Hotels and entertainment
Electronics	Leisure products
Engineering	Office equipment
Healthcare equipment and supplies	Oil and gas
Machinery and equipment components	Paper and forest products
Renewable energy	Media and publishing
Pharmaceuticals	Transport infrastructure
Metals and mining	Textiles and apparel
Software and IT	Water utilities
Telecommunications	Miscellaneous

8.3.1.5 Summary statistics

Tables 8.4, 8.5 and 8.6 report descriptive statistics of the sample by firm, industry and country respectively. They are presented in three separate tables to provide a clearer picture of the sample. The firm-level data (Table 8.4) indicate that, except for ROIC, the values of variables do not vary across firms over time. ROIC has a high standard deviation of 13.32, indicating that this value varies greatly across firms over time. Moreover, the high standard deviations of the firm size and sales growth variables confirm variation in firm observations. It is a common belief that firm size and firm growth vary in all countries worldwide. ROA, ROIC, R&D intensity and sales growth show higher skewness and kurtosis than other variables. One reason for this is that the values of these variables are not logarithmically transformed. In general, logarithmic transformation reduces the skewness and kurtosis. Table 8.5 clearly shows that technology-based firms invest more in R&D than those in non-technology-based industries, with a difference of approximately 32 percent. Tabrizi (2005) also points out that innovative firms spend more on R&D than non-innovative firms. In general, technology-based firms place more weight on bringing new knowledge to the markets, advancing technology, and increasing employee skills, internal

competencies and capabilities. These results support considering control of the industry effect in the model.

Table 8.6 shows descriptive statistics for country-level factors, including investor protection and country-level governance variables. The results show that BRIC countries are ahead of other emerging countries in R&D investment. Investor protection may vary not only by firm but also by country. Israel, Malaysia and South Africa have higher than average values for each of the investor protection components, which ensure balanced and strong investor protection. In contrast, in several countries, such as China, Indonesia and Russia, investor protection components vary greatly, indicating unbalanced and low investor protection. For instance, China has a disclosure index of 10, which is strong, but its score for the directors' liability index is 1, which indicates weak investor protection. On the other hand, Malaysia, Poland and Colombia have higher than average values for country-level governance components, indicating balanced and strong governance systems. Russia's government effectiveness and Pakistan's accountability are very low compared with other countries. Most interestingly, emerging countries still suffer from a lack of control of corruption. The data show that this value is low compared with other components. Among emerging countries, only Malaysia has higher than average values for both investor protection and country governance factors. When compared with the median, India, Israel, South Africa, Malaysia and Bangladesh have stronger investor protection, while Poland and Colombia have higher governance. This suggests that, among the sample countries, investor protection is stronger than governance.

Table 8.4: Sample by Firm

Variable	Mean	Standard Deviation	25%	Minimum	75%	Maximum	Skewness	Kurtosis
ROA	0.09583	0.10049	0.04569	-0.5095	0.13473	1.38429	1.83170	20.7376
ROIC	11.2362	13.3173	4.84000	-49.440	15.3700	190.470	3.11021	31.7871
R&D intensity	0.01340	0.03546	0.00103	0.00000	0.01046	0.56101	8.19602	98.1054
Leverage	0.26685	0.17483	0.12342	0.00000	0.39289	0.85863	0.40124	2.45744
Firm size	5.60229	0.84762	4.99050	3.66950	6.18292	8.64330	0.39833	2.91994
Sales growth	0.15500	0.59238	-0.03695	-1.5331	0.26712	22.5106	21.2309	719.792
Tangibility	0.48427	0.18637	0.34538	0.05703	0.62196	0.96268	0.11058	2.38450

Source: Author's calculations

Table 8.5: Sample by Industry

	Technology-based Industries				Non-technology-based Industries			
Variable	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
ROA	0.09556	0.09839	-0.50950	0.95239	0.09632	0.10416	-0.29166	1.38429
ROIC	11.2542	12.4647	-47.5100	166.190	11.2041	14.7194	-49.4400	190.470
R&D intensity	0.01774	0.04145	0.00000	0.56101	0.00569	0.01854	0.00000	0.43474
Leverage	0.25136	0.16793	0.00000	0.85863	0.29442	0.18334	0.00000	0.80964
Firm size	5.55981	0.82941	3.75097	8.00070	5.67792	0.87441	3.66950	8.64330
Sales growth	0.16529	0.66898	-1.53317	22.51064	0.13668	0.42266	-0.76285	6.64761
Tangibility	0.46694	0.18793	0.05703	0.96268	0.51513	0.17955	0.07258	0.92924

Source: Author's calculations

Table 8.6: Sample by Country

Country	Frequency	Composition (%)	R&D Intensity	Disclosure	Liability	Investor Suits	Investor Protection	Government Effectiveness	Regulatory Quality	Rule of Law	Control of Corruption	Political Stability	Voice and Accountability	Country Governance
India	171	39.130	0.0141	6.0000	4.0000	7.3840	5.8152	0.7500	0.6583	0.6700	0.4072	0.5582	0.8300	0.6443
Turkey	68	15.561	0.0061	8.6597	4.0000	5.0000	5.8979	0.5000	0.5965	0.6621	0.4200	0.5501	0.5480	0.5475
China	52	11.899	0.0163	10.000	1.0000	3.8723	4.9553	0.5000	0.5539	0.6616	0.3550	0.7235	0.3768	0.5282
Israel	27	6.1785	0.0504	7.0000	9.0000	9.0000	8.3000	1.0000	0.8200	0.8300	0.5000	0.5017	0.7100	0.7277
South Africa	21	4.8055	0.0028	8.0000	8.0000	8.0000	8.0000	0.5000	0.7922	0.4116	0.4315	0.7028	0.8300	0.6118
Malaysia	19	4.3478	0.0035	10.000	9.0000	7.0000	8.7000	0.7500	0.7658	0.6700	0.4200	0.7142	0.7751	0.6838
Greece	18	4.1190	0.0091	1.3448	3.6293	5.0000	3.3095	0.7500	0.7034	0.7500	0.3300	0.7261	0.9200	0.6958
Indonesia	12	2.7460	0.0046	9.5294	5.0000	3.0000	5.8588	0.5000	0.6759	0.5000	0.5229	0.6080	0.6300	0.5708
Philippines	10	2.2883	0.0032	2.0000	3.0000	8.0000	4.3000	0.7500	0.7266	0.4200	0.3394	0.6772	0.6885	0.5992
Russia	9	2.0595	0.0048	6.0000	2.0000	6.0000	4.7000	0.2500	0.7421	0.6202	0.3066	0.6333	0.5555	0.5167
Brazil	8	1.8307	0.0230	5.0000	8.0000	3.0000	5.3000	0.5000	0.5947	0.3353	0.4529	0.7098	0.7500	0.5568
Pakistan	8	1.8307	0.0094	5.5902	5.8197	6.8361	6.0492	0.5205	0.5921	0.5533	0.3208	0.4620	0.3411	0.4453
Poland	4	0.9153	0.0203	7.0000	2.0000	8.8571	5.9571	0.7500	0.8854	0.7500	0.4343	0.8075	1.0000	0.7710
Jordan	3	0.6865	0.0108	4.0000	4.0000	1.0000	3.0000	0.5000	0.7837	0.6700	0.4747	0.7411	0.6511	0.6342
Sri Lanka	3	0.6865	0.0006	4.5000	5.0000	7.0000	5.4750	0.5000	0.6220	0.4560	0.4200	0.6170	0.4560	0.5110
Bangladesh	2	0.4577	0.0020	6.0000	7.0000	7.0000	6.7000	0.5000	0.5107	0.3750	0.4593	0.5657	0.4614	0.4771
Chile	2	0.4577	0.0015	7.3636	6.0000	5.0000	6.1091	0.7500	0.9418	0.7864	0.7155	0.7500	0.7900	0.7918
Total	437	100												
Min.			0.0000	1.0000	1.0000	1.0000	3.0000	0.2500	0.4500	0.3300	0.2500	0.4100	0.1700	0.4200
Max.			0.5610	10.000	9.0000	9.0000	8.7000	1.0000	0.9500	0.8300	0.7800	0.8500	1.0000	0.8100
Mean			0.0134	7.0033	4.4816	6.3781	5.9619	0.6562	0.6648	0.6474	0.4092	0.6029	0.6989	0.6131
Median			0.0033	6.0000	4.0000	7.0000	5.7000	0.7500	0.6800	0.6700	0.4200	0.5700	0.7900	0.6300

Source: Author's calculations

8.3.2 Model

In order to examine the impact of the influence of country governance factors on the relationship between R&D spending and firm performance, the following model was devised. A semi-logarithmic model is used for the analysis, firstly because the investor protection and governance variables are dummy variables which take values of 0 and 1, so logarithms for these variables cannot be used as the logarithm of 0 does not exist. Secondly, ROA, ROIC and sales growth can be negative; thus, the logarithm cannot be used for these values.

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3 ln(Firm\ Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(1)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3(R\&D\ Intensity2_{it}) + \beta_4\ In(Firm\ Size_{it}) + \beta_5(Sales\ growth_{it}) + \beta_6(Leverage_{it}) + \beta_7(Tangibility_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(2)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3(Firm\ Size_{it}) + \beta_4 ln(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Investor\ protection_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(3)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3 ln(Firm\ Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Disclosure_{it}) + \beta_8(R\&D*Liability_{it}) + \beta_9(R\&D*Suits_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(4)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3\ ln(Firm\ Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Country\ Governance_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(5)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3\ ln(Firm\ Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Gov.Effect_{it}) + \beta_8(R\&D*Reg.Quality_{it}) + \beta_9(R\&D*law_{it}) + \beta_{10}(R\&D*Con.Corrupt_{it}) + \beta_{11}(R\&D*Pol.Stability_{it}) + \beta_{12}(R\&D*Accountability_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(6)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3\ ln(Firm\ Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Investor\ protection_{it}) + \beta_8(R\&D*Country\ governance_{it}) + \eta_i + d_t + I_i + v_{it} \quad \textbf{(7)}$$

$$Performance_{it} = \alpha_i + \beta_1(Performance_{it-1}) + \beta_2(R\&D\ Intensity_{it}) + \beta_3\ ln(Firm\ Size_{it}) + \beta_4(sales\ growth_{it}) + \beta_5(Leverage_{it}) + \beta_6(Tangibility_{it}) + \beta_7(R\&D*Disclosure_{it}) + \beta_8(R\&D*Liability_{it}) + \beta_9(R\&D*Suits_{it}) + \beta_{10}(R\&D*Gov.Effect_{it}) + \beta_{11}(R\&D*Reg.Quality_{it}) + \beta_{12}(R\&D*law_{it}) + \beta_{13}(R\&D*Con.Corrupt_{it}) + \beta_{14}(R\&D*Pol.Stability_{it}) + \beta_{15}(R\&D*Accountability_{it}) + \eta_i + d_t + I_i + \nu_{it} \quad (8)$$

where subscript *i* represents the country and *t* represents the year. Here α_i, and $\beta_1$to β_{15}represent relationships between performance and the explanatory variables. The error component ε_{it} is separated into four sub-components $\varepsilon_{it} = \eta_i + d_t + I_i + \nu_{it}$, while η_i is considered as an individual effect to control for individual heterogeneity, which is then eliminated by taking first differences. The time dummy, denoted by d_t, captures the time-specific effect to control for macroeconomic variables on R&D and performance. As the industries are separated into technology-based and non-technology-based, an industry dummy I_i is used to capture industry-specific effects. ν_{it} is a random disturbance term which is assumed to be i.i.d. normal.

8.3.3 Method

In order to examine the moderating effect of investor protection and country governance on the relationship between a country's R&D and firm performance, a GMM estimation was performed, following Pindado et al. (2015). Dynamic GMM estimation was used to address endogeneity concerns due to unobserved heterogeneity and reverse causality. For example, R&D investment has an impact on firm performance (Ehie and Olibe, 2010), but performance may also impact on R&D investment, as a higher firm value may encourage managers to commence new R&D activities (Pindado et al., 2015).

The GMM estimation consisted of the following steps. First, as the current performance of firms may influence their future performance, the lag of performance (a dependent variable) was included as an independent variable. Second, the first difference of all variables was taken in order to control for unobserved heterogeneity and omitted variable bias. The results show no first-order AR(1) serial correlation problems arising from the

first-difference transformation; however, there is a problem of second-order serial correlation AR(2). This suggests that the assumptions of the dynamic GMM estimation hold. Third, the lagged values of the explanatory variables were used as instruments. Lagged levels of t-1, t-2 and t-3 were used as instruments for the difference equation, and one lag as an instrument for the level equation, since system GMM was being used. This is because external instruments may not be readily available (Liu et al., 2015) and establishing them is extremely complex (Pindado et al., 2014). However, in order to be included in the model, the internal instruments must be valid. The Hansen J statistic of over-identifying restrictions was applied to test the validity of the instruments, and the results show that the instruments are valid in the model.

In addition, two Wald tests were used to examine the joint significance of the time dummy and the explanatory variables. These provide good results for the model.

8.4 Results and discussion

Table 8.7 presents the results of the GMM estimation. Eight models (1 to 8) were used to examine the moderating effects. Model 1 is the basic model of this estimation, the results of which show that R&D intensity and performance have a negative relationship. With a one-unit change in R&D intensity, firm performance decreases by 28.75 units. This may happen if the current-year R&D investment makes a profit in the same year. Therefore, in Model 2, the square of R&D intensity was added, and the results show that R&D intensity and firm performance are positively related, confirming a non-linear relationship. Yeh et al. (2010) also reach the conclusion that R&D and firm performance have a non-linear relationship. Figure 2 shows that, after reaching an optimum level, R&D investment gradually decreases.

Table 8.7: Results Summary - GMM Estimation

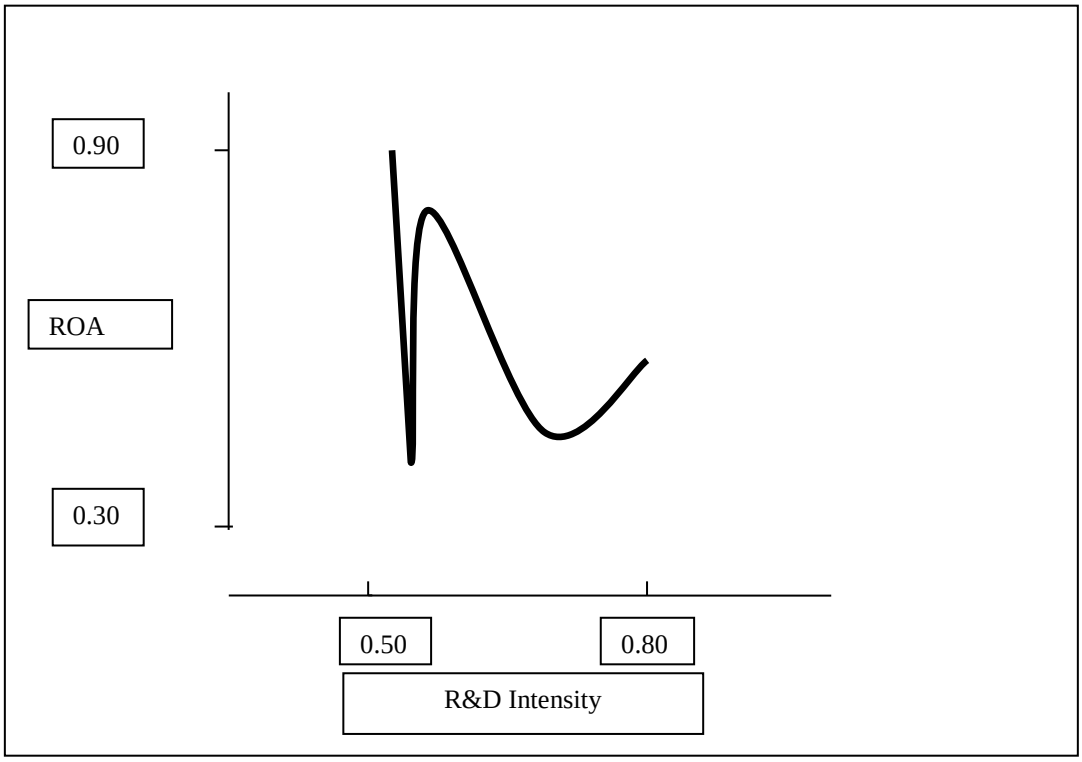
Dependent variable: ROA	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
ROA_{t-1}	0.33901***	0.34842***	0.33420***	0.31604***	0.36055***	0.37214***	0.34126***	0.32839***
	(0.05816)	(0.05455)	(0.06048)	(0.06026)	(0.06107)	(0.06206)	(0.06026)	(0.06084)
R&D Intensity	-0.28745**	-0.80528**	-1.74769***	-1.98745**	-0.86995**	-1.20102**	-1.61770**	-1.15217***
	(0.10148)	(0.33087)	(0.66749)	(0.81784)	(0.40987)	(0.58546)	(0.72354)	(0.33043)
R&D Intensity ^{2}		1.25087*						
		(0.69471)						
R&D Intensity*Investor Protection Index			1.49245**				1.019671*	
			(0.67411)				(0.57103)	
R&D Intensity*Disclosure Index				-0.07532				-1.20411**
				(0.79452)				(0.50119)
R&D Intensity*Liability Index				1.16469***				1.16232***
				(0.20589)				(0.17395)
R&D Intensity*Shareholder Suits Index				0.69993**				1.92426***
				(0.30763)				(0.66634)
R&D Intensity*Country Governance Index					0.62488		0.34465	
					(0.41149)		(0.41353)	
R&D Intensity*Government Effectiveness						0.93129*		-1.03571
						(0.52909)		(0.72584)
R&D Intensity*Regulatory Quality						0.11677		-0.03907
						(0.13669)		(0.11459)
R&D Intensity*Rule of Law						-0.81639		-0.22111
						(0.63002)		(0.35535)
R&D Intensity*Control of Corruption						0.48994**		0.11645
						(0.21218)		(0.18279)
R&D Intensity*Political Stability						-0.20242		0.12335
						(0.19184)		(0.08610)
R&D Intensity*Voice & Accountability						0.48013*		0.29057
						(0.28443)		(0.28213)

Size	0.02092**	0.01671*	0.01430*	0.02047***	0.01477**	0.01718**	0.01327*	0.02526***
	(0.00866)	(0.00922)	(0.00853)	(0.00795)	(0.00794)	(0.00771)	(0.00730)	(0.00676)
Sales Growth	0.01685*	0.01683*	0.01568**	0.01463**	0.01508**	0.01427**	0.01493**	0.01268*
	(0.00876)	(0.00882)	(0.00716)	(0.00774)	(0.00780)	(0.00716)	(0.00711)	(0.00760)
Leverage	-0.27373***	-0.26935***	-0.26858***	-0.27593***	-0.22654***	-0.25118***	-0.26978***	-0.23612***
	(0.03773)	(0.03762)	(0.03132)	(0.03043)	(0.03201)	(0.03197)	(0.03280)	(0.02703)
Tangibility	-0.16526**	-0.19321***	-0.15350***	-0.17499***	-0.16188***	-0.17639***	-0.15303***	-0.15372***
	(0.04755)	(0.05132)	(0.04221)	(0.04760)	(0.04173)	(0.05070)	(0.04141)	(0.04010)
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total Observations	2549.00	2549.00	2549.00000	2549.00	2549.00	2549.00	2549.00	2549.00
AR(1)	-4.61	-4.8400	-4.51000	-4.42	-4.5100	-4.4800	-4.46	-4.4100
P-value	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
AR(2)	1.43	1.48000	1.44000	1.19	1.47000	1.44000	1.44	1.33000
P-value	0.152	0.14000	0.15100	0.233	0.14200	0.15000	0.151	0.18300
z_1	27.44(7)	29.6(8)	30.25(8)	30.93(10)	30.96(8)	19.85(13)	30.77(9)	23.99(16)
P-value	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
z_2	3.36	3.39(5)	2.87(5)	2.5(5)	5.03(5)	4.4(5)	3.89(5)	4.98(5)
P-value	0.0054	0.00510	0.01460	0.03	0.00020	0.00060	0.0018	0.00020
Hansen	159.58(146)	168.48(147)	191.32(168)	235.84(210)	198.05(175)	333.74(304)	209.42(188)	339(325)
P-value	0.209	0.10800	0.10500	0.107	0.11200	0.11600	0.136	0.28500

Levels of significance: * <0.10, ** <0.05, ***<0.01; Standard errors in parenthesis

The results show that with a one-unit change in R&D intensity, the probability of high firm performance increases by 125 units. This implies that R&D intensity takes time to show returns on the investment, confirming the general view that R&D intensity does not create benefits in the current year. In other words, strategic decisions such as R&D investment have a threshold level. Therefore, the results strongly support Hypothesis 1.

Figure 8.2: Non-Linear Relationship between R&D and Firm Performance



In Model 3, the interaction terms of the investor protection index are added. R&D intensity is interacted with the investor protection index. The positive coefficient on the interaction term suggests that investor protection has a significant influence on R&D spending in increasing firm performance. The results remain robust in Model 7 after including the country governance index in the regression. This implies that investor protection enhances R&D investment by facilitating external finance (Hiller et al., 2011) and capital allocation (Xiao, 2013), which in turn increase firm performance. These results confirm the moderating role of investor protection on the relationship between R&D and firm performance. Therefore, the results support Hypothesis 2.

In Model 4, in order to examine which aspects of investor protection drive the positive effect on firm performance, the investor protection index is split into three sub-components: disclosure, directors' liability and shareholder suits. The base model shows that R&D intensity and firm performance have a negative relationship, but the relationship becomes positive when the interaction terms, except disclosure, are present. These results suggest that R&D intensity influences firm performance when directors are more liable for their activities, which makes them more accountable for their decisions. The positive relationship between R&D intensity, shareholder suits and firm performance is consistent with the idea that the possibility of shareholder suits puts pressure on directors to make investments such as in R&D that will enhance firm value. Directors' liability and shareholder suits remain robust when new governance variables are added into the regression in Model 8. In addition, disclosure becomes significant. The negative coefficient of the interaction term of disclosure and R&D investment implies that disclosure of R&D-related activities does not influence firm performance. This is because most investors in emerging markets are unaware of R&D-related activities or annual reports. Moreover, a substantial percentage of investors in emerging markets are illiterate.

In Model 5, the country governance index is interacted. The results show that the interaction between country governance index and R&D investment has no influence on firm performance. This is because firm-level governance has a greater influence than country governance on strategic decisions such as R&D in generating firm performance. The contrasting effects of the country-level governance components may be another reason for the insignificance. Therefore, the results do not support Hypothesis 3.

In order to examine aspects of country governance in greater depth, country governance is sub-divided into government effectiveness, regulatory quality, rule of law, control of corruption, political stability, and voice and accountability. It can be seen from the results of Model 6 that only government effectiveness, control of corruption and voice and

accountability have a positive influence on R&D intensity and firm performance. This implies that effective government may increase R&D spending as a result of spill-overs creating networks between firms and individuals. Moreover, control of corruption may facilitate the size of R&D investment, as it motivates innovation-related FDI and reduces investment costs. A high level of accountability of managers and directors to shareholders influences the relationship between R&D and firm performance. Voice and accountability ensures the responsible behaviour of managers, which influences investments in general, and R&D investments in particular. Moreover, high accountability ensures responsible decisions, actions and commitment to accomplishing the task. In addition, high accountability guarantees organisational learning and innovation. Interestingly, in Model 8, when three more variables of investor protection are introduced into the regression, these country-level governance variables become insignificant. The results suggest that investor protection, whether aggregate (Model 7) or separate (Model 8), tend to have a greater influence on the relationship between R&D and firm performance.

ROA_{t-1} impacts positively on firm performance, indicating the persistent performance of the firm. Following path-dependent theory, this indicates that past-year performance motivates a firm to grow more. Firm performance is also influenced by firm size. A larger firm size indicates greater assets, higher capacity, higher investment and greater human capital, which help to utilise more resources and obtain greater returns. The coefficient of sales growth is positive and significant, implying that growth opportunities help firms to expand knowledge, skills and abilities, and to provide new products to customers, which in turn increases firm performance. In contrast, leverage shows a negative impact on firm performance. This is because high leverage increases the probability of bankruptcy. Similarly, tangibility and firm performance are negatively related. Greater tangibility indicates higher fixed assets, such as equipment and buildings, and lower investment. However, higher investment creates more value for firms.

Table 8.8: Robustness Test

Dependent variable: ROIC	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
$ROIC_{t-1}$	0.32548***	0.30947***	0.29790***	0.28841***	0.31386***	0.28515***	0.30707***	0.27625***
	(0.06676)	(0.07282)	(0.06853)	(0.06600)	(0.06587)	(0.06539)	(0.06896)	(0.06376)
R&D Intensity	-41.0297**	-83.53255**	-206.7691**	-152.2283*	-158.5874*	-189.7526***	-239.8045***	-91.61253*
	(12.83565)	(23.9575)	(102.0035)	(63.2158)	(84.75506)	(70.16853)	(83.15336)	(53.59715)
R&D Intensity ^{2}		107.3062**						
		(49.96016)						
R&D Intensity*Investor Protection Index			179.2447*				103.5832*	
			(101.6571)				(59.66239)	
R&D Intensity*Disclosure Index				-156.907*				-221.3451***
				(80.65221)				(73.59762)
R&D Intensity*Liability Index				122.29***				94.18442***
				(40.29115)				(25.62528)
R&D Intensity*Shareholder Suits Index				167.0042***				275.8891***
				(64.56421)				(76.62181)
R&D Intensity*Country Governance Index					129.4959		108.3986**	
					(84.70142)		(43.01148)	
R&D Intensity*Government Effectiveness						40.98203		-132.972
						(81.80536)		(81.59818)
R&D Intensity*Regulatory Quality						26.10056		-4.76183
						(21.49742)		(15.57178)
R&D Intensity*Rule of Law						-63.55827		9.29344
						(76.23429)		(44.41675)
R&D Intensity*Control of Corruption						51.66614*		-0.76609
						(27.56927)		(20.3361)
R&D Intensity*Political Stability						-35.56865*		2.12354
						(20.85312)		(12.57721)
R&D Intensity*Voice & Accountability						143.7323***		56.49137
						(54.98981)		(35.56836)

Size	3.61181**	2.33438*	3.47277***	4.18488***	3.47588***	3.47346**	3.70869***	3.92055***
	(1.43249)	(1.33657)	(1.09780)	(1.22285)	(1.13490)	(1.01697)	(1.13978)	(0.98160)
Sales Growth	2.74672**	2.75763*	2.45074**	2.11113*	2.42449**	1.97972**	2.18203**	1.86360*
	(1.34867)	(1.41090)	(1.22624)	(1.10525)	(1.20188)	(0.97474)	(1.02054)	(1.13083)
Leverage	-39.59039***	-37.92565***	-31.38161***	-30.66891***	-31.83194***	-32.02911***	-35.95089***	-30.36872***
	(5.81462)	(5.65427)	(4.59028)	(4.22288)	(4.54046)	(4.32129)	(4.35212)	(3.85153)
Tangibility	-36.74622***	-33.5642***	-28.06347***	-34.03286***	-31.47292***	-31.58779***	-30.0136***	-30.52369***
	(8.54340)	(8.25)	(6.86035)	(8.17854)	(7.11744)	(7.35731)	(7.43422)	(6.68155)
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total Observations	2549.00	2549.00	2549.00	2549.00	2549.00	2549.00	2549.00	2549.00
AR(1)	-3.17	-3.10000	-3.10000	-3.07	-3.17000	-3.0100	-3.01	-3.0100
P-value	0.00200	0.00200	0.00200	0.00200	0.00200	0.00300	0.00300	0.00300
AR(2)	1.36	1.34000	1.33000	1.15	1.33000	1.15000	1.27	1.15000
P-value	0.173	0.18200	0.18400	0.251	0.18400	0.25200	0.203	0.24900
z_1	24.76(7)	21.49(8)	19.66(8)	19.73(10)	22.62(8)	16.71(11)	24.37(9)	24.27(16)
P-value	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
z_2	1.91(5)	2.2(5)	1.95(5)	2.19(5)	1.93(5)	2.42(5)	1.96(5)	2.69(5)
P-value	0.0917	0.05320	0.08460	0.0546	0.08740	0.03540	0.083	0.02080
Hansen	161.36(156)	169(151)	192.44(171)	219.06(195)	181.62(159)	294.52(266)	192.41(170)	339.51(325)
P-value	0.368	0.15000	0.12500	0.114	0.10600	0.11100	0.115	0.27900

Significance levels: * <0.10, ** <0.05, ***<0.01; Standard errors in parenthesis.

8.5.1 Robustness Test

In order to test the robustness of the models, ROIC is considered as a dependent variable. ROIC measures the efficiency of the firm on the basis of capital investment, expressed as profit per dollar of invested capital. ROIC has advantages over ROA in measuring profitability. For example, it does not include non-operating items in measuring profitability. Moreover, ROA can easily be skewed when a firm has excess cash. In contrast, ROIC overcomes these shortcomings. Moreover, it helps to compare firms with different financial structures. Thus, robustness was tested using ROIC.

Table 8.8 reports the results of GMM estimation, where ROIC is the dependent variable. The results show that investor protection factors interacting with R&D have a significant impact on firm performance. All the results in Models 1, 2, 3, 5 and 8 are similar to those for ROA. In Model 4, the results show that disclosure and R&D jointly negatively impact on firm performance. This implies that higher disclosure of R&D negatively impacts on firm performance. Therefore, R&D disclosure principles play a vital role. If R&D costs are treated as an expense in the period they are incurred, net income decreases. In Model 6, the composite country governance index becomes significant. This is because the capital investments (ROIC) rather than total assets (ROA) of a firm are influenced by both investor protection and country governance. The implication is that the external environment is very important for investment and the ability to gain returns on it. In Model 7, the results become robust, as control of corruption and voice and accountability, together with R&D, have an impact on firm performance. The results for control of corruption and voice and accountability remain the same as for ROA. On the other hand, political stability negatively influences R&D investment. This is because political stability varies greatly between emerging markets because many are less democratic and less accountable to their people, which discourages foreign investment in innovative activities.

From the test for robustness, it can be concluded that safeguards (investor protection) have a greater impact on the R&D and firm performance relationship than systems (country governance). This is because investors seek safeguards for their investments. The recent financial crisis also led them to prefer safeguards to systems. With risky and uncertain investments like R&D, investors seek protection from possible losses.

8.6 Conclusion

Country-level factors play an important role in attracting investors, and especially foreign investors, to innovative activities in emerging markets. Thus, this study has examined the moderating effects of country-level factors, such as investor protection and governance, on the relationship between R&D and firm performance. In order to analyse the moderating effect, GMM estimation was applied to panel data for 437 firms from 17 emerging countries. In the first part of analysis, the R&D intensity and firm performance relationship was investigated. Consistent with Yeh et al. (2010), it is found that there is a non-linear relationship between R&D intensity and firm performance. This is because R&D intensity takes time to show returns on investment. Moreover, it confirms the common view that R&D intensity does not create benefits in the current year.

In the second part of the study, the moderating effects of investor protection on the relationship between R&D and firm performance were examined. Whereas the first part showed that R&D intensity and firm performance have a negative relationship, the relationship becomes positive when the interaction terms are included in the regression. The results show that R&D investment may generate higher profits when there is strong investor protection. Investor protection enhances R&D investment by facilitating external finance (Hiller et al., 2011) and capital allocation (Xiao, 2013), which in turn improves firm performance. More insightful information is provided when investor protection is separated into the sub-components of disclosure index, liability index and shareholder suits index. The results indicate that R&D intensity influences firm performance when directors

are more liable for their activities. Moreover, the positive relationship between R&D intensity, shareholder suits and firm performance is consistent with the idea that the possibility of shareholder suits puts pressure on managers and directors to make investments such as in R&D that will enhance firm value. However, disclosure shows a negative impact when ROIC is considered as the dependent variable. This is because, if R&D costs are treated as an expense in the period they are incurred, net income is decreased. Moreover, disclosure of information relating to innovative activities does not influence most investors in emerging markets.

In the third part of the study, the moderating effects of country-level governance factors on the R&D and firm performance relationship were investigated. The results show that the combined country governance factor has no influence on R&D investment and firm performance. This suggests that firm-level governance factors may be more influential in firm-level strategic decisions such as R&D. Contrasting effects among country governance factors may be another reason for this result. Therefore, when the country governance factors are separated into the sub-components of government effectiveness, regulatory quality, rule of law, control of corruption, political stability and voice and accountability, it is found that government effectiveness, control of corruption and voice and accountability have an influence on the R&D and firm performance relationship. This implies that good governance facilitates R&D investment by facilitating networking between firms and individuals. Moreover, control of corruption increases innovative activities in a country, which influences firm performance. Control of corruption may decrease the cost of fixed investments, thus increasing R&D activity. It is also found that accountability together with R&D positively influence firm performance. This is because high accountability guarantees organisational learning and innovation.

Overall, in comparing investor protection and country governance, it is found that investor protection factors tend to moderate the relationship between R&D and firm performance to

a greater extent than country governance. This is because, with risky and uncertain investments such as R&D, investors seek protection from possible losses.

This study contributes to the debate over which factors moderate the relationship between R&D and firm performance most. Moreover, it will help national and foreign investors to make decisions about R&D in emerging countries. This analysis could be extended to analyse the influence of macroeconomic factors on the R&D and firm performance relationship, and future work might be extended to other emerging countries. The main limitation of this study is that, due to missing values of R&D and investor protection factors, not all emerging countries were included.

Chapter 9: Financing Behaviour of R&D Investment in Emerging Markets – The Role of Multinationality and Financial Systems

9.1 Introduction

In order to finance R&D, firms need to raise capital from internal or external sources. However, there is a dilemma about whether to raise capital from internal sources, external sources, or both. Schumpeter (1942) argued that, due to agency problems, R&D investment is preferably financed internally. Moreover, internal sources are less costly and easier to raise. However, due to financial constraints, firms may depend on external sources for R&D investment (Hottenrott and Peters, 2012). Furthermore, external financing provides tax shields. Brown and Peterson (2009) emphasised both internal and external sources of finance for R&D investment, while Brown et al. (2009) found that neither internal nor external finance appear to be easy sources of R&D investment. The latter argued that firms build up cash reserves when funds are sufficient and spend them in years when funds are limited. Similarly, the Modigliani-Miller (M-M) theorem posits that firms choose optimum levels of investment to obtain higher returns, which do not depend on how firms raise capital. This inconclusive situation and the challenges of the recent global financial crisis prompt the investigation described in this chapter.

This chapter examines sources of financing for R&D investment, which will direct firms to make financial policies and reach financial goals with least cost. Moreover, studying sources of financing will help firms to prepare budgets for R&D projects. However, firms' financing decisions are highly correlated with multinationality, as well as national institutional settings. Mudambi et al. (2012) observed that multinationality has a significant impact on the performance of a firm's initial public offering (IPO) performance. Similarly, institutional settings such as (bank-based and market-based) financial systems embed firms in a specific environment within which to choose sources of finance (David et al., 2008). Therefore, identifying appropriate channels for financing R&D investment in the context of multinationality and financial systems promotes the long-run growth of the firm. This

study will also help investors, lenders, managers, R&D workers and policy makers to be aware of sources of finance for R&D and how to promote R&D activities.

This study examines sources of finance for emerging countries, as they are growing faster than developed countries in terms of GDP and purchasing power per capita. It is assumed that growth rates in emerging markets will be three times higher than those of advanced economies by 2020. Faster growth may lead to higher rates of return than on similar investments in developed countries (Logue, 2011). Emerging markets are considered to be low-cost innovation centres and lands of opportunity for investors. In addition, investment in R&D helps firms to emerge from crises and provides sustainable long-term growth (OECD, 2009). Therefore, in recent years, emerging markets have considerably increased their R&D investments. Emerging-market firms must consider appropriate, sufficient and cost-effective sources of finance for R&D investment, as Jensen and Meckling (1976) proposed that financing and investment decisions are interactive processes. However, there have been few empirical studies regarding the financing of R&D investments in emerging markets. Most earlier studies have focused on the link between financial constraints and R&D investment, and most have been based on developed countries. For the USA, these have included Himmelberg and Petersen (1994), Hall (1990, 2002), Bhagat and Welch (1995), Bah and Dumontier (2001), Brown et al. (2009), Chaio (2002), Bougheas (2004) and Wang and Thornhill (2010). Those on the UK have included Bhagat and Welch (1995), Bah and Dumontier (2001), Bougheas (2004) and Brown et al. (2012). For Japan, studies have included Bhagat and Welch (1995), Bah and Dumontier (2001), Bougheas (2004) and David et al.(2008), and for Germany, Muller and Zimmermann (2006) and Czarnitzki and Kraft (2009). This study seeks to close this gap.

Nohria and Gulati (1997) observed a relationship between organisational slack and R&D activities. The theory of financial slack posits that organisational slack affects R&D financing differently depending on firm size (Chen and Humbrick, 1995), profitability

(Bhat, 2008), type of ownership (Kim et al., 2008), experimentation with new strategies, new products and new markets (Hambrick and Snow, 1977) and global competitive pressure. Therefore, local firms' and MNEs' sources of finance for R&D investment may be different in emerging markets. On the other hand, pecking order theory suggests that firms follow an order in financing R&D investment, using first internal resources, then debt, and finally equity. This may happen due to information asymmetry and the nature of a country's financial system. Benito (2003) examined financial systems and pecking order and found that firms in market-based financial systems follow a pecking order for the financing of R&D investments.

This chapter makes two main contributions. First, it examines behavioural differences between local firms and MNEs in financing R&D investments in emerging markets. Previous research does not appear to have divided firms between local firms and MNEs to observe R&D financing. Second, evidence is provided of a relationship between financial systems and R&D investment in emerging markets. Earlier research has not focused on emerging markets. In relation to financial systems, the study distinguishes between bank-based and market-based systems. In order to examine the sources of finance for local firms and MNEs in bank-based and market-based finance systems GMM estimation is applied using panel data from a sample of 310 firms during the period 2003-2012. After controlling for firm size, sales growth, export orientation and foreign ownership, it is found that emerging market firms do not use external funding for R&D investment. Interesting results are obtained when the sample is divided between local firms and MNEs, and bank-based and market-based finance. Local firms' and MNEs' sources of finance for R&D investment are different. Local firms do not use external funding for R&D investment, while MNEs use both internal and external funding for R&D in emerging markets, following financial slack theory. This result implies that access to finance plays a role in R&D financing. The study also finds that the financial system of the country in which firms are embedded

influences their choice of source of finance. Firms under bank-based financial systems use external funding, while those under market-based financial systems use internal funding for R&D investments in emerging markets, following pecking order theory.

This chapter is organised as follows. Section 9.2 presents the hypotheses of the study, Section 9.3 introduces the data and research methods, Section 9.4 presents and discusses the results, and Section 9.5 draws conclusions from this study.

9.2 Hypotheses to be tested

Sources of finance for R&D investment may be different for local firms and MNEs. In general, local firms are small and less resource-intensive than MNEs (Boardman et al., 1997; Tsang et al., 2008; Poulis et al., 2012). Thus, it is assumed that local firms have less capability to repay loans or continue with long-term R&D projects, making it harder to obtain external funding. Local firms have less access to multiple sources of funding; thus, external finance may be expensive for them. Moreover, owing to higher risk and uncertainty and constrained resources, local firms with greater debt-equity ratios will spend less on R&D. Transaction cost theory and the positive theory of agency argue that debt financing may discourage R&D investment. On the other hand, MNEs are large and have good networks in the national and international arena. As MNEs have sufficient resources and capability-based advantages over local firms (Xu et al., 2005), it is expected that they will have more internal funds to invest in R&D. Moreover, owing to operations and production activities in different areas, MNEs have access to multiple sources of funding. In addition, good networks and international exposure help MNEs to obtain external financing for R&D investments. Thus, better financial position, greater production capability, positive corporate brand image and greater access to trade (Poulis et al., 2012) allow MNEs to use both internal and external funding for R&D investment. Moreover, Brown and Peterson (2009) emphasised both internal and external sources of finance for R&D investment. Therefore, the following hypotheses are postulated:

Hypothesis 1: *Owing to the risky and costly nature of R&D investment, local firms do not use external funding for R&D investment.*

Hypothesis 2: *As MNEs have sufficient internal resources and multiple sources of funding, they use both internal and external funding for R&D investment.*

Different financial systems have comparative advantages for financing. Consequently, financing choices for R&D investment depend on countries' financial systems (David et al., 2008). In bank-based financial systems, banks tend to be more active, more efficient and larger (Demirguc-Kunt and Levine, 1999). Such systems provide more credit facilities, promote long-term relationships with firms and resolve moral hazard problems. Thus, firms can easily get debt for long-term R&D investments. Disciplinary role theory and monitoring theory of debt posit that firms prefer debt as a mode of financing R&D. Debt financing is monitored by the client and also reins in managerial discretion, which positively affects R&D investment. Moreover, debt finance reduces over-investment, provides tax shields, and enables greater incremental innovation in firms. On the other hand, in market-based systems, stock markets tend to be larger, more active and more efficient (Demirguc-Kunt and Levine, 1999). Market-based systems are superior for long-term financing. Moreover, market-based systems transmit prices, encouraging firms to engage in strategic investments such as R&D. Thus, firms can easily raise money from the market for R&D investment, and it is less costly because firms need not make regular interest payments. Schumpeter's (1942) hypothesis and Myers' (1984) pecking order theory both emphasise internal funding as a source of finance for R&D investment. Due to information asymmetry and the lower collateralisable value of R&D, it is difficult for firms to obtain external finance in a market based system. Therefore, the following hypotheses are postulated:

Hypothesis 3: *Bank-based financial systems provide more credit facilities, and are more efficient and active, leading firms to rely on external funding for R&D investment.*

Hypothesis 4: *Market-based financial systems are superior for long-term financing such as R&D, leading firms to rely on internal funding for R&D investment.*

The existing literature suggests that, in addition to internal and external funding, firms' R&D is also affected by important factors such as firm size, sales growth, export orientation and foreign ownership, which are considered as control variables. Connolly and Hirschey's (2005) study supported size advantages in the valuation effects of R&D expenditure. However, the existing literature has provided inconclusive results for the relationship between size and R&D. Larger firms have sufficient assets and capacity to invest more in R&D. They also tend to be more diversified, more technologically complex and better aware of technological opportunities (Lall, 1983). In contrast, Kriaa and Karray (2010) argued that, due to better networks of communication and co-ordination and informal controls, smaller size may have a positive effect on R&D activities. A high sales growth rate indicates a firm's potential for growth, greatly contributing to an increase in R&D investment. According to Mueller (1967), "The faster a firm's sales are increasing, the more confidence it will have about its ability to secure the benefits from uncertain R&D projects, and the more patience it can afford to show in waiting for these benefits."

Export-oriented firms will be more aware of new technologies and will also strive harder to maintain the competitiveness of their technologies (Lall, 1983). Exporting firms need to adapt their products and processes to meet the nature of demand, tastes and product standards in foreign markets (Kumar and Aggarwal, 2005). R&D activity may help firms to compete more effectively in international markets (Kumar and Saqib, 1996). Thus, export-orientated firms need to invest more in R&D than non-exporting firms. Kumar and Saqib's (1996) study found a significant positive influence of export orientation on R&D investment. Foreign ownership may induce a firm to undertake R&D if knowledge from the parent needs to be adapted to local conditions or if specific projects require collaboration with a foreign owner (UNCTAD, 2003). Foreign ownership creates better access to finance for R&D investment, and Kriaa and Karray (2010) found a significant positive influence of foreign ownership on R&D investment.

9.3 Data and methodology

9.3.1 Data

This chapter focuses on emerging markets, selected on the basis of lists of emerging markets drawn from the IMF, Goldman Sachs, FTSE, MSCI, The Economist, S&P, Dow Jones, BBVA and Columbia University EMGP (see Appendix 2). Thomson Reuter DataStream, LexisNexis and firms' annual financial reports were used to collect data from a sample of 51 emerging markets. In order to avoid sample selection bias, all listed firms in an emerging market were considered. First, 25,251 firms were identified from all emerging markets on DataStream. As there were missing values in these data, annual financial reports were used to fill in the gaps where possible. The LexisNexis database was used to collect data about whether a firm was local or an MNE. DataStream, LexisNexis and annual financial reports provided 310 firms from 20 emerging markets (see Tables 9.1 and 9.2). The time period considered for this analysis was 2003-2012, in order to close a gap in the literature regarding the latest data. Countries with at least two firms were taken into account. South Korea, Taiwan and Singapore were excluded from the sample because these countries are now considered to be emerged countries. The firms included in the analysis must have 10 consecutive years of data, since the analysis is based on balanced panel data. Panel data were used because they enable the researcher to control for firm heterogeneity, give more information, greater variability and more degrees of freedom, avoid mulitcollinearity problems, provide more efficient results and are more suited to identifying and measuring effects that are not detectable in pure cross-sectional or pure time series data (Baltagi, 2013).

Table 9.1: Sample Selection

Description	No. of Countries	No. of firms
Initial search on DataStream	51	25251
Firms with10 consecutive years of data	37	892
Countries with at least two firms	23	878
Dropped: Countries that are already emerged	3	568
Final sample	**20**	**310**

Source: DataStream, LexisNexis and Annual reports

Table 9.2: Sample by Country

Country	No. of firms	Percentage of firms	Cumulative percentage
Hong Kong	62	20.00	20.00
India	52	16.77	36.77
Turkey	30	9.68	46.45
China	23	7.42	53.87
South Africa	23	7.42	61.29
Israel	22	7.10	68.39
Bangladesh	21	6.77	75.16
Greece	19	6.13	81.29
Malaysia	13	4.19	85.48
Philippines	8	2.58	88.06
Indonesia	7	2.26	90.32
Sri Lanka	5	1.61	91.94
Brazil	4	1.29	93.23
Mexico	4	1.29	94.52
Pakistan	4	1.29	95.81
Russia	4	1.29	97.10
Chile	3	0.97	98.06
Peru	2	0.65	98.71
Poland	2	0.65	99.35
Thailand	2	0.65	100.00
Total	310	100	100.00

Source: Author's calculations

Table 9.3 displays definitions of the variables. From the existing literature, these variables have been found to have a significant effect on firms' R&D investment. In this study, R&D expenditure is considered as a dependent variable which takes the logarithm of firms' annual R&D expenditure. The independent variable is internal and external funding. The control variables are firm size, sales growth, export orientation and foreign ownership. All variables are standardised to a common USD exchange rate. Some explanatory variables have higher scales than other, and the absolute value of variables increases the presence of heteroscedasticity (Grabowski, 1968). In order to avoid these problems, the natural

logarithm is adopted for R&D and size variables, cash flow to sales and debt to total asset ratios, and the percentage of foreign shareholders.

Table 9.3: Definitions of Variables

Variable	Type of data	Description
R&D	Continuous	R&D expenditure of a firm in a year (ln log)
Internal funding	Ratio	Measured by ratio of cash flows to sales
External funding	Ratio	Measured by ratio of debt to total assets
Size	Continuous	Measured by total assets (ln log)
Sales growth	Ratio	Annual sales growth of the firm
Export-oriented	Dummy	A dummy variable that takes a value of 1 if a firm exports
Foreign ownership	Percentage	Percentage of foreign shareholders to total shareholders
Market dummy	Dummy	Takes a value of 1 if the firm is an MNE, and 0 if it is local
Country dummy	Dummy	Takes a value of 1 if the country is market-based, and 0 if it is bank-based

Table 9.4 reports the summary statistics of all variables used for analysis of emerging markets. The results show that emerging-market firms do not depend on external funding. The recent financial crisis restricted firms from obtaining external funds. Although the internal funds variable shows significant variations, emerging-market firms rely on internal funding. The growing importance of emerging markets raises investor interest. Thus, foreign ownership in emerging markets is higher. Foreign investment, market competition and globalisation increase a firm's size in emerging markets.

Table 9.4: Summary Statistics for All Firms

Variable	Mean	Standard Deviation	Minimum	Maximum
R&D	2.79634	1.50840	0	6.36103
Internal funding	12.4723	18.9665	-191.19	291.59
External funding	0.20387	0.18290	0	0.89991
Size	5.63364	0.87232	2.84073	8.57482
Sales growth	0.28944	3.62701	-0.94654	182.106
Export-oriented	0.45788	0.49830	0	1
Foreign ownership	14.2641	24.0204	0	95
Market dummy	0.56997	0.49516	0	1
Country dummy	0.58603	0.49262	0	1

Source: Author's calculations

Table 9.5 reports the summary statistics for local firms and MNEs in emerging markets. Local firms are defined as those that operate domestically and MNEs are firms that operate in more than one country. MNEs are more export-oriented than local firms. Firm-specific advantages of MNEs allow them to manage disadvantageous positions as a result of lower transaction costs and lower international trade barriers in foreign markets than local firms. The export behaviour of firms is also influenced by ownership structure (Athukorala et al., 1995). MNEs have more foreign ownership than local firms. As most MNEs' headquarters and parent companies are administered or controlled by two or more nations, they have greater foreign ownership than local firms.

Table 9.5: Summary Statistics for Local Firms and MNEs

	Local Firms				MNEs			
Variable	**Mean**	**Std Dev**	**Min.**	**Max.**	**Mean**	**Std Dev**	**Min.**	**Max.**
R&D	2.56415	1.50157	0	5.98412	2.97105	1.49073	0	6.36103
Internal funding	12.4305	19.0091	-95.79	291.59	12.7202	17.8354	-155.25	69.56
External funding	0.21878	0.19982	0	0.89991	0.19282	0.16820	0	0.88721
Size	5.44267	0.90229	2.98182	8.57482	5.77894	0.81754	2.94052	8.55341
Sales growth	0.27994	2.17944	-0.94654	53.5833	0.29721	4.41872	-0.87891	182.107
Export-oriented	0.35442	0.47851	0	1	0.53598	0.49884	0	1
Foreign ownership	9.69633	20.1836	0	95	17.7306	26.0390	0	90
Country dummy	0.48856	0.50005	0	1	0.65975	0.47392	0	1

Source: Author's calculations

Table 9.6 reports the summary statistics for firms under bank-based and market-based finance systems in emerging markets. Bangladesh, Indonesia, India, Israel, Greece, Pakistan and Sri Lanka are considered to be bank-based, while Brazil, China, Chile, Hong Kong, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Turkey and Thailand are considered to have market-based financial systems (World Bank, 1991; Demirguc-Kunt and Levine, 1999; Allen et al., 2012). Bank-based finance provides greater credit facilities to firms than market-based finance; thus, firms under bank-based finance systems have more external funding than those under market-based finance. On the other hand, firms with market-based finance have strong stock markets that attract investment by

foreign investors. This also influences firms' sales and export performance. As a result, firms with market-based finance have more foreign ownership, higher sales growth and better export performance than those with bank-based finance.

Table 9.6: Summary Statistics for Bank-based and Market-based Countries

	Bank-based				Market-based			
Variable	**Mean**	**Std Dev**	**Min.**	**Max.**	**Mean**	**Std Dev**	**Min.**	**Max.**
R&D	2.80711	1.39596	0	6.13468	2.78808	1.58378	0	6.36103
Internal funding	12.1149	16.1242	-99.96	137.3	12.9350	19.7644	-155.25	291.59
External funding	0.24142	0.21435	0	0.89991	0.17756	0.15153	0	0.85699
Size	5.44425	0.87343	3.1038	7.73149	5.76842	0.84405	2.94052	8.57482
Sales growth	0.17095	0.34730	-0.77542	7.56387	0.37369	4.72897	-0.94655	182.107
Export-oriented	0.55150	0.49753	0	1	0.39171	0.48827	0	1
Foreign ownership	9.00601	19.9688	0	95	17.9933	25.8864	0	95
Market dummy	0.46830	0.49919	0	1	0.64129	0.47975	0	1

Source: Author's calculations

9.3.2 Method of study

Panel data were estimated using GMM, following previous studies (Hiller et al., 2011; Pindado et al., 2015). The panel data GMM estimation technique is used to control for endogeneity and individual heterogeneity. For example, firm size and R&D investment causality may run in both directions – from firm size to R&D investment and vice versa – which may create an endogeneity problem. Individual heterogeneity is important for this analysis because R&D investment decisions depend on firm-specific factors such as strategy, firm culture and the propensity to innovate (Hillier et al., 2011). As difference GMM estimation has a problem with weak instruments (Alonso-Borrego and Arellano, 1999), system GMM was used. Moreover, system GMM is more efficient than difference GMM (Blundell and Bond, 2000). A two-step estimation was performed, following Windmeijer's (2005) finite sample correction.

In order to determine the consistency and validity of the model, the Hansen J statistic, second-order auto-correlation test and two Wald tests were used. The Hansen J statistic shows that the instruments are valid in the model. The second-order auto-correlation AR(2)

test shows that there are no second-order serial correlations, and the two Wald tests for the time dummy and explanatory variables show that the model passes the specification tests. The model for the analysis is as follows:

$$ln(RD_{it}) = \alpha_i + \beta_1(Internal\ Fund_{it}) + \beta_2(External\ Fund_{it}) + \beta_3 ln(Size_{it}) + \beta_4(Sales\ growth_{it}) + \beta_5(Export\ oriented_{it}) + \beta_6(Foreign\ ownership_{it}) + \eta_i + C_i + M_i + \varepsilon_{it} \quad \textbf{(1)}$$

In order to control for individual heterogeneity, $\eta_i$is taken as the individual effects in the model and then eliminated by taking the first differences of the variables. Country, market and time dummies are also included in the empirical model. The country dummy captures country-specific effects, the market dummy captures market-specific effects and the time dummy captures the time-varying effects that control the effect of macroeconomic variables on firms' value. ε_{it} is the random disturbance, which is assumed to be i.i.d. normal.

9.4 Results

Table 9.7 presents the econometric results for the whole sample. As can be seen, R&D investment is highly persistent in emerging markets. This implies that about 76 per cent of past R&D behaviour affects current levels of R&D investment. The results show that emerging-market firms do not use external funding for R&D investment. With a one-unit change in external funding, the probability of R&D investment decreases by 35.32 percent. Internal funding also exhibits the same sign for R&D investment, implying that emerging-market firms may depend on equity finance for R&D investment. Brown et al. (2009) also observed that, rather than internal or external funding, firms may use equity issues. The control variables of firm size, sales growth, export orientation and foreign ownership are found to be important determinants of R&D investment. Firm size has a significant positive impact on R&D investment in emerging markets. According to Schumpeter's (1942) hypothesis, larger firms make greater R&D investments. Lall's (1983) study of India obtained similar results. Sales growth increases a firm's probability of engaging in R&D investment. Demand-pull theory indicates that the greater the market demand, the

greater the percentage of expenditure allocated to R&D. The results confirm the demand-pull theory. Firms with greater export orientation are more likely to engage in R&D investment. Outward-oriented firms will be more aware of new technologies and will also strive harder to maintain the competitiveness of their technologies (Lall, 1983). Anwar and Sun (2013) reached the same conclusion, based on Chinese electrical appliance industries. Foreign ownership has a positive and significant impact on R&D investment. Similar results were found by Lee (2012) based on Korean firms.

Table 9.7: Results Summary for All Firms

Variable Name	**All Firms**	**Standard Error**
$R\&D_{t-1}$	0.76036***	(0.06604)
Internal funding	-0.00208**	(0.00107)
External funding	-0.35319***	(0.14285)
Size	0.25448***	(0.07854)
Sales growth	0.03812***	(0.01701)
Export-oriented	0.38077*	(0.22613)
Foreign ownership	0.00232***	(0.00080)
Market dummy	Yes	
Country dummy	Yes	
Year dummy	Yes	
Total observations	2732	
AR(1), *P*-value	-3.42	0.001
AR(2), *P*-value	0.95	0.345
z_1, *P*-value	89.25(9)	0.000
z_2, *P*-value	3.26(9)	0.0008
Hansen, *P*-value	157.53(137)	0.111

Significance levels: * <0.10, ** <0.05, ***<0.01; Standard errors in parenthesis.

Table 9.8 presents the results for local firms and MNEs in emerging markets. After controlling for the financial systems of a country, the results show that local firms' and MNEs' financing of R&D investment are different, following organisation slack theory. This result implies that access to finance plays a role in R&D financing. External funding negatively affects local firms, meaning that local firms do not use external funding for R&D investment. This is because local firms are relatively small and find it difficult to obtain external funding for non-collateralisable and long-term R&D projects. In addition, external funding may be expensive for R&D projects due to their risky and uncertain

nature, and because debt holders have an inherent bias towards prudence. Moreover, local firms may use equity, venture capital or FDI for R&D investment. With a one-unit change in external funding, local firms' R&D decreases by 0.11 percent. This conforms with Hypothesis 1.

Table 9.8: Results Summary for Local Firms and MNEs

Variable Name	Local Firms	Standard Error	MNEs	Standard Error
$R\&D_{t-1}$	0.92793***	(0.03827)	0.87997***	(0.05658)
Internal funding	-0.00109	(0.00085)	0.00652*	(0.00333)
External funding	-0.46829*	(0.23972)	0.58659*	(0.31179)
Size	0.12116**	(0.05432)	-0.02388	(0.08967)
Sales growth	0.04701***	(0.01660)	0.01179	(0.03963)
Export-oriented	0.25002*	(0.14105)	0.08868*	(0.05254)
Foreign ownership	0.00154**	(0.00073)	0.00248**	(0.00124)
Country dummy	Yes		Yes	
Year dummy	Yes		Yes	
Total observations	1171		1558	
AR(1), *P*-value	-4.15	0.000	-2.71	0.007
AR(2), *P*-value	-0.45	0.650	1.13	0.259
z_1, *P*-value	131.75(8)	0.000	61.07(8)	0.000
z_2, *P*-value	1.72(9)	0.0910	1.77(9)	0.0763
Hansen , *P*-value	121.58(118)	0.392	129.92(126)	0.387

Levels of significance: * < 0.10, ** < 0.05, ***< 0.01; Standard errors in parenthesis.

On the other hand, MNEs use both internal and external funding for R&D investments. Brown and Peterson's (2009) study also emphasised the use of both internal and external finance sources for R&D investment. As MNEs have more internal resources and better access to finance, they may use both sources for R&D financing. These results support Hypothesis 2. The results show that with a one-unit change in internal funding, R&D investment increases by 0.65 per cent, while for external funding it increases by 58.66 per cent. It can therefore be said that MNEs are keener to use external funding than internal funding for R&D investment. This is because large firms like MNEs may have easy access to external funding (Chiu et al., 2012). With regard to the other regressors, the R&D investments of both types of firm depend on export performance and foreign ownership,

while local firms' R&D is affected by their size and sales growth. Moreover, both local firms and MNEs show a higher persistence of R&D investment.

Table 9.9 reports the results for bank-based and market-based finance. The hypothesis suggests that bank-based finance provides credit facilities, which boost firms to invest more in R&D, and external funding provides tax shields and encourages more incremental innovation by firms. The results show that with a one-unit change in external funding, R&D investment increases by 103.10 per cent. Thus, consistent with David et al. (2008), the results support Hypothesis 3.

Table 9.9: Results Summary for Bank-Based and Market-Based Countries

Variable Name	Bank-Based	Standard Error	Market-Based	Standard Error
$R\&D_{t-1}$	0.80711***	(0.10723)	0.71832***	(0.07679)
Internal funding	0.00152	(0.00223)	0.00728*	(0.00433)
External funding	1.03099**	(0.50474)	-0.56288*	(0.30680)
Size	0.22147**	(0.10341)	0.22296***	(0.07541)
Sales growth	0.03143	(0.06419)	0.01550	(0.05249)
Export-oriented	-0.99760**	(0.39255)	0.04259	(0.09872)
Foreign ownership	0.00134	(0.00144)	0.00255***	(0.00095)
Market dummy	Yes		Yes	
Year dummy	Yes		Yes	
Total observations	1126		1603	
AR(1), *P*-value	-3.25	0.001	-2.54	0.011
AR(2) , *P*-value	1.52	0.129	0.70	0.485
z_1, *P*-value	61.08(8)	0.000	66.59(8)	0.000
z_2 , *P*-value	3.77(9)	0.0003	1.68(9)	0.0969
Hansen, *P*-value	30.48(38)	0.802	50.07(40)	0.352

Significance levels: * < 0.10, ** < 0.05, ***<0.01; Standard errors in parenthesis.

In line with Hypothesis 4, firms with market-based finance rely on internal funding for R&D investment, which is consistent with Bougheas' (2004) study. It also follows pecking order theory for R&D financing. Market-based finance provides greater flexibility in firms' R&D investment. Moreover, due to weak banking systems, it is difficult to obtain external funding for R&D in market-based finance systems. With regard to the other regressors, the size of firms in both bank-based and market-based finance systems significantly positively affects R&D investment. Strong capital markets under market-based finance attract foreign

owners. On the other hand, export orientation negatively affects R&D in bank-based systems. One explanation for these results is that exporting firms form a relatively low percentage of total firms. Both bank-based and market-based finance firms show higher persistence rates in R&D investment.

9.5 Conclusion

The growing importance and recent increased investment in R&D in emerging markets make this an interesting topic for research. Moreover, the recent global financial crisis made emerging markets illiquid and vulnerable. Thus, by applying system GMM to firm-level panel data over the period 2003-2012, this chapter has examined sources of finance for R&D investment in emerging markets. The sample firms were split between local firms and MNEs, and between firms under bank-based and market-based finance systems in emerging markets.

The results reveal that local firms' and MNEs' sources of finance for R&D investment are different. Local firms do not use external funding for R&D investment, following transaction cost theory and the positive theory of agency. External funding may be expensive for R&D projects due to their risky and uncertain nature. On the other hand, MNEs use both internal and external funding for R&D investments, which is consistent with pecking order theory, according to which firms first use internal funds, then turn to external finance. Although Myers emphasised the order of finance sources, both sources of finance may be used. As MNEs are large, they are ensured availability of internal funding and access to multiple sources of debt financing, MNEs may use both internal and external funding for R&D investment. In addition, both local firms' and MNEs' R&D investment decisions are affected by their export performance and level of foreign ownership. In the case of local firms, firm size and sales growth have significant positive impacts on R&D investment.

It is found that the financial systems of the country in which a firm is embedded determine its choice of sources of finance for R&D projects. Firms in bank-based finance environments use external funding for R&D investment, consistent with disciplinary role theory and the monitoring theory of debt. Banks provide flexible credit facilities and monitor the client, which positively affects R&D investment. David et al.'s (2008) results were similar. Firms in market-based finance environments use internal funding for R&D investment, following pecking order theory and Schumpeter's hypothesis. Internal funding can be raised easily and is less costly in market-based systems. Bougheas (2004) found a positive relationship between internal funding and R&D investment. In addition to internal and external funding, for firms in both bank-based and market-based finance environments, size has a significant effect on R&D investment in emerging markets.

It is hoped that this study will be helpful to investors, lenders, managers and policy makers when considering R&D investments in emerging markets. Although this study has considered the financing of R&D investments, a limitation is that it has not separated different sources of internal finance, such as cash flows and equity, nor external finance sources such as banks, government grants, venture capital and FDI. Another limitation is that, owing to missing values, not all emerging markets have been included in the analysis. However, the empirical results of this study may provide lessons for other emerging markets. Further research is needed on other emerging markets to identify specific sources of finance for R&D investment under different financial environments.

Chapter 10: Summary and Conclusions

10.1 Background of the study

R&D is used as a source of firm growth, and firms' technological advancement, competitive advantage, market power, profitability and innovativeness depend on their R&D investment. In addition, increased R&D investment ensures a country's economic growth. It is widely accepted that a country is poorer with less investment in R&D. An inefficient R&D strategy may cause low economic growth, low wages, large unemployment rates, and even trade deficits (Perez-Sebastian, 2015). Therefore, identifying appropriate R&D determinants and sources of finance may enhance R&D investment and help policy makers to increase innovative activities in emerging markets. Thus, this thesis has examined the firm-, country- and institutional-level determinants and sources of financing for R&D investment, and has assessed the impact of R&D investment on firm performance in and around emerging markets. Using emerging markets as the sample for this study was motivated by the distinct importance of R&D investment for emerging countries. In recent years, R&D investment in emerging markets has increased considerably for strategic reasons (Gorodncihenko et al., 2008), and because it produces higher returns than in advanced countries (Lederman and Maloney, 2003).

10.2 Summary of research methods

This thesis is empirical in nature and has followed a positivist approach. Quantitative methods were adopted to analyse the sample data. The sample data were collected from secondary sources. The datasets used capture the available data from recent periods. Firm-level sample data were collected mainly from the DataStream database, while macroeconomic data and data on R&D intensity were collected from LexisNexis and the World Bank's World Development Indicators database. The World Bank's Worldwide Governance Indicators provided six indicators which encapsulate different aspects of country-level governance quality: government effectiveness, regulatory quality, rule of

law, control of corruption, political stability and absence of violence, and voice and accountability. Data on investor protection were sourced from the World Bank's Doing Business index, based on Djankov et al. (2008). The primary focus was on the investor protection index (IPI), a composite score calculated on the basis of several components capturing different aspects of the degree of investor protection. These constituent indices include the extent of disclosure, which assesses the transparency of related-party transactions, the degree of director liability and the ease of shareholder law suits. GMM estimation was mainly used for the data analysis, as well as OLS and fixed- and random-effects models with an IV approach. In addition, a Granger causality test was used to examine causality between the US and emerging markets.

10.3 Summary of findings

Chapter 5 examined the determinants of firm-level R&D spending during a financial crisis. The relationship between financial crisis and R&D investment in emerging markets was also tested. In order to examine the relationship, a Granger causality test and GMM estimation were used, with panel data from a sample of 310 firms from 20 emerging markets during the period 2003-2012. The sample was divided between local firms and MNEs, and between innovative and non-innovative firms. The financial crisis did not affect all firms, industries and countries in the same way (Fillippetti and Archibugi, 2011; OECD, 2012). Therefore, it is found that both local firms and MNEs were adversely affected by the recent financial crisis. However, MNEs were affected 1.62 times as much as local firms due to their greater international exposure. On the other hand, innovative and non-innovative firms showed different results. Non-innovative firms were negatively affected, while innovative firms were positively affected by the financial crisis. The results suggest that the degree to which firms' R&D was affected by the financial crisis depended on their R&D policy. These empirical results support the cyclical and counter-cyclical views of R&D investment. The cyclical view suggests that financial crises have a negative

impact on R&D investment. Stiglitz (1993) and Hall (2002) argued that firms will decrease their R&D investments during a financial crisis due to credit rationing and limited internal funding. On the other hand, the anti-cyclical view suggests a positive relationship between financial crises and R&D investment. This may occur if firms have no financial constraints. Therefore, Paunov (2012) pointed out that firms without financing constraints are less likely to abandon innovative projects. Overall, the financial crisis adversely affected the R&D investment of emerging-market firms. It is also found that firm age, firm size, export orientation, debt ratio and foreign ownership are the main determinants of R&D investment in emerging markets during a financial crisis. When the sample was split between crisis-affected and less-/unaffected countries, some interesting results were revealed for R&D determinants. The results show that the R&D determinants of affected and less-/unaffected countries behave differently. For affected countries the determinants are firm size, exports, profitability and foreign ownership, while for less or unaffected countries they are firm size, sales growth and profitability. These result simply that, whether or not a country is affected, firm size and profitability play an important role in R&D spending. This also confirms RBV, indicating that firm resources and capabilities are important determinants of R&D investment, even during a financial crisis. Moreover, it is found that the probability of a decrease in R&D investment is 60 per cent higher in affected countries than in less-/unaffected countries. The work presented here has profound implications for future studies of R&D investment in emerging markets and may help policy makers, investors, managers and senior executives to make decisions about R&D investment in emerging markets.

Chapter 6 examined the macroeconomic determinants of a country's R&D investment. A fixed- and random-effects regression model with an IV approach was applied, using panel data from36 countries for the period 2002-2011. It is found that GDP growth, exports, trade openness, patents and financial crisis are the main macroeconomic determinants.

Interesting results emerged when the sample countries were split between advanced and emerging countries. It is found that GDP growth, exports, trade openness, patents and financial crisis are the macroeconomic determinants for advanced countries, while exports, trade openness, FDI, patents and market size are the macroeconomic determinants for emerging countries. Among the common determinants, only patents have a positive impact on R&D investment for both advanced and emerging countries. This implies that both types of country encourage protection of property rights. Export intensity positively affects emerging countries, while negatively affecting advanced countries' R&D intensity. On the other hand, trade openness is negatively related to R&D intensity in emerging countries, while positively related in advanced countries. In general, the results of the analysis suggest that macroeconomic determinants behave differently for R&D investment between advanced and emerging countries due to their different nature and purpose, and their level of economic development. This finding, in particular, will help investors and policy makers in emerging countries.

Chapter 7 examined the important role played by institutional environments in R&D investment in emerging countries. Scott (1995) and Oliver (1997) pointed out that strategic choices such as R&D investment are driven by the institutional framework, along with industry conditions and firm-specific resources. Consistent with this statement, and using GMM estimation on panel data for 666 firms from 20 emerging markets during the period 2006-2013, it is found that institutional quality has a significant impact on innovation in emerging markets. The results show that government effectiveness and rule of law have significant positive impacts, while corruption and political instability have significant negative impacts on R&D investment in emerging countries. These results imply that effective government may create a favourable environment for R&D investment by facilitating access to finance and market entry, attracting more investment and, in particular, accelerating technological investment. Moreover, strong legal systems attract

investors and increase their confidence in investment. On the other hand, corruption increases investment costs and discourages foreign investors in emerging markets. In addition, political unrest discourages local and foreign investors from investing in R&D. These results support the theoretical predictions of institutional theory, and will be helpful for policy makers and R&D investors in emerging markets to establish how external environments facilitate innovation, and consequently promote economic growth.

Chapter 8 examined how, in addition to firm-level factors, country-level factors also influence firm-level decision making such as R&D investment. Turk (2015) pointed out the importance of country-level factors in firm financing and investment decisions, while Jong et al. (2008) found that country-level factors such as rule of law and a strong economy influence firm-level decisions. Similarly, Xiao (2013) confirmed that country-level investor protection (safeguards) has a significant impact on R&D investment, while Hiller et al. (2011) found evidence for country-level governance factors (systems). Although opponents of country-level factors have claimed that these factors influence the innovative activities of emerging countries in directly, country-level factors are moderators in facilitating a favourable environment for doing business. This study has sought to identify which factors moderate the relationship between R&D and firm performance. Using GMM estimation of panel data for 437 firms from 17 emerging countries, it is found that a country's safeguards tend to moderate the relationship between R&D and firm performance to a greater extent than its systems. These results indicate that safeguards promote firm-level innovation in emerging markets, while the systems of emerging countries are substituted by firm-level corporate governance. Moreover, in the case of risky and uncertain investments such as R&D, investors seek protection from possible losses. The investor protection index was then split into three sub-components: disclosure, directors' liability and shareholder suits. The results suggest that R&D intensity influences firm performance when directors are more liable for their activities, making them more

accountable for their decisions. The positive relationship between R&D intensity, shareholder suits and firm performance is consistent with the idea that the possibility of being sued by shareholders puts pressure on directors to make investments such as R&D that will enhance firm value. The negative coefficient of the interaction term of disclosure and R&D investment implies that disclosure of R&D-related activities does not influence firm performance. This is because most investors in emerging markets do not read or are unaware of R&D-related activities or annual reports. Moreover, a substantial percentage of investors in emerging markets are illiterate. On the other hand, when country governance was split into six sub-factors – government effectiveness, regulatory quality, rule of law, control of corruption, political stability, and voice and accountability –only government effectiveness, control of corruption and voice and accountability were found to have a positive influence on R&D intensity and firm performance. This implies that effective government may result in increased R&D spending as a result of spill-overs creating networks between firms and individuals. Moreover, control of corruption may facilitate the size of R&D investment, as it motivates innovation-related FDI by reducing investment costs. High accountability of managers and directors to shareholders influences the relationship between R&D and firm performance. Voice and accountability ensure the responsible behaviour of managers, which influences investment in general, and R&D investment in particular. Moreover, high accountability ensures that responsible decisions and actions are taken, fosters commitment to accomplish tasks, and guarantees organisational learning and innovation. Interestingly, when three more variables of investor protection were introduced into the model, these country-level governance variables became insignificant. The results suggest that investor protection, whether aggregate or broken down, tends to have a greater influence on the relationship between R&D and firm performance. Therefore, this study contributes to the debate on whether safeguards or systems are more important for firm-level strategic decision making such as R&D decisions.

Chapter 9 examined the financing behaviour of R&D investment in selected emerging markets. In order to examine the sources of finance, panel data GMM estimation was used for a sample of 310 firms from 20 countries during the period 2003-2012. The results show that, overall, emerging markets do not tend to use external funding for R&D investment. Interesting results were produced when the sample was divided between local firms and MNEs, and between bank-based and market-based financial systems. It is found that R&D financing behaves differently for local firms and MNEs. Local firms do not use external funding, while MNEs use both internal and external funding for R&D investment. It is also found that a country's financial system may restrict firms in a specific environment from choosing a particular source of finance. Firms within bank-based systems tend to rely on external funding, and firms within market-based systems depend more on internal funding for R&D investment. These results support the theoretical predictions. In particular, they confirm that financial slack affects R&D financing differently, depending on firm size, profitability, type of ownership and the extent to which the firm experiments with new strategies, products or markets (Hambrick and Snow, 1977). Moreover, firms within market-based financial systems follow a pecking order in financing R&D investments. This study will be helpful for various stakeholders, including investors and managers, in explaining R&D financing behaviour in emerging markets.

10.4 Contribution of the study

This study makes various contributions. First, it takes into account firm-, macro- and institutional-level variables in analysing their impacts on firms' R&D investment decisions in emerging countries. These variables were separated into different levels due to their distinct importance. Moreover, including all variables in a single model might have produced misleading results regarding the significance of the variables. Second, this is through to be the first study that relates the impact of financial crises to R&D investment in emerging markets. The recent financial crisis had adverse effects worldwide, so it was

essential to examine how local firms and MNEs, and innovative and non-innovative firms, behaved during the crisis. Third, this study has compared the macroeconomic determinants of R&D investment behaviour between advanced and emerging markets. This will be helpful for policy makers in emerging markets, where policy making and implementation tend to follow developed markets. Fourth, the study has identified the institutional determinants of R&D investment in emerging markets. As institutional settings vary among emerging markets, this study will provide guidance to investors in emerging markets. Fifth, the study has shown which country-level factors, such as investor protection (disclosure, directors' liability and shareholder suits) and country governance factors (government effectiveness, rule of law, regulatory quality, corruption, political stability and voice and accountability) better facilitate firm-level R&D activities. Sixth, the study has identified which sources of financing (debt or cash flow) are used for R&D investments in emerging markets. In addition, it has examined the influence of national financial systems (bank-based or market-based) on financing decisions with regard to R&D investment in emerging markets. Finally, the advanced methodology of GMM has been used for the data analysis, which controls for the problem of endogeneity, and the use of panel data has taken into account unobserved heterogeneity.

10.5 Implications of the study

The implications of this study are as follows. First, this study has examined the relationship between financial crises and R&D investment in emerging markets. The study separated local and multinational, and innovative and non-innovative firms. The results of this analysis show that both local and multinational firms were negatively affected by the recent financial crisis. However, MNEs were more greatly affected than local firms. Moreover, innovative and non-innovative firms behaved differently during the crisis period. In particular, innovative firms continued to invest in innovation, while non-innovative firms reduced their R&D investment. This knowledge will give a general idea

of how particular firms are likely to behave during a financial crisis. It will also enable managers, and particularly foreign investors, in these firms to make informed decisions about R&D investment during a financial crisis. In addition, the results confirm that RBV holds true even in a crisis period. Specifically, it is found that firm age, firm size, export orientation, debt ratio and foreign ownership are the main R&D determinants, even in the presence of economic slowdown. This knowledge will help managers to concentrate more closely on firm resources and capabilities to increase innovative activities even during a crisis period.

Second, this study has compared the macroeconomic determinants of R&D investment between advanced and emerging countries. The results show that emerging and advanced markets' macroeconomic determinants are different with regard to innovation. The study has explained the reasons for this difference. Research in this area will be of particular interest to policy makers on sustainable innovation in emerging markets, as emerging markets' policies tend to follow those of developed markets.

Third, this research has shown the importance of the external environment, in particular institutional settings for firms' decision making on innovation. In a recent study, Wu et al., (2016) also pointed out that the institutional environment may impact R&D activity by providing supports or constraints beyond the capacity of an individual firm. In consistent with this view, our findings reveal that government effectiveness and legal system support the R&D investment while corruption and political environment discourage R&D investment in the emerging markets. Thus, to make R&D investment strategy and decision, managers need to assess and consider the institutional settings of a country. Moreover, it will create awareness among the emerging markets policymakers that to promote innovative activities and subsequently sustainable development should take into account institutional environment.

Fourth, the existing literature has shown a relationship between R&D and firm performance. However, external factors such as investor protection and good governance may contribute to this relationship. This study has revealed that this relationship may be more greatly strengthened by stronger investor protection than by good governance. This implies that investor protection is important for R&D activity-based growth of firms. This information will help firms to make changes to their strategies in order to increase their R&D activities.

Fifth, this study has examined the sources of finance for R&D investment in emerging markets. In particular, it has observed how multinationality and institutional settings play a role in firm financing. The results show that local firms do not use external funding, while MNEs use both internal and external funding for R&D investments. This implies that organisational slack plays an important role in financing decisions. On the other hand, bank-financed firms tend to use external funding, while market-financed firms tend to use more internal funding for R&D investments. This means that the institutional setting in which a firm operates is important for its financing policy. This new knowledge will direct managers, investors and lenders in emerging markets to set appropriate financing policies for firms.

10.6 Limitations of the study

As with other research, this study has limitations. First, this study has related the financial crisis to R&D investment in emerging countries. However, the recent financial crisis mainly affected developed countries. Thus, it would be interesting to examine and compare the impact of future financial crises on developed and emerging countries. Moreover, the corporate governance of firms, such as foreign ownership, should be taken into account because, in the presence of foreign ownership, firms may have greater access to finance for investment in innovative activities during a recession. This will ensure the persistence of investment in R&D, even during a crisis period, and implies that foreign ownership may a

play a different role in alleviating the crisis effect and, consequently, increasing R&D investment. Second, this study has examined the macroeconomic differences between advanced and emerging countries with regard to R&D investment. However, due to data availability, the number of countries in the sample was reduced. A larger number of sample countries and equal distribution between advanced and emerging countries might change the results. Third, the study has measured the institutional determinants of R&D investment in emerging countries. However, there is controversy about which factors constitute institutions. Fourth, this study has separated country-level governance systems and investor protection because of their distinct roles. However, most researchers (e.g. Pindado et al., 2015) have used both as country-level governance factors. Fifth, the study has measured financing sources for R&D investment in emerging markets. It has also examined MNEs and local firms, as well as bank-based and market-based systems in the analysis. However, in addition to these factors, management quality/ability may also influence firms' financing behaviour. Finally, it was important to consider R&D reporting in the analysis. Due to differences between accounting standards in different countries and flexibility in IAS 38, firms may have manipulated their R&D expenditure.

10.7 Areas for future research

The results of this analysis help explain the macroeconomic and institutional-level determinants of R&D investment in emerging countries. Further analysis might be carried out in the domain of developed countries because the macroeconomic policies and institutional settings of developed countries are different from those of emerging markets. Moreover, further research on workforce diversity and innovation would be valuable. Greater diversity in terms of skills and ethnicity might help a firm to be more innovative and dynamic. In addition, CEO tenure might impact on R&D investment. For example, a short-term CEO might want to benefit from investments that provide quick returns. Future studies might focus on the reporting dilemma of R&D (see Table 10.1). There is

considerable debate about whether R&D expenditure should be treated as an expense which goes through the income statement, or as an intangible asset (capitalised) on the balance sheet which is amortised year by year (Anagnostopoulou, 2008). IAS 38 (2004) mandates that firms classify their research costs entirely as expenses or capitalise development costs when certain criteria are met.

Table 10.1: R&D Reporting

	Standards	**R&D expensed as incurred**	**R&D capitalisation conditions**	
International	IAS 38 and IAS 36	Research cost	Development cost	Yes
UK	SSAP 13	Research cost	Development cost	Yes
Bangladesh	BAS 38	Research cost	Development cost	Yes
China	CAS 6	Research cost	Development cost	Yes
Korea	Korean GAAP	Research cost	Development cost	Yes
Sweden	BFN R1, RR 15	Research cost	Development cost	Yes
Italy	Accounting Standard No. 24	Research cost	Development cost	Yes
USA	SFAS N° 2	Yes		
	SFAS N° 86 (Software development costs)			
Japan	ASBJ	Yes		
Germany	German GAAP	Yes		
Indonesia	PSAK. 19-90	Yes		
France	Art. 361-2, PCG 99	Yes		
Australia	AASB 1011	Yes		

However, according to US Generally Accepted Accounting Principles (GAAP), R&D expenditure should be fully expensed and is required to be disclosed in the same period, whereas before 1975, US GAAP allowed firms to capitalise R&D. In the reliability/relevance trade-off, IAS comes down on the side of relevance, while US GAAP favours the side of reliability (Cazavan-Jeny and Jeanjean, 2006). Similarly, the accounting standards of the USA (GAAP), Japan (ASBJ), Australia (AASB 1011), Indonesia (PASK 19-90) and France (Art. 361-2, PCG 99) support immediate expensing rather than capitalisation. Thus, most current accounting standards are in favour of immediate expensing rather than capitalisation (Anagnostopoulou, 2008). They argue that an expensing policy may help a firm to manage future write-downs more accurately and to

maintain their competitiveness in stock markets by avoiding cross-listing problems (Khazabi, 2008). In addition to R&D reporting, terrorism and innovation would be interesting areas for further research.

Appendix 1: List of Advanced and Emerging Countries

	Advanced Economy		**Emerging Economy**
1	Austria	1	Brazil
2	Belgium	2	Bulgaria
3	Canada	3	China
4	Czech Republic	4	Colombia
5	Denmark	5	Croatia
6	Estonia	6	Hungary
7	Germany	7	India
8	Finland	8	Lithuania
9	France	9	Mexico
10	Ireland	10	Poland
11	Israel	11	Romania
12	Japan	12	Russian Federation
13	Korea	13	Turkey
14	Latvia	14	Ukraine
15	Netherlands		
16	Norway		
17	Portugal		
18	Singapore		
19	Slovak Republic		
20	Spain		
21	UK		
22	USA		

Source: IMF 2011

Appendix 2: List of Emerging Countries, 2013

List of Emerging Countries									
	IMF	Goldman Sachs BRICS+N11	FTSE	MSCI	The Economist	S&P	Dow Jones	BBVA	Columbia University EMGP
Argentina	√						√	√	√
Bahrain							√	√	
Bangladesh		√						√	
Brazil	√	√	√	√	√	√	√	√	√
Bulgaria	√						√	√	
Chile	√		√	√	√	√	√	√	√
China	√	√	√	√	√	√	√	√	√
Colombia			√	√	√	√	√	√	
Czech Republic			√	√	√	√	√	√	
Egypt		√	√	√	√	√	√	√	
Estonia	√						√	√	
Greece				√					
Hong Kong					√				
Hungary	√		√	√	√	√	√	√	√
India	√	√	√	√	√	√	√	√	√
Indonesia	√	√	√	√	√	√	√	√	
Iran		√							
Israel									√
Jordan							√	√	
Kuwait							√	√	
Latvia	√						√	√	
Lithuania	√						√	√	

Malaysia	√		√	√	√	√	√	√	
Mauritius							√	√	
Mexico	√	√	√	√	√	√	√	√	√
Morocco			√		√	√	√	√	
Nigeria		√						√	
Oman							√	√	
Pakistan	√	√	√				√	√	
Peru	√		√	√	√	√	√	√	
Philippines	√	√	√	√	√	√	√	√	
Poland	√		√	√	√	√	√	√	√
Qatar							√	√	
Romania	√						√	√	
Russia	√	√	√	√	√	√	√	√	√
Saudi Arabia					√				
Singapore					√				
Slovakia							√	√	
Slovenia									√
South Africa	√	√	√	√	√	√	√	√	√
Sri Lanka							√	√	
South Korea		√			√			√	√
Sudan								√	
Taiwan			√		√	√		√	√
Thailand	√		√	√	√	√	√	√	√
Turkey	√	√	√	√	√	√	√	√	√
Tunisia								√	
UAE			√				√	√	
Ukraine	√							√	
Venezuela	√							√	

Vietnam		√							

Appendix 3: Summary of Literature Findings for R&D Determinants (Firm-, Macro- and Institutional-Level)

Authors	Country/Market	Methods	Positive Relation	Negative Relation	No relation
Lee and Hwang (2003)	Korea	Fixed effect model	Firm size, Sales	Dividend	
Bhagat and Welch (1995)	US, Canada, British, European and Japan	Vector auto regression (VAR)	Debt ratio and tax payment for Japanese firm. Stock return for all firm except Canada	Debt ratio and tax payment for US firm	
Cheng and Chen (2006)	China	Factor Analysis	Assets, Sales, Staff numbers, R&D staff, Technical staff	Profit to sales ratio, Debt ratio	
Grabowski (1968)	US	OLS	Patent, product diversification, availability of fund		
Grabowski and Vernon (2000)	US	OLS	Expected return, cash flow		
Mahlichi and Schluga (2006)	Japan	Fixed effect Estimation	Expected return		
Lee S. (2012)	Korea	FGLS	Ownership concentration, foreign ownership	Institutional ownership	
Pamukcu and Utku-ismihan (2009)	Turkey	Probit Model	Human capital stock, import penetration, IPR-related technology transfer, Foreign direct investment, value added	Profitability	
Lall (1983)	India	OLS	Firm size, age, Number of foreign license agreement, Royalties, High level management wage	Export, General wage	
Simanjumtak and Tjandrawinata (2011)	US	Random Effect Model	Profitability, R&D intensity and cash flow		

Authors	Country/Market	Methods	Positive Relation	Negative Relation	No relation
Howe and McFetridge (1976)	Canada	Covariance Analysis	Current sales, cash flow and government incentives		
Griffiths and Webster (2010)	Australia	Fixed effect estimation	Managerial dimension, competitive strategy, communication with employee, past profit and growth rate		
Waterson and Lopez	UK	WLS			Firm size and Concentration
Wan et al.,(2005)	Singapore	Multiple Regression	Decentralize structure, Presence of organization resources, Belief that innovation is important, Willingness to take risk, Willingness to exchange ideas		
Othman and Ameer (2009)	Malaysia	OLS	Sales and sales growth	Diversification	
Mishra (2007)	India	Tobit model	Firm size, market share and human capital		
Lai et al.(2015)	Taiwan, Japan, Korea (2011)	Logistic Regression	Firm size, and Goodwill and Patent		
Ayygari et al.(2011)	US	GMM	Access to finance, highly educated manager, ownership by families, individual or manager, and foreign competition		

Author's	Country	Methods	Positive relation	Negative Relation	No relation
Kumar and Saqib (1996)	India	Probit and Tobit Model	Competition, export-orientation and vertical integration		
Alessandri and Pattit (2014)	US	Fixed Effect estimation	Stock option	Managerial ownership	
Avermaete et al.,(2003)	Belgian	Chi-square Test	Age, size, regional economic performance		
Tan and Hwang (2002)	Taiwan	Bivariate Probit Model	Imported Technology		
Gannicott (1984)	Australia	2SLS	Foreign Ownership	Firm Size	Government Subsidy
Driver and Guedes (2012)	UK	Fixed Effect and GMM	Ownership of CEO	Governance	
Cumming and Macintosh (2000)	Cananda	Ordered Multinomial discrete dependent variable model	Patent protection, strategic alliance, early stage firms	Debt-equity ratio	
Chiang and Mensha (2004)	US	Pearson Correlation, Regression	Larger market share, higher percentage of technical employees, diversified product		
Galende and Fuente (2003)	Spain	Multiple Regression	Size, debt, human resources, commercial resources, organizational resources, diversification and		

			internationalization		
Anwar and Sun(2013)	China	IV approach	Foreign Presence		

Authors	Country/Market	Methods	Positive Relation	Negative Relation	No relation
Lynskey (2004)	Japan	Negative Binomial Regression	Technological capability, availability of internal fund, Venture Capital Funding, University-Industry Linkage		
Spithoven and Teirlinck (2015)	Belgium	Generalized Tobit Model	Internal R&D capability, Network Resources, Formal and informal protection		
Pindado et al,(2015)	US, Japan and EU	GMM	Legal system, Financial system		
Hillier et al.,(2011)	US, Japan and 9 EU Countries	GMM	Legal environment, minority shareholder protection, strong law enforcement, bank-based financial system, effective board control, a strong market for corporate control		
Wang (2010)	26 OECD	Extreme-Bound-Analysis	Tertiary education and proportion of scientific researcher, Patent right protection, Income growth	Foreign technology Inflow	
Guloglu et al.(2012)	G7	Fixed Effect Regression	High technology export, FDI Inflow and rate of R&D Investment	Rate of Interest	Trade Openness
Sameti et al.,(2010)	30 OECD	Fixed effect Model	Trade Openness, Economic growth, Government subsidy		

Author's	Country/Market	Methods	Positive Relation	Negative Relation	No relation
Pindado et al.(2010)	Eurozone	GMM	Size, firm growth and Market Share	Free cash flow, depend on external finance, labour intensity, and Capital Intensity	
Bhattacharya and Bloch (2004)	Australia	Probit Model	Firm size, market structure, R&D intensity, trade share, profitability		
Becker and Pain (2008)	UK	IV approach	Sales, profitability, market competition, interest and exchange rate, government funded R&D		
Wang and Kafouros (2009)	China	OLS	Technological opportunities, Level of foreign presence		International Trade, FDI
Varsakelis (2006)	29 Countries	Random Effect Model	Quality of education and quality of government institutions		
Allard et al., (2012)	107 countries	SUR		Political instability	
Blind (2012)	21 OECD	WLS	Regulation		
Mahendra et al.,(2015)	Indonesia	Logit model	Institutional quality, Access to finance		

Srholec (2011)	Developing countries	Logit multi-level model	National economy, Technological and institutional framework		

Abbreviations

2SLS	Two-stage least squares
ADF	Augmented Dickey-Fuller unit root test
B/S	Black-Scholes equation
CIS	Community Innovation Survey
EBIT	Earnings before income and tax
FDI	Foreign direct investment
GLS	Generalised least squares
GMM	Generalised methods of moment
GNP	Gross national product
IFC	International Finance Corporation
i.i.d.	Independent and identically distributed
IPO	Initial public offering
IV	Instrumental variable
LIMS	Limited information maximum likelihood
MNEs	Multinational firms
NBER	National Bureau of Economic Research
OLS	Ordinary least squares
R&D	Research and development
RBV	Resource-based view
RJV	Resource joint venture
ROA	Return on assets
ROIC	Return on invested capital
SFAS	Statement of Financial Accounting Standards
TFP	Total factor productivity
US GAAP	US Generally Accepted Accounting Principles

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