

The price and volatility transmission of
international financial crises to the South
African equity market

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*To my parents,
Manuel and Maria da Câmara*

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Abstract

There is a large body of research that indicates that international equity markets co-move over time. This co-movement manifests in various instruments, ranging from equities and bonds to soft commodities. However, this co-movement is more prevalent over crisis periods and can be seen in returns and volatility transmission effects. The recent financial crisis demonstrated that no local market is immune to transmission effects from international markets. South African financial market participants, such as investors and policymakers, have a vested interest in understanding how the equity market in particular and the economy in general react to international financial crises. This study aims to contribute an improved understanding of how the South African equity market interacts with international equity markets, by identifying the degree of price and volatility transmission before, during, and after an international financial crisis.

This was done by investigating the possibility of changes in price and volatility transmissions from the Asian financial crisis (1997–1998), the dotcom bubble (2000–2001) and the more recent subprime financial crisis (2007–2009). An Exponential Generalized Autoregressive Conditional Heteroskedasticity (E-GARCH) model was employed within the framework of an Aggregate Shock model. The results indicate that during the international financial crises studied, the JSE All Share Index was directly affected through contagion effects inherent in the returns of the originating crisis country. Volatility transmissions during international financial crises came directly from the originating crisis country. Finally, the FTSE 100 Index was the main exporter of price and volatility transmission to the JSE All Share Index.

Keywords: volatility transmission; international financial crisis; E-GARCH; financial market contagion

Opsomming

Daar is 'n groot verskeidenheid navorsing wat aandui dat internasionale aandelemarkte saam beweeg met verloop van tyd. Hierdie mede-beweging word gemanifesteer in verskillende finansiële instrumente, wat wissel van aandele en effekte, tot sagte kommoditeite. Hierdie mede-beweging verhoog egter oor krisis tydperke en word gerealiseer in die oordrag van prys en volatiliteit effekte. Die onlangse finansiële krisis het beklemtoon dat geen plaaslike mark immuun is teen oordrag-effekte vanaf internasionale markte nie. Suid-Afrikaanse finansiële mark deelnemers, soos beleggers en beleidsmakers, het 'n gevestigde belang in die begrip van hoe die aandelemark in besonder, asook die ekonomie oor die algemeen, reageer op internasionale finansiële krisisse. Hierdie studie het ten doel om by te dra tot die verbetering van die begrip oor die interaksie van die Suid-Afrikaanse aandelemark met internasionale aandelemarkte, deur die graad van die prys- en volatiliteitsoordrag voor, tydens en na 'n internasionale finansiële krisis te identifiseer.

Ten einde hierdie doel te bereik, is die moontlikheid van verandering in die aard van die prys en die volatiliteitsoordrag vanaf die Asiatiese finansiële krisis (1997–1998), die dotcom-krisis (2000–2001) en die meer onlangse subprima finansiële krisis (2007–2009), ondersoek. 'n *Exponential Generalized Autoregressive Conditional Heteroskedasticity* (E-GARCH) model word binne die raamwerk van 'n *Aggregate Shock*-model geïmplementeer. Die empiriese resultate dui daarop dat, tydens die internasionale finansiële krisisse, die JSE se Algehele Indeks direk beïnvloed was deur oordrag-effekte in terme van die prysoordrag vanaf die land waar die krisis afkomstig was. Volatiliteitsoordrag gedurende internasionale finansiële krisisse was direk afkomstig vanaf die land waar die krisis aanvang gevind het. Ten slotte, was die FTSE 100-Indeks die vernaamste uitvoerder van prys en volatiliteitsoordrag na die JSE se Algehele Indeks.

Sleutelwoorde: volatiliteitsoordrag; internasionale finansiële krisis; E-GARCH; finansiële markbesmetting

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Chapter 1

Introduction and background

1.1 Introduction

Financial markets around the world have become increasingly interconnected, and financial globalisation has benefited national economies, investors and savers (Häusler, 2002:1). Emerging economies too, have benefited from the global financial integration, but this has also brought about increased financial turbulence (Boshoff, 2006:61). This turbulence has been caused by the change in the structure of markets that results from financial globalisation, thereby creating new risks and challenges for market participants and policymakers alike (Häusler, 2002:1). The South African financial markets have been no exception, and have been severely affected by financial crises (Boshoff, 2006:61). Given the extent of international financial market integration, there appears to be a greater need to understand the influence of financial crises originating abroad.

An investigation into the influence of crises on financial markets, other than the originating country, requires a clear distinction between contagious and non-contagious crises (Boshoff, 2006:62). A *contagious crisis* is an event in a particular country that has a significant and immediate impact on markets in other countries. The transmission of these crises is also known as “financial contagion”, and this transmission is “fast and furious” according to Kaminsky *et al.*, (2003:3). In contrast, a *non-contagious* crisis is a crisis to which initial outside market reaction is slow and limited, although the impact on outside markets may be large over a longer period (Kaminsky *et al.*, 2003:2). Local financial markets and economies have become much more vulnerable to volatility in international financial and economic markets through contagion effects (Khalid & Rajaguru, 2005:8).

When equity markets are correlated during periods of financial stability, this correlation can be regarded as interdependence between markets (Daly, 2003:74), but when correlation between equity markets increases during periods of financial turmoil, their relation can be defined as *contagion* (Bongiglioli & Favero, 2005:1300). Contagion thus implies that a collapse of one market produces a fall in another market, but interdependence on the other hand implies that there is a fall in both markets owing to the markets being influenced by the same macro-economic factors (Gonzalo & Olmo, 2005:5). In essence, interdependence implies that there are no significant changes in cross-market linkages after a financial crisis, while contagion implies a fundamental increase in cross-market linkages after a shock (Daly, 2003:75).

Preliminary research has indicated that there are numerous theories on channels of crisis transmission. Investor behaviour, through the possibility of herding, fads and irrational exuberance, as well as economic linkages through trade and finance, are some of the theories of contagion mentioned by Kaminsky *et al.*, (2003:4). Additional theories of crisis transmission include product competitiveness, a forced-portfolio recomposition, *wake-up call*, an income effect, and a credit crunch (Forbes, 2000:3). These numerous theories can be organised into three main categories, namely those on *trade linkages*, on *financial linkages* and on *linkages based on investor behaviour* (Boshoff, 2006:63). All of the above-mentioned theories try to determine the reason that a crisis in one country can affect markets of different sizes and structures around the world. The complexities of financial markets require various theories in order to better comprehend its inner workings.

Finance theory is just as important to consider when undertaking any equity market study (Bodie *et al.*, 2007:243). Modern portfolio theory states that the return on an individual security has two risk components. The first component is *systematic risk*, which is that element of risk in a security that cannot be diversified away and that influences the entire market (Marx *et al.*, 2006:34). Systematic risk can change over time when the macro-economic variables that affect the valuation of all risky assets change (Reilly & Brown, 2003:244). The second risk component is *unsystematic risk*, which is risk that is specific to an individual equity and that can be diversified away (Marx *et al.*, 2006:34). Unsystematic risk represents that component of a security's return that is not correlated to general market moves.

Financial market stability, a prerequisite for economic prosperity, is negatively affected by uncertainty or risk. By being able to identify, measure and manage this risk or uncertainty, financial market stability will be greatly enhanced. The capital asset pricing model (CAPM), proposed by William Sharpe in his book "Portfolio theory and capital markets" (1970:95), indicates that beta is the only relevant measure of an equity's risk. Beta is a standard measure of systematic risk based upon an asset's covariance with the market portfolio (Reilly & Brown, 2003:248). Alternatively, beta measures can be used to determine the amount by which the price of an individual security moves up or down when compared with the amount by which the equity market as a whole moves up or down, that is, the relative volatility of a security (Sharpe, 1970:91).

If investors and policymakers know the level of price and volatility transmission between international and local equity markets in general, risk assessment and indeed price risk management could greatly be improved.

1.2 Problem statement

The significance of financial crises is evident in their effect on economic fluctuations. Disruptions to the efficient functioning of financial markets can result in the increased cost of financial intermediation, curb the availability of an economic lifeline in the form of credit, restrain activity in the real sector of the economy, and eventually expose a country to periods of low growth and/or economic recession (Allen & Gale, 2000:2).

Studying the influence of price and volatility transmission from international financial crises to the South African equity market involves addressing three significant areas, namely *financial stability*, *volatility*, and *price and volatility transmission across exchanges*. Firstly, financial stability is greatly affected by volatility, and during an international financial crisis, financial stability is of paramount importance not only in the crisis country, but also in countries that have trade relations with the crisis country concerned.¹ Regulators need to take account of volatility transmission from foreign financial markets when seeking to stabilise the financial system through policy formulation (Corsetti *et al.*, 2005:2). Volatility transmission between equity markets in a crisis country and the South African equity market influences the equity price of not only South African equity shares, but also other domestic markets, such as the money market, bond market and foreign exchange market (Chinzara, 2011:47). Understanding the reaction of the South African equity market and the South African economy to international financial crises is essential for achieving some degree of financial market stability. Since the asset channel is important for the transmission mechanism of monetary policy, the global transmission of equity market shocks can influence the effectiveness of monetary policy (Mishkin, 1995:6).

Secondly, volatility transmission between equity markets and the underlying linkages influencing them have important implications for portfolio diversification, the cost of capital, the pricing of financial securities, and the transmission of risk between equity markets. Equity traders in a given market incorporate not only domestic information, but also information generated by other equity markets into their buy and sell decisions. Provided that the information generated by international equity markets is relevant to the pricing of domestic securities, this behaviour by traders is consistent with the efficient-market hypothesis (Koutmos & Booth, 1995:1). Thus, by understanding the way in which equity markets interact, hedging and trading strategies can be better implemented.

¹ The problem of increased integration into the global economy is the increased exposure to global crises. A country's financial markets may experience a downturn that may or may not be related to the country's sovereign risk, when it is integrated into the global economic system (Collins & Biekpe, 2003:182).

Finally, a number of studies have been conducted on the transmission of price and volatility across exchanges. Examples include Barclay *et al.*, (1990),² Hamao *et al.*, (1990)³ and Lin *et al.*, (1994).⁴ In addition to these studies, Kanas (1998) studied the volatility transmission between the three largest European equity markets and found that there were a greater number of transmission effects during the post-crash period than during the pre-crash period, indicating greater interdependence between the markets studied after the market crash.⁵ Locally, Piesse and Hearn (2005) found evidence of volatility and returns transmission between sub-Saharan African equity markets, and Collins and Abrahamson (2004) investigated whether various African equity markets are integrated more regionally or globally.

Although Collins and Biekpe (2003) investigated the possibility of contagion from the 1997 Asian financial crisis on African economies, including South Africa, no in-depth attempt has yet been made to investigate the influence of international financial crises on the South African equity market in terms of price and volatility transmission. The possibility of changes in the nature of price and volatility transmission before, during, and after a financial crisis has occurred have also not been investigated yet. This study thus aims to build upon the existing literature on South African equity market interaction with international equity markets. If investors and policymakers know the level of price and volatility transmission between international and local equity markets in general, risk assessment and indeed price risk management could be improved substantially. Given the fact that international economies and international financial markets, in particular, are not governed by borders, the question that needs answering is: *what effect does a financial crisis in one country or region have on the equity markets and financial market policy-structure in other countries, in this particular case South Africa?*

1.3 Research aim and objective

In light of the above question, this study aimed to contribute to an improved understanding of how the South African equity market interacts with international equity markets, by identifying the degree of price and volatility transmission before, during and after an

² Barclay *et al.*, (1990) found evidence of correlations amongst dual-listed equities on the New York Stock Exchange and the Tokyo Stock Exchange.

³ Hamao *et al.*, (1990) found volatility transmission effects between New York and London to be weaker than the transmission effect between the Japanese market and New York. Koutmos and Booth (1995) too found volatility transmission effects between New York, London and Tokyo.

⁴ Lin *et al.*, (1994) used a signal-extraction model and an Aggregate Shock model to study how returns volatilities of equity indices are correlated between Tokyo and New York.

⁵ See Ramchand and Susmel's (1998) investigation on the relationship between time- and state-varying volatility and correlation between the US and Japan, the UK, Germany and Canada; and Ng (2000) who investigates the extent to which volatility within the Pacific-Basin region is influenced by a world factor, and how much is explained by a regional factor.

international financial crisis. South African financial market participants, such as investors and policymakers, will then be able to better understand how equity markets in particular and the economy in general react to international financial crises. To this end, the Asian financial crisis (1997–1998), the dotcom bubble (2000–2001) and the more recent subprime financial crisis (2007–2009) are examined. The possibility of changes in the nature of price and volatility transmissions as a result of these international financial crises was investigated.

1.4 Methodology

The research aim and objective is achieved through a literature review and an empirical study. The literature review sought to determine the causes and general effects of the Asian financial crisis, the dotcom bubble and the subprime financial crisis on financial markets and the general economic system. An overview of the theories of crisis transmission will be provided, and the effect of the 11 September 2001 terrorist attacks (9/11 attacks) on price and volatility transmission will be explained.

The empirical study centres on the Autoregressive Conditional Heteroskedasticity (ARCH) family of models, which makes it possible to model the attitude of investors not only towards expected returns, but also towards risk or uncertainty. These models are also capable of processing the volatility (variance) of a series. Since financial data exhibits periods of unusually high volatility followed by low volatility, it is preferable to examine the conditional volatility of the series because it will aid an investor or policymaker in estimating the riskiness of an asset at a certain period of time (Asteriou & Hall, 2007:250). An Exponential Generalised Autoregressive Conditional Heteroskedasticity (E-GARCH) model⁶ was employed within an Aggregate Shock (AS) model framework. E-GARCH models (Samouilhan, 2006:250) allow the conditional volatility to be a function of both the magnitude and direction of innovations (good news and bad news).⁷ Furthermore, by modelling the returns of the markets simultaneously, problems associated with the univariate E-GARCH model can be eliminated (Koutmos & Booth, 1995:749). Firstly, problems with estimated regressors can be avoided because the two-step procedure is eliminated. Secondly, the efficiency and power of the tests for cross-market transmissions can be improved. Thirdly, a multivariate E-GARCH model allows own market and cross-market innovations (news) to exert an asymmetric impact on the volatility in a given market.

⁶ Developed by Nelson (1991).

⁷ Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models on the other hand, assume that good news and bad news of similar magnitudes have the same influence on the level of volatility (Nelson, 1991).

ARCH and Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models treat heteroskedasticity as a variance to be modelled (Engle, 2001:156). In these models, however, magnitude has a more important role than the impact of information on the direction of returns (Engle, 2001:166). The efficient-market hypothesis states that the asset returns in the past cannot improve the forecast of asset returns in the future (Yang, 2008:16). Since Generalised Autoregressive Conditional Heteroskedasticity (GARCH) innovations are serially uncorrelated, these models do not violate the efficient-market hypothesis (Yang, 2008:16). The goal of ARCH and GARCH models is to provide a volatility measure (such as a standard deviation) that can be implemented in financial decisions pertaining to risk analysis, portfolio selection and derivative pricing (Engle, 2001:158). Although the focus of this dissertation will mainly be on risk (volatility) analysis, it should be noted that both portfolio selection and derivative pricing in all their elements are ultimately affected by risk (volatility).

The type of data employed in any analysis will affect the conclusions made. Since data of a higher frequency (for example, intra-day or daily) contains too much noise,⁸ and lower frequency data (for example, monthly) will make it more difficult to capture changes in information, weekly data was used in this study. International financial markets do not trade during the same trading hours and since differences in opening and closing times between these interacting financial markets may lead to spurious casual relationships (Cheung *et al.*, 2010:88), the use of weekly data avoids the overlapping and non-synchronous trading problem.⁹ The period under review was from 03/01/1995 to 31/07/2010, since the financial crises investigated in this study occurred during this period. These financial crises and the years in which they occurred are presented in Table 1.1.

Table 1.1 International financial crises under review

Crisis	Year
Asian financial crisis	1997–1998
Dotcom bubble	2000–2001
9/11 terror attacks	2001
Subprime financial crisis	2007–2009

Source: Compiled by the author

The returns data of the crises presented in table 1.1 will form the basis of the empirical analysis in chapter 4. The relationship between the South African equity market with regard

⁸ See Worthington and Higgs (2004), Roca (1999), Ramchand and Susmel (1998), Tay and Zhu (2000), and Aggarwal *et al.*, (1999) for evidence of noise in the use of daily data.

⁹ See Cheung *et al.*, (2010:88) and Hung and Cheung (1995:282) on the use of weekly data as a means of avoiding the non-synchronous trading problem.

to price (returns) and volatility transmission will be tested against the indices presented in Table 1.2.

Table 1.2 Indices studied

Index	Country
JSE All Share Index (JSE)	South Africa
Hang Seng Index (HSI)	Hong Kong
Financial Times Stock Exchange 100 Share Index (FTSE 100)	UK
Dow Jones Industrial Average (DJIA)	US

Source: Compiled by the author

The Johannesburg Securities Exchange All Share Index (JSE) served as a proxy for the South African market and as the overall benchmark in this study. The Hang Seng Index (HSI) was a proxy for the Asian region.¹⁰ The Dow Jones Industrial Average (DJIA) represented the United States (US). The London Financial Times Stock Exchange 100 Share Index (FTSE 100) served as a proxy for the European Union (EU). The market returns for all these exchanges was statistically tested to establish the volatility transmission characteristics between these markets and regions according to the respective financial crisis emanating from these regions. Before the formal econometric study was conducted, the behaviour of the data used in this study was analysed through descriptive statistical tests and statistical inference.

1.5 Chapter outline

Chapter 2 will provide overviews of the 1997 Asian financial crisis, the dotcom bubble (2000–2001), the 9/11 attacks on the US (2001), and the first and second stages of the subprime financial crisis (2007–2009) with regard to their causes and general effects on the global economy. It will also include a brief overview of the theories of crisis transmission. Chapter 3 will explore the concepts concerning volatility and volatility interactions. It will also explain ARCH and GARCH models and the E-GARCH model used in this study. Chapter 4 will provide an overview of volatility transmission. It will then focus on the data and research methodology and detail the descriptive statistical tests conducted on the market returns of the four exchanges studied. This chapter will also present the empirical results obtained from the E-GARCH models and the interpretation thereof. It will finally discuss the evolving global financial system, as well as the future structure and regulatory framework of the global financial system. The concluding remarks on this study will be provided in Chapter 5.

¹⁰ After studying interdependence and volatility transmission between Asian equity markets during the Asian Financial crisis, In *et al.*, (2001) found that overall the Hong Kong market played an important role as an information producer and in propagating volatility across markets in the region.

Chapter 2

International financial crises

Good-bye financial repression, hello financial crash

Corsetti *et al.* (1998:30)

2.1 Introduction

Numerous in-depth studies have been conducted on the causes and effects of and subsequent policy recommendations on each crisis covered within this chapter.¹¹ The aim of this chapter is to summarise the events that led up to each crisis and their subsequent effects on the global economic environment, and thereby provide a background to the empirical analysis that follows in chapter 4.

In realising this aim, this chapter provides a brief overview of the causes and general effects of the Asian financial crisis (1997), the dotcom bubble (2000–2001), and the first and second stages of the subprime financial crisis (2007–2009) in Sections 2.2 to 2.4. The effect of the 9/11 attacks on economic and financial contagion will be included under the overview of the dotcom bubble, not because of its insignificance in this regard but rather its timing. Therefore, this crisis provided an opportunity to explore the behavioural nature of the South African equity market in the wake of both financial and political crises. This chapter ends with a brief overview of the theories of crisis transmission in Section 2.5.

2.2 The Asian financial crisis

Between 1970 and 1999, the regional economies of Thailand, Malaysia, Indonesia, Singapore, and South Korea experienced average annual growth rates ranging from 6.9% in Indonesia to 8.4% in South Korea (Berg, 1999:3). Despite a cyclical downturn in interest rates during the 1990s, capital inflows to Asia increased substantially within the same period (Berg, 1999:5). New diversification opportunities and the promise of a high rate of return from investments, through the maintenance of high interest rates by the Southeast Asian economies, resulted in these large capital inflows and rapid rising asset prices (IFRI, 1998). To protect themselves from large currency appreciations against their US dollar peg, the Southeast Asian economies adopted tight fiscal and monetary policies (Berg, 1999:5). As a result, these economies were transformed from poor, less-developed countries, to middle-income emerging markets, giving rise to the term “Asian economic miracle” (Berg, 1999:3).

¹¹ See Berg (1999), Gordon (2005), Wang (2007), and Bianco (2008) on the effects and policy recommendations of the Asian financial crisis, the dotcom bubble and subprime financial crisis.

Eighteen months before the Asian financial crisis manifested, a number of economic indicators highlighted likely future economic problems in the Southeast Asian region. Nearly all the Asian economies had undergone financial sector deregulation and capital account liberalisation prior to the outbreak of the crisis (IFRI, 1998). Regional macro-economic and structural weaknesses were at the heart of the Asian financial crisis (Corsetti *et al.*, 1998:3). In countries such as Thailand, unsustainable current account deficits and overvalued exchange rates played a significant role in their economic problems (Berg, 1999:3). However, these problems were not only confined to Thailand. All of the countries in Southeast Asia were characterised by large current account deficits, with the smallest being recorded in Indonesia, at 3.3% of GDP in 1996 (Berg, 1999:9).

A large current account deficit usually results in a loss of confidence in the particular economy, as it indicates that the country will have to delve into its foreign currency reserves or borrow money from abroad in order to pay for their imports (Colander & Gamber, 2006:198). Domestic currency depreciations are a further result of large current account deficits, especially when the underlying cause of the deficit points to serious economic problems. There appeared to be little reason for alarm within the Southeast Asian region, except in the Philippines, where a boom in investments, and not declining savings, caused the deficits (Berg, 1999:9).

Some of the other concerns at the time included lower exports amongst the Southeast Asian countries (Thailand and South Korea in particular) over the 1996 to 1997 period, owing to a decline in semi-conductor prices,¹² increased Chinese competition and exchange rate appreciation (Berg, 1999:9).¹³ Although there was a problematic rise in macro-economic factors by the end of 1996, there was no clear evidence of large macro-economic problems in the region before 1997 (Berg, 1999:9).

As mentioned earlier, during the 1990s substantial capital inflows were finding their way into the Asian countries of South Korea, Malaysia, Thailand, the Philippines, and Indonesia. These inflows ranged from 3% of GDP in countries such as South Korea to 10% of GDP in Malaysia. Even though foreign capital inflows may be problematic owing to sudden reversals, current account deficits on the other hand are not problematic if they are financing investments (Berg, 1999:9). This was not the case for all of these growing Asian economies though. Most of these booming economies were battling with poorly regulated and undercapitalised domestic financial institutions acting as intermediates between the surging

¹² Semi-conductors was one of the main export products from the Southeast Asian region (Berg, 1999:9).

¹³ These appreciations were driven by the US dollar relative to the Chinese yen.

capital inflows and subsequent investment booms (Berg, 1999:10). The economic growth experienced by most Southeast Asian economies was the result of increased capital investment (Krugman, 1994:70). Total factor productivity, or increased efficiency, remained unchanged or in some instances increased only marginally (Krugman, 1994:70). In order to achieve long-term growth, total factor productivity and not capital investment should be the main driver of economic growth (Krugman, 1994:70).

Persistent and large current account deficits, built up by sustained capital accumulation, was a contributing factor to the crisis, especially since the profitability of new investment projects was low (Corsetti *et al.*, 1998:3). Investments in most Southeast Asian countries were concentrated into sectors with already excessive capacity and non-traded sectors such as equity exchanges and the real estate sectors, respectively (Berg, 1999:10).¹⁴ Inefficient investments and the financial fragility of the corporate sector, caused by a high ratio of debt to equity, were the results of a weak financial sector, strong capital inflows and a credit boom (Berg, 1999:10). A slowdown in growth, increase in interest rates, or decline in asset prices would have resulted in a large number of insolvent companies (Berg, 1999:12). This is because high-priced property was held up as collateral against ever-growing lending activity by undercapitalised banks, and a number of companies outside the financial sector being plagued by excessive leverage (Berg, 1999:12).

Since these economies' debt markets were underdeveloped, it meant that banks were relied upon as the primary source for financing (IFRI, 1998). However, the structural deformation in the financial and banking sector forced banks into borrowing excessively from foreign countries in order to feed the domestic credit boom (Corsetti *et al.*, 1998:3). Furthermore, international banks appeared to have neglected sound risk assessment standards when large amounts of funds were lent out to Southeast Asian financial intermediaries (Corsetti *et al.*, 1998:4).¹⁵ The liabilities of these unregulated financial institutions were perceived as being guaranteed by their respective governments, which paved the way for moral hazard and crony capitalism problems (Krugman, 2000:47). The resulting credit boom in the region's economies created asset price inflation, particularly in risky assets where crony capitalism was prevalent (Krugman, 2000:47). Domestic institutions appeared to have had no real incentive to hedge themselves against short-term foreign borrowings, owing to the apparent rigidity and historical stability of nominal exchange rates (IFRI, 1998).

¹⁴ See also International Financial Risk Institute (1998) on the concentration of investments in the Southeast Asian countries.

¹⁵ In Thailand, Korea and Indonesia, for example, the ratio of short-term external liabilities to foreign reserves was well above 100% (Corsetti *et al.*, 1998:4).

In an attempt to limit their maturity mismatches between short-term deposits and long-term lending, most banks in the region lent out funds at floating rates. However, these banks were basing their balance-sheet risk management on the assumption that there would be no sharp and sustained interest rate increases. However, by 1997 this proved to be a major error. The sustained overvaluation of Southeast Asian countries' currencies led to speculative currency attacks (IFRI, 1998). This situation resulted in interest rate increases and subsequent insolvency of long-term borrowers, thus transforming interest rate risk into credit risk (IFRI, 1998). In Thailand alone, the average daily repurchase rate almost doubled by the third quarter of 1997 to 19.5%, while the interbank rates increased by nearly the same amount over the same period to 19.8% (IFRI, 1998).

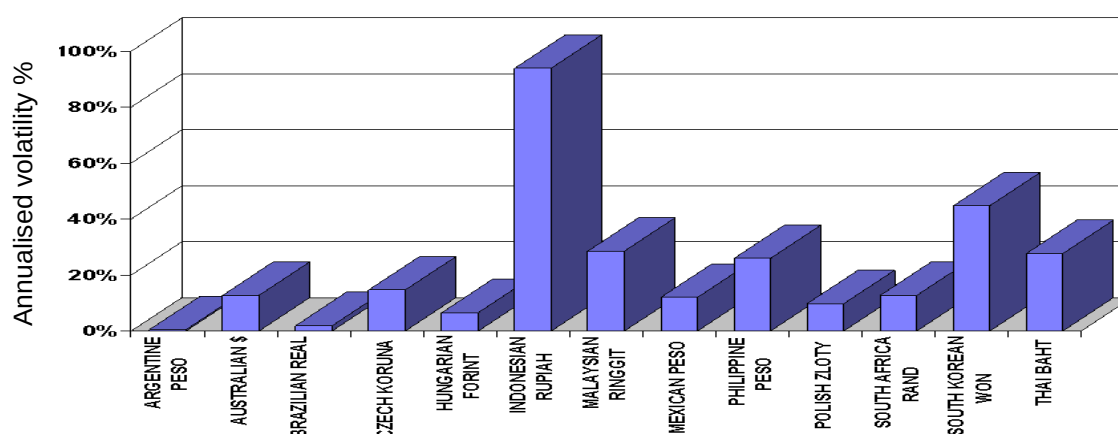
Only three countries had capital adequacy ratios that were higher than the Basel Capital Accord requirements at the time (IFRI, 1998). Apart from the above-mentioned problems, financial markets, through over-the-counter (OTC) and off-balance-sheet activities, contributed to the severity and dynamics of the financial crisis. Over-the-counter currency derivatives, such as non-deliverable forwards, have played a role in increasing the volatility of domestic securities and currencies (IFRI, 1998). In most Southeast Asian economies, currency market volatility spilled over to domestic equity markets and subsequently contributed to unsettling the real economy (IFRI, 1998).

The effect of the above-mentioned factors forced the government of Thailand to change their currency regime from a fixed currency (pegged to the US dollar) to a floating currency on 2 July 1997. This event marked the official start of the Asian financial crisis (IFRI, 1998). Before this change in currency regime had occurred, concerns over Thailand's increasing short-term debt levels and property deflation resulted in its currency and equity markets experiencing downward pressure as investors started to withdraw large amounts of capital (IFRI, 1998). Expectations of inflationary financing and a large current account deficit heightened investor concerns, as they became weary of the inability of the local currency unit, the Thai baht, to maintain its peg to the US dollar (Corsetti *et al.*, 1998:1). After depleting their foreign currency reserves in an attempt to defend the baht against currency speculators, Thailand's government decided to float the Thai baht against the US dollar (IFRI, 1998). During the initial stages of the crisis, the problems experienced in Thailand were regarded as being confined to the country. However, when conditions worsened in Thailand, the equity markets of Malaysia and the Philippines came under pressure as investors started to sell their assets amid a loss of confidence in a region that was characterised by a combination of high external debt, government overspending and financial sector irregularities (IFRI, 1998). The crisis spread rapidly from Thailand to the

other members of the Association of Southeast Asian Nation (ASEAN), Indonesia, Malaysia and the Philippines. Rapid reversals of financial inflows, fuelled by deteriorating domestic and international market sentiment, led to the collapse of the region's currencies (Corsetti *et al.*, 1998:6). Investor concerns over a highly leveraged corporate sector exacerbated the decline of these countries' currencies against the US dollar (IFRI, 1998).

After the financial crisis broke, the economies of Thailand, Indonesia, South Korea and Malaysia experienced a major credit crunch, as a contraction in liquidity placed pressure on the daily operations of the corporate sector and financial system (IFRI, 1998). An increase in non-performing loans and insolvency, owing to asset price deflation and rising interest rates, impaired banks' ability to distinguish between good and bad borrowers effectively (IFRI, 1998). The economic slowdown in the Southeast Asian region resulted in large capital withdrawals from South Korea, Thailand, Malaysia and Indonesia during 1997 and at the beginning of 1998. The net outflow of funds, excluding offshore funds, during 1997 was nearly US\$6 billion and contributed to decreasing economic growth opportunities and currency devaluations in the region (IFRI, 1998).

Figure 2.1: The annualised volatility of emerging-market currencies (02/07/1997–27/07/1998)

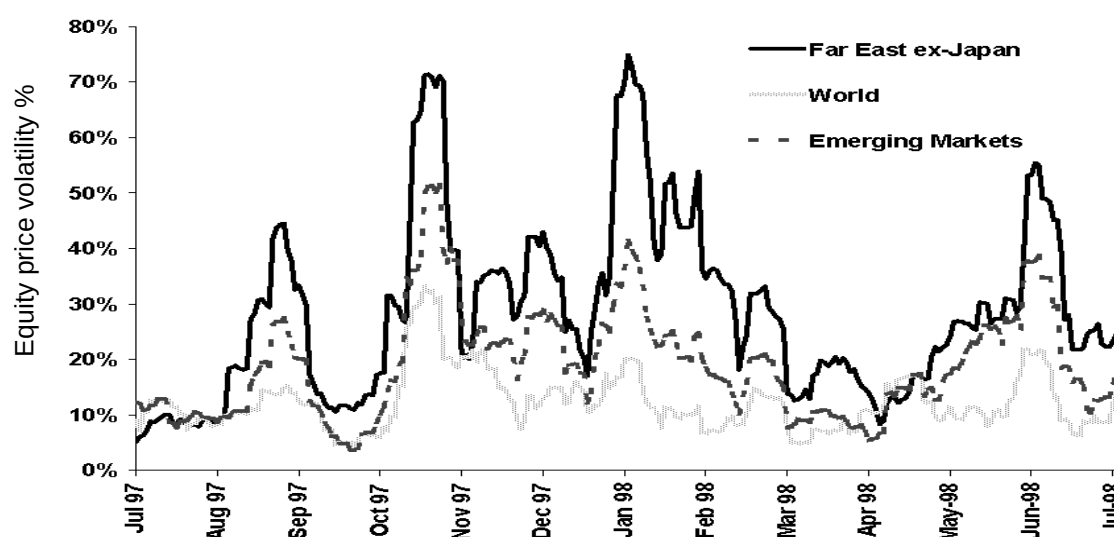


Source: International Financial Risk Institute (1998)

Rising volatility (see Figure 2.1) and deteriorating economic fundamentals attributed to the outflow of capital from the ASEAN countries (IFRI, 1998). The depreciation of nearly all the Asian countries' currencies against the US dollar resulted in other emerging-market currencies being perceived as overvalued and investors started to regard emerging-market investments as high-risk, low-return investments. As a result of this perceived risk, the currencies of Eastern European countries also began to come under pressure (IFRI, 1998).

This perception of greater risk in emerging economies increased over time, regardless of the effect the Asian financial crisis had on the respective emerging economies, resulting in the cost of capital becoming more expensive in emerging economies (IFRI, 1998). This was evident in the widening of the yield spreads of the Latin American Brady bonds and the increase in borrowing costs across emerging markets. In turn, these increases in borrowing costs hampered the ability of issuers of debt instruments to service their debt (IFRI, 1998).

Figure 2.2: Equity price volatility in Asia, emerging markets and the rest of the world



Source: International Financial Risk Institute (1998)

The volatility experienced in the currency (shown in Figure 2.1) and debt markets was soon transferred to equity prices. Figure 2.2 provides a comparison between the volatility of equity price indices for Asia, the emerging markets and the rest of the world. After a three-day decline in Asian equity prices, a global correction in equity market prices was triggered. The HSI shed 23% of its value, and because of the uncertain corporate earnings in the US (owing to its exposure in Asia), the DJIA fell by 7.2% on 27 October 1997 (IFRI, 1998).

The sharp decline of the DJIA was transferred to major markets around the world, with the bond and equity markets of emerging economies such as Brazil, Mexico and Russia being hardest hit (IFRI, 1998). Around the globe, many exchanges including those of Brazil, Taiwan, Malaysia, Thailand, India, Bangladesh, Japan, Argentina and Hungary activated circuit breakers¹⁶ and other trading restrictions after the 7.2% decline of the DJIA (IFRI, 1998). Liquidity in some emerging economies came under severe pressure as increased

¹⁶ A circuit breaker is a measure used by equity markets in order to avert panic during large price fluctuations, by suspending trade when a predefined event occurs (Wuite, 2009:80).

selling produced heightened market stress (IFRI, 1998). As a result of surging volatility, options trading in South Africa also experienced a selling overhang (IFRI 1998).

The speed of volatility transmission between different countries and different asset markets was a surprising feature of the Asian financial crisis (IFRI, 1998). High levels of volatility within the underlying markets made it very difficult for market participants to hedge themselves against unexpected changes in market events (IFRI, 1998). Preserving pricing efficiency was a problem during the peak of the Asian financial crisis in October 1997. As a result of surging international market volatility, price limits were frequently exceeded, resulting in the price discovery process of the cash and futures markets being greatly disrupted (IFRI, 1998).

Although there were heightened levels of financial market volatility and risk aversion with regard to emerging markets, it was the rapid reversals of financial inflows and regional macro-economic and structural weaknesses that were at the heart of the Asian financial crisis. High external debt, government overspending and financial sector irregularities were the main protagonists in the Asian financial crisis. Unsurprisingly, indiscretions by financial market participants as well as external forces, such as political motivations, have a tendency to distort financial market actions. The dotcom bubble is an example of this distortion.

2.3 The dotcom bubble

Former Chairman of Federal Reserve's Board of Governors, Alan Greenspan, marks August 9 1995 as the day the dotcom boom was born (Greenspan, 2007:164). This was the day of Netscape's initial public offering. However, there appeared to be no signs of a bubble within the aggregate US equity market until 1998 (DeLong & Magin, 2006:1). Unlike the Asian financial crisis, the ultimate demise of financial market gains during the run-up of the dotcom obsession and its eventual downfall cannot be attributed entirely to fundamental economic changes within the economy of the US, but partly to investor behaviour or *misbehaviour*. This misbehaviour can be attributed to negligence on behalf of investors with regard to their investment decisions during the run-up to the dotcom boom. By examining the relationship between a company's identity and shareholder reaction with regard to ".com" name change announcements by companies operating within the Internet industry, Lee (2001:793) found that the aim of a company name is to convey meaning, reputation, and identity that encourage employees and investors to identify with the particular company. Announcements of ".com" name changes during the Internet boom period (prior to March 2001) carried information signals that may have been the source of irregular returns and trading activity

(Lee, 2001:802). Evidence of substantial increases in equity prices and trading volume were found when a “.com” suffix was attached to a company’s name (Lee, 2001:802). The association with a booming and potentially rewarding economic sector such as the Internet seemed to have been the main allure for investors (Lee, 2001:802). However, announcements with regard to name changes can also generate negative abnormal returns when investors disapprove of managerial decisions such as making investments in an unattractive sector of the economy where future profit generation may be weak (Lee, 2001:794).

Investor behaviour may have had a significant impact on the build-up of the dotcom bubble, but this behaviour was fuelled by a technological revolution that was set to transform the way in which the US economy, and indeed the global economic system, operated. The potential of electronic commerce was discovered during the late 1990s, when approximately 7 000 to 10 000 new dotcom companies were established (Wang, 2007:79). Investors and entrepreneurs were attracted to these companies owing to their ability to communicate with their customers throughout vast geographic regions via the Internet without requiring the investment of large amounts of capital on physical operating facilities, such as large buildings (Wang, 2007:79). Apart from the influence of investor behaviour at the time, one needs to step back and attempt to understand the factors influencing investor sentiment.

In order to understand the cause and impact of the dotcom bubble fully, it is important to look at the dynamics of the equity market boom of the 1920s. In the same way that electricity and the internal combustion engine changed the economic landscape with a technological leap in the 1920s, so too were computer hardware, software and ultimately the Internet set to alter the economic landscape once more in the 1990s. A parallel comparison can be made between the equity market boom, bubble and bust of the 1920s and 1990s, where 1919 is aligned with 1990 and 1929 with 2000 (Gordon, 2005:1). The performance of the US economy during these periods exhibits a very similar evolution of macro-economic variables (Gordon, 2005:1). Real GDP growth, real GDP per capita, employment, and productivity were near identical, and the unemployment rate of 1928 was identical to the rate in 1999 (Gordon, 2005:1). Although a comparison of the success of the economy during the 1920s and 1990s can be made, both of these periods also share similar breakdowns especially in terms of over-investment and equity market bubbles (Gordon, 2005:3). The acceleration in productivity growth can be attributed to the invention of “general purpose technologies” such as electricity, the combustion engine and the Internet, which occurred during the 1920s and 1990s (Gordon, 2005:1). Between 1919 and 1929, electricity generation doubled, while motor vehicle registrations more than tripled (Gordon, 2005:7). Law firms, business services,

medical practices, the manufacturing sector and indeed the rest of the US economy were all automating and streamlining themselves in the computer age of the 1990s (Greenspan, 2007:173). The use of personal computers by Americans during the 1990s grew at the same rate as electricity generation did in the 1920s (Gordon, 2005:7).

This growth in productivity helped to keep inflation low during both these periods, while the general purpose technologies resulted in an increase in fixed investment, which eventually became excessive and unsustainable (Gordon, 2005:1). Netscape may be an ideal example of excessive and unsustainable investment. When equities in Netscape, a software producer in the southern region of San Francisco Bay,¹⁷ traded for the first time, its price increased from US\$28 a share to US\$71 in one day (Greenspan, 2007:164). During 1995, the DJIA broke the 5 000 mark and ended the year over 30% in the green, and the NASDAQ index, featuring mainly technological companies, gained 40% before the end of 1995 (Greenspan, 2007:164). The productivity effects of general purpose technologies also led to excessive and unsustainable levels of investment during the 1920s.

In his economic comparison between the 1920s and 1990s, Gordon (2005:5) finds that in real terms, equity prices increased by 17% per annum between 1923 and 1929, which is virtually identical to the 16.9% per annum increase in equity prices between 1994 and 2000. The investment boom during the 1920s and 1990s featured a prominent and unsustainable growth of investment in production equipment and software (Gordon, 2005:18). Spending on consumer durables plus investments as a share of real GDP, reached a peak of 27.1% in 1925 compared with a peak of 26.3% in 1999 (Gordon, 2005:18).

Despite a strong increase in equity prices, the fragility of the financial system was a common feature during the equity market boom and bust that occurred during the 1920s and the 1990s (Gordon, 2005:28). The equity market boom of the late 1990s was sustained by an over-statement of corporate profits, most of which involved corruption, cheating and bad accounting practices (Gordon, 2005:29). Large profits by investment banks as well as an increase in consumer demand, driven by capital gains on equities, is another parallel between the US economy of 1920s and that of the 1990s (Gordon, 2005:29). The weakness of the banking system in the 1920s (in part due to poor regulations) increased the fragility of the financial system (Gordon, 2005:30). When comparing the equity market boom, bubble and bust of the 1920s with that of the late 1990s, it is clear that business cycles materialise

¹⁷ Commonly known as Silicon Valley (Gordon, 2005:1).

from the interaction between multiple factors (Gordon, 2005:38).¹⁸ Even with better-equipped institutions, a greater ability to distribute information and advanced policies (when compared to the 1920s), the dotcom bubble is a reminder that over-investment is still possible in this era of the “new economy” (Gordon, 2005:38).

Over-investment seemed to continue unhindered in the late 1990s. Between 1998 and February 2000, the returns on the publicly traded equity of companies in the Internet sector increased by over 1 000% and by early 2000 the Internet sector made up 6% of the total market capitalisation of all publicly traded companies in the US (Ofek & Richardson, 2003:1113).

The flow of money from US citizens into equity markets was increasing significantly, and the US was becoming a “shareholders’ nation” (Greenspan, 2007:174). By the end of 1996, the total value of equity holdings was 120% larger than the GDP of the US (Greenspan, 2007:174).¹⁹ Although the Federal Reserve had no explicit mandate to focus on the equity market, during this time the increase in equity prices seemed to be a legitimate concern (Greenspan, 2007:175). On December 5 1996, Mr. Greenspan²⁰ questioned the sharp rise of asset values during a keynote address²¹ at the American Enterprise Institute, asking: *“But how do we know when irrational exuberance has unduly escalated asset values ...?”* (Greenspan, 2007:177). He continued to question whether equity prices were representing excessive expectations that could not be met, stating that: *“We as central bankers need not be concerned if a collapsing financial asset bubble does not threaten to impair the real economy ... but we should not underestimate, or become complacent about the complexity of the interactions of asset markets and the economy”* (Greenspan, 2007:177). Clearly, in the eyes of Mr. Greenspan, irrational exuberance represented the relationship between the real value of companies and how investors feel about the equities of these companies.

Although there might be different views regarding the start and duration of the dotcom bubble, its effects on wealth creation and destruction are not disputed. Investors were evidently reminded of the extent to which international financial markets are interlinked, as the irrational exuberance speech on 5 December 1996 led to declines of 3% in Tokyo and Hong Kong, 4% in Frankfurt and London, and 2% in the US at the opening of trade the following day (DeLong & Magin, 2006:3).

¹⁸ These factors include irrational exuberance or “emotional speculation” by market participants, the questionable market practices of investment bankers as well as accounting fraud and pyramid building during the 1990s and 1920s, respectively (Gordon, 2005:38).

¹⁹ This figure had doubled since 1990 (Greenspan, 2007:174).

²⁰ Mr. Greenspan was the Federal Reserve’s Chairman of the Board of Governors during that particular period.

²¹ This keynote address became famous as the “irrational exuberance speech”.

For three years after the “irrational exuberance speech”, equity markets and investors appeared to ignore the signs that all was not well, and continued to invest in their feeling about company valuations, particularly in difficult to value technology companies. The extent of investor feelings about the value of technology companies was evident in the advertising during the Super Bowl Sunday event of January 2000, which featured 17 dotcom companies, which had paid over US\$2 million dollars each for a 30-second television advertising spot (Economist, 2005:138). This irrational exuberance by markets and its participants could not even be deterred by monetary policy, as equity markets continued to rise despite interest rates increasing from 4.75 to 6.5% between mid-1999 and mid-2000 (Greenspan, 2007:202). The NASDAQ composite index doubled in value during this period and reached a peak in March 2000 without any credible fundamental news supporting these equity valuations (DeLong & Magin, 2006:8).

This sharp rise in equity prices came to a sudden halt as investors started to question the basis of their investment decisions, particularly with regard to the uncertainty about the profitability of the much-admired technology companies. Between March and December 2000, the technology-heavy NASDAQ index lost 50% of its value, but the decline experienced by the broader markets was less severe. The Standard and Poor’s 500 index declined by 14%, while the DJIA lost 3% of its value (Greenspan, 2007:207). As a result, about 5 000 dotcom companies exited the market between the spring of 2000 and spring 2003 (Wang, 2007:79).

The aftermath of the dotcom bust was not limited to declining equity prices and company bankruptcies, but by the second quarter of 2000 the US economy was in recession (Greenspan, 2007:212). With a projected budget surplus of US\$5.6 trillion over ten years (Greenspan, 2007:213), the US economy was given a much needed lifeline when the new government administration signed a US\$1.35 trillion tax break on 7 June 2001 (Greenspan, 2007:223). The calmness of the recession was overstated, as was evident in the Standard and Poor 500 index declining by a further 20% between January and December 2001. This unforeseen decline in equity values resulted in a US\$376 billion downward revision of tax collections on capital gains in eighteen months (Greenspan, 2007:224). Growth in the economy of the US was sliding down, and unemployment was rising fast owing to declining investments and its effects on company profits. By August 2001, the US labour department announced that an additional 100 000 people were unemployed (Bose, 2002:3411). Four days after this announcement, the World Trade Centre and the Pentagon were attacked by terrorists (Bose, 2002:3411).

Unlike the other crises studied in this dissertation, the 11 September 2001 attacks were not financial in nature, but political. Thus, one might expect that the effects of this crisis on the international financial system would have been less significant than a crisis with more direct financial market implications. However, the significance of the impact or importance of the 9/11 attacks on the financial markets is evident in the closure of equity markets in the US for a period of four days after the terrorist attacks (Charles & Darné, 2006:690). When equity markets reopened on 17 September 2001, the DJIA declined by 7.1%, a record one-day point decline (Barnhart, 2001). US equities lost US\$1.4 trillion in value and the DJIA declined by 14.3% in one week, the largest drop in history, up to 2001 (Fernandez, 2001).

Evidence of the impact of the 9/11 attacks on financial markets outside the US can be found in numerous studies. International equity markets experienced large permanent and temporary shocks during the period of the 9/11 attacks (Charles & Darné, 2006:683). Terrorist attacks resulted in significant increases in volatility across the different regions, especially in the developed region of Europe (Nikkinen *et al.*, 2006:27). Latin America and the transition economies of Asia were only modestly affected by the events in the US, and the impact on the Middle East and North African region was also minimal (Nikkinen *et al.*, 2008:29).

The response of international financial markets to shocks varies according to the degree of integration of each region with the global economy (Nikkinen *et al.*, 2006:29). Even when cross-country correlations increased after the 9/11 attacks, there was no increase in volatility (Strauss *et al.*, 2004:96). In fact, cross-country volatility declined by nearly one-third just after the 9/11 attacks, and daily co-movements increased by 40% over the same time (Strauss *et al.*, 2004:96). After the 9/11 attacks, global equity markets moved closer together and became less volatile (Strauss *et al.*, 2004:103). This claim will be examined in the coming chapters of this dissertation, as volatility transmission to the South African equity market becomes one of the central subjects of this study. The final crisis providing insight to the nature of volatility transmission towards the South African equity market is the subprime financial crisis, which will be discussed subsequently.

2.4 The subprime financial crisis

Since the advent of the subprime financial crisis in 2007 and the more recent, related global economic downturn²², numerous studies have been conducted and articles have been

²² The current European Union sovereign debt crisis can be directly attributed to the subprime crisis. Unfortunately, since the crisis is very much ongoing, its effects on volatility transmission towards the South African equity market fall beyond the scope of this study.

written and presented around the world that seek to explain its origins and effects, and offer remedial policies. In this section, a brief overview of the causes and effects of the subprime crisis will be given, followed by an important topic that has been linked to the subprime crisis, the new financial architecture. Some critical revelations about the subprime crisis will conclude this section.

2.4.1 The crisis background

Since the advent of the subprime financial crisis, numerous economies across the globe have experienced severe economic recession.²³ The subprime crisis can trace its roots back to the crash of the dotcom bubble in 2000 and the 9/11 attacks in 2001, after the economy of the US was sliding into recession. In response to the economic downturn after 9/11, the Federal Reserve began to decrease short-term interest rates from approximately 6.5% in 2000 to 1% by July 2003 in a bid to stimulate consumer spending in a weakening economy (Bianco, 2008:4). It appears that the interest rate policy of the Federal Reserve during 2000 and 2003 was misguided by incorrect low inflation data (Bianco, 2008:4). The creation of a low interest rate environment contributed to the creation of a housing market bubble in the US, which began in 2001 and peaked in 2005 (Bianco, 2008:3). This bubble was created by the unsustainable and rapid increase in the valuation of real property values relative to incomes and other indicators of affordability, which was followed by decreases in home prices and rising mortgage debt levels (Bianco, 2008:4).

Although the housing bubble played an integral part, the core of the crisis was an interplay between global macro-economic imbalances created over the last decade and financial market developments and innovations, which were at least thirty years in the making (FSA, 2009:11). The accumulation of large current account surpluses in oil-exporting countries and East Asian emerging economies, particularly those with very high savings rates such as Japan and China, has been an important driver of these macro-economic imbalances (FSA, 2009:12). These countries have had to accumulate claims on the rest of the world, as their high domestic savings rates exceeded domestic investment needs. A major beneficiary of these excess savings has been the US, where the net inflow of foreign savings received increased from 1.5% of its national output in 1995 to approximately 6% of national output in 2006 (Bernanke, 2009:2). In contrast to the high savings regions, large current account deficits started to build up in the US and other developed economies such as the UK, Ireland and Spain (FSA, 2009:11).

²³ For a detailed review of the economies affected by the subprime crisis, visit the interactive facility on <http://news.bbc.co.uk/2/hi/business/8235141.stm>

Unlike these developed economies, the countries with large current account surpluses typically have fixed or managed exchange rates and their central bank reserve claims are invested in a variety of equities, property and income assets (especially risk-free government bonds; FSA, 2009:13). This situation has driven a reduction in risk-free interest rates, that is, those earned on Treasury bonds.²⁴ Together with market-specific circumstances, such as the dotcom bubble and 9/11 attacks in the US, a historically low interest rate environment was created (FSA, 2009:13). A global surplus in savings was responsible for driving down interest rates and increasing house prices around the world (Bianco, 2008:4). This situation created two important effects. Firstly, there was a rapid growth in credit extension, particularly in the US and the UK. Secondly, in an attempt to offset a declining risk-free rate, investors embarked on a fierce search for higher yields on their investments, particularly in bond-like instruments that provide a spread above the risk-free rate without adding excessive risk (FSA, 2009:14).

In response to the quest for higher yields, there has been a sharp increase in financial innovation, focusing particularly on the origination, packaging, trading and distribution (originate-to-distribute model)²⁵ of securitised credit instruments. This acceleration in financial innovation has resulted in substantial growth in securitised credit, and brought about a significant change in the nature of the securitised credit model (FSA, 2009:14).

During its early developmental stages, securitisation was seen as a means to reduce banking system risks, and since credit risk was passed on to end investors, banks had the opportunity to lower the need for expensive bank capital, thereby cutting their credit intermediation costs (FSA, 2009:15). When functioning properly, the financial system allocates funds with proper attention to risk to the most productive economic users (Bernanke, 2009:2). Owing to the increased inflow of funds, the surplus availability of funds created a situation in which financial institutions competed aggressively for borrowers, thus resulting in credit becoming relatively cheap and easy to obtain (Bernanke, 2009:2). In a situation in which money is virtually free, the rational lender will continue to lend until there is nobody left to lend to, and so mortgage lenders started to relax lending standards and created new means of stimulating business and generating profits (Soros, 2008:xv).

²⁴ This is of particular importance, since mortgage rates in the US are usually set relative to the yield of ten-year Treasury bonds (Bianco, 2008:4).

²⁵ A process by which a loan originated by a particular bank is sold to another financial market participant. The originate-to-distribute model allows banks to increase their lending activities without contravening excessive risk-taking measures implemented by regulators. See definition of securitisation and CDOs on page 23 for an explanation of how this process works.

One of the new means created to stimulate business and generate profits was the extension of credit to individuals who did not qualify for prime credit. Subprime borrowing²⁶ has been identified as the main catalyst of increasing home-ownership rates and surging demand for housing in the US between 2001 and 2006 (Bianco, 2008:6). Home-ownership rates in the US increased from 64% in 1994 to a peak of 69.2% in 2004. This increase in home-ownership fuelled an unprecedented rise in the value of homes – 124% between 1997 and 2006 (Bianco, 2008:6). In order to take advantage of the underlying market situation and increase the level of their spending, many homeowners decided to refinance their homes at lower interest rates and took out a second mortgage against the added value (Bianco, 2008:6). Between 1997 and 2006, consumers drew more than US\$9 trillion in cash from their home equity (Soros, 2008:xv), and by 2005 40% of all homes purchased were serving as investments or second homes (Soros, 2008:xvi). This created a situation in which household debt as a percentage of income increased to 130% in 2007, a figure that represents a 30% increase on the average amount during the previous decade (Bianco, 2008:6). The share of subprime mortgages to total originations increased from 9% in 1996 to 20% in 2006, as rising real estate values prompted lenders to take on more risk (Bianco, 2008:6).

The risk premium required by lenders offering subprime loans declined as the average difference in mortgage interest rates between subprime and prime mortgages declined from 2.8% in 2001 to 1.3% in 2007 (Bianco, 2008:6). This led to the growth of subprime mortgages, and by 2006 these loans totalled US\$600 billion, representing approximately one-fifth of the US's home loan market (Bianco, 2008:6). The growth in subprime mortgage extension was in part fuelled by innovative products designed to attract more borrowers. Mortgage lenders devised clever means to make houses appear affordable whilst most popular of these being adjustable-rate mortgages, which were initially introduced with “teaser” rates (Soros, 2008:xvi). These mortgages are introduced with a low interest rate in the first two years, and subsequently reset to a higher rate in order to compensate lenders for the higher risk of default, sometimes doubling the monthly payment (Bianco, 2008:7). Owing to a declining interest rate environment, mortgage lenders assumed that after the two-year period mortgages would be refinanced, thereby allowing them to take advantage of the higher prices and generating a new set of fees (Soros, 2008:xvi).

The rise of this creativity was accompanied by a collapse in credit standards, as mortgage lenders happily extended credit to individuals with low credit ratings, i.e. subprime borrowers

²⁶ “Subprime” is a term used in the US to describe the practice of mortgage extension to individuals who do not qualify for prime credit.

(Soros, 2008:xvi). Examples of lax credit standards include alt-A loans or “liar loans”,²⁷ “NINJA” loans,²⁸ and automated underwriting, which resulted in much quicker decisions²⁹ and required minimal documentation (Bianco, 2008:8). The speed of the automated underwriting system held immense appeal and in 2007 generated 40% of all subprime loans (Bianco, 2008:8).

A decline in credit standards and negligence on the part of mortgage lenders played an important role in causing the subprime crisis. However, financial innovation was ultimately responsible for transmitting this crisis globally. Securitisation and collateralised debt obligations are two examples of financial innovation that spearheaded the transmission of the subprime crisis. Banks may, for example, create debt instruments from home loans that they have originated. This is done through securitisation, where home loans are converted into tradable assets (Wuite, 2009:345). Banks usually set up special-purpose vehicles (SPVs) or conduits, in order to facilitate this process (Wuite, 2009:345). The main reason that banks undertake the process of securitising their assets is the attraction of bypassing capital adequacy requirements imposed by regulators. Banks achieve this by moving their assets off their balance-sheets and into SPVs. This allows banks to manage the risks of their credit portfolios better and reduce financial risk (Wuite, 2009:345). By reducing their risk profile in this manner, regulations allow them to hold less regulatory capital than would have otherwise been possible. This means that banks have more capital at their disposal to undertake additional lending activities (Wuite, 2009:345). Once these securitised instruments have been created, they may be sold on to investors as bonds. Securitisation allows banks to create a series of credit instruments from a single group of assets (with varying degrees of risk and reward), which appeal to different investor needs (Wuite, 2009:345).

The process of securitisation results in the creation of collateralised debt obligations (CDO). A collateralised debt obligation is a tradable financial security that has an underlying pool of assets, such as mortgage bonds. Debt is collateralised through the process of securitisation. For example, a bank may collateralise its home loan book and sell it to a SPV. The assets bought by the SPV can then be sold to investors as bonds with different levels of creditworthiness or subordination, maturities and risk profiles (Wuite, 2009:86). These bonds are known as collateralised debt obligations (CDOs) and allow the holder to exchange a set of interest payments as compensation for bearing the credit risk of the SPV.

²⁷ Liar loan applications do not require the borrower to provide any documentation to support the income stated on the finance application form (Bianco, 2008:7).

²⁸ NINJA is an acronym for no income, no job, no assets (Soros, 2008:xvi).

²⁹ Often, decisions on whether to grant loans were made within 30 seconds (Bianco, 2008:8).

Banks were at the forefront of financial innovation as they sold off mortgages with the highest risk by repackaging them into CDOs (Soros, 2008:xvii). Top-tier tranches have first call on all underlying cash flows, and could thus be sold with a AAA rating, whereas lower tiers carried higher risk but provided higher yields (Soros, 2008:xvii). Securitisation also spread to other forms of credit, most notably credit default swaps (CDSs), and as hedge funds entered the CDS market,³⁰ the market for these instruments grew exponentially (Soros, 2008:xix). By 2007, the estimated nominal value of outstanding CDS contracts was US\$42.6 trillion, nearly equal to the entire household wealth of the US (Soros, 2008:xix). In comparison, the capitalisation of the equity market and treasury market in the US was only US\$18.5 trillion and US\$4.5 trillion, respectively (Soros, 2008:xix). Through securitisation, and a tendency by rating agencies to assign investment-grade ratings to CDOs in the form of mortgage-backed securities,³¹ subprime loans could be originated, packaged and readily transferred to investors throughout the world (Bianco, 2008:8).

The ability to transfer risk through securitisation led mortgage lenders to believe that securitised credit intermediation would reduce risk throughout the entire banking system, and that credit losses would reduce the likelihood of banking system failure (FSA, 2009:15). Securitisation, through risk tiering and geographic diversification, was meant to provide this reduction of risk (Soros, 2008:xvii). Instead, risk was increased, as the mortgage ownership was transferred from banks or mortgage lenders, who knew the origin of these securities, to investors who did not (Soros, 2008:xvii). The entire originate-to-distribute model was fee based, which meant that higher volumes translated into larger bonuses (Soros, 2008:xvii). Lax mortgage standards appear to have been the result of “moral hazard”, as each link in the mortgage chain collected profits, while assuming it was passing on the underlying risk (Bianco, 2008:8).

When the subprime crisis broke, it became apparent that the diversification of holding the underlying risk, guaranteed by securitisation, had not been achieved (FSA, 2009:16). Instead, the majority of holdings in securitised credit, and the losses that arose after the crisis broke, were not on the books of the end investor who intended to hold these securitised assets to maturity, but on the books of extremely leveraged banks and bank-like institutions (FSA, 2009:16). This situation can be attributed to the trading operations of banks that followed an originate-to-distribute model, as well as an “acquire and arbitrage”

³⁰ Many specialised credit hedge funds acted as licensed insurance companies (Soros, 2008:xix).

³¹ As well as investors chasing higher yields as a result of the global macro-economic imbalances mentioned earlier.

model (FSA, 2009:16).³² These models resulted in risks being held on the balance-sheets of bank and bank-like institutions, owing to the multifaceted and less transparent nature of the models (FSA, 2009:16). An intricate series of various relationships between numerous institutions was created, each one performing a small part of the credit intermediation and maturity transformation process. Since these institutions had highly leveraged balance-sheets, each one required a small portion of capital to support their functioning (FSA, 2009:16).

The pursuit of higher profits, driven by the inexpensive and abundant availability of funds, may be responsible for this excessive risk-taking behaviour by financial institutions. The undisclosed risk holding by financial institutions may also have been the result of unregulated financial innovation that was made possible in an environment created by the prevalence of the new banking model. Ultimately, the subprime financial crisis has highlighted the desire of calculable risk and confirmed the reality of random uncertainty.

2.4.2 The new banking model

As mentioned, financial innovation was at the core of the new banking model. Traditionally banks were institutions that received deposits from economic surplus units and made loans to economic deficit units. Owing to a changing macro-economic environment and increased financial market sophistication, banks and financial institutions performing similar economic roles were on the lookout for alternative revenue streams. These institutions pursued these alternative revenue streams through the originate-to-distribute model and the acquire-and-arbitrage model. These alternative revenue streams were all aimed at generating fee-based income and increasing potential profit.

The Financial Services Authority (2008:16) identifies five important features in the new banking model that contributed to the credit boom. These features exacerbated the self-reinforcing character of the downswing, thus increasing systemic risk. The features include the growth of the financial sector, increased leverage, changing forms of maturity transformation, an over-reliance on sophisticated calculations, and intrinsic pro-cyclicality.

The growth of the financial sector: The internal activities of the banking system had grown faster than end services to the real economy, and the progression of the securitised credit

³² The process by which a financial institution acquires a loan after it has been transformed into a financial security through the process of securitisation. After acquiring this security, the financial institution intends to profit from any market inefficiencies (arbitrage) by exploiting the price differences of identical securities on different markets (Wuite, 2009:20). See example on pages 23 and 24.

model was accompanied by a high rate of growth of wholesale financial services (FSA, 2009:16). The growth of the financial sector relative to the overall economy, particularly in securitised credit, increased the potential impact of financial system instability on the general economy (FSA, 2009:18).³³

Increased leverage: From 2003, the measured on-balance-sheet leverage of many commercial and investment banks increased significantly (FSA, 2009:19). An increase in the leverage of the entire financial system was instrumental in driving the boom and creating vulnerabilities that increased the severity of the economic crisis (FSA, 2009:19). The number of off-balance-sheet vehicles, which were highly leveraged and not included in standard measures risk-adjusted leverage, grew rapidly during the boom years prior to the outbreak of the crisis (FSA, 2009:20). As the crisis grew, liquidity provision commitments and reputation concerns forced numerous banks to take the off-balance-sheet assets back onto their balance-sheets, which resulted in large one-off increases in measured leverage (FSA, 2009:20). Owing to their high and imperfectly understood entrenched leverage, structured credit products such as CDOs created trading positions that were extremely vulnerable to shifts in confidence and liquidity (FSA, 2009:20).

Changing forms of maturity transformation: An important function of the banking system is to hold assets with a longer term structure than the term structure of their liabilities, enabling the non-bank sector to hold assets for a shorter time than liabilities (FSA, 2009:21). The risks arising from uncertainties in the cash flows of households and the corporate sector are absorbed, and maturity transformation provides a more favourable structure of interest rates to long-term capital investment (FSA, 2009:21). In order to manage the risk of bank customers withdrawing their monies before their contractual dates, banks use an intricate and interconnected set of risk management tools. These tools include liquidity policies intended to limit the extent of maturity transformation, committed lines from other banks, and central bank facilities (FSA, 2009:21). However, large and inadequately appreciated risks were created by changes in the pattern of maturity transformation (FSA, 2009:21). In recent decades, aggregate maturity transformation has shifted from central bank-regulated banking books to other forms of “shadow banking” (FSA, 2009:21).³⁴ When banks and bank-like institutions attempted to liquidate their positions simultaneously during the outbreak of the crisis, a problem with the maturity transformation regime at the time became apparent. The over-reliance on the assumption that banks could hold long-term maturity assets funded by

³³ See also Bianco (2008:7).

³⁴ These include off-balance-sheet activities such as the creation of SPVs.

short-term liabilities, and sell the assets readily in liquid markets was exaggerated (FSA, 2009:21).

An over-reliance on sophisticated calculations:³⁵ The complex nature of the calculations used to measure and manage risk made it very difficult for top management and boards to assess and provide judgement on the risks being undertaken (FSA, 2009:22). Market participants were under the impression that complexity in the financial system had been met by the evolution of mathematically sophisticated and effective risk measuring and managing techniques (FSA, 2009:22).³⁶

Intrinsic pro-cyclicality: With credit intermediation becoming more securitised, the complexity of securitised credit relied on market practices that increased intrinsic pro-cyclicality in the financial system (FSA, 2009:22).³⁷ This created a situation in which the holders of credit assets became more reliant on credit ratings as a means to provide re-assurance (FSA, 2009:22). Once the crisis broke, however, the ratings became imperfect predictors of risk, as they were subject to rapid downgrades (FSA, 2009:22).

These five features of the new banking model (discussed above) operated in a persistent environment of strong global growth, low inflation and reduced macro-economic volatility that encouraged a cycle of falling risk aversion and rising irrational exuberance (FSA, 2009:25). By 2004, however, this new banking model came under pressure as the persistent low interest rate environment in the US was slowly being reversed (Bianco, 2008:5).³⁸ This situation made it difficult for many homeowners to refinance their mortgages after their loans were reset to higher repayment levels (Bianco, 2008:10). Residential mortgage foreclosures in the US increased by 93% in July 2007 and 115% in August 2007, compared with the respective months a year earlier (Bianco, 2008:14). This situation led to the unravelling of the credit boom, which began early in 2007 after house prices started to decrease and mortgage delinquencies and defaults increased (Bernanke, 2009:2). On 22 February 2007, HSBC dismissed the head of its US mortgage lending unit after the business realised losses of US\$10.8 billion (Soros, 2008:xx).

As the subprime mortgage crisis started to intensify, the equity of one of the largest subprime lenders in the US, New Century Financial, declined by 84% before the company

³⁵ For an elaboration on the “misplaced reliance on sophisticated maths”, see Box 1A in the “Tuner review” (FSA, 2009:23).

³⁶ See also Honohan (2008a:43) on how risk management techniques failed to keep up with an ever more complex financial market environment.

³⁷ See also Honohan, (2008b:16) and Bianco (2008:9) on pro-cyclicality in the financial system.

³⁸ Interest rates rose from 1 to 5.25% during this period (Bianco, 2008:5).

filed for Chapter 11 bankruptcy protection on 2 April 2007 (Bianco, 2008:13). On 15 June 2007, investment bank Bear Stearns announced that it had trouble meeting margin calls on two of its mortgage hedge funds (Soros, 2008:xx). Against this backdrop, the official outbreak of the financial crisis took place in August 2007 (Soros, 2008:xi).³⁹ As liquidity evaporated in the market owing to problems in the US subprime mortgage market, global credit markets came under intensified pressure after BNP Paribas suspended three of its investment funds worth €2 billion (Soros, 2008:xi). The French international bank was unable to value the assets under its investment funds, as a result of liquidity problems within financial markets (Soros, 2008:xi). In response to these market events, the European Central Bank (ECB) had to provide €95 billion to the euro zone banking market after short-term credit markets froze (Soros, 2008xi).⁴⁰

After recording losses on perceived safe assets, financial institutions cut back on their lending as investors began to pull out from a variety of credit markets (Bernanke, 2009:2). The shock on the banking system impaired the ability of banks to extend credit to the real economy (signalling a credit crunch), and played a central role in exacerbating the economic downturn (FSA, 2009:28). In Europe, the ECB continued to provide the financial system with liquidity. On 10 August 2007, the ECB provided an additional €61 billion and three days later a further €47.7 billion (Soros, 2008:xiv). Across the Atlantic, the US Federal Reserve responded by providing as much overnight funds as required to combat the credit crunch (Soros, 2008:xiv). Bear Stearns filed for Chapter 11 bankruptcy protection in March 2008 (BBC, 2008). This happened after its share price declined by 98% from US\$158 a year earlier, and resulted in the company being bought over for US\$2 a share by rival bank JP Morgan Chase (BBC, 2008). However, this situation was not confined to the US; Britain experienced its first bank run in a hundred years when Northern Rock customers swiftly withdrew their monies after losing confidence in the bank and financial system in general (Soros, 2008:xiv). After the crisis was triggered by defaults of low-grade subprime mortgages, a large number of weaknesses were rapidly revealed as the problems soon spread to CDOs (Soros, 2008:xxi). Investment banks were forced to bail out their SPVs as it became more difficult to value the off-balance-sheet CDOs when the market for asset-backed commercial paper became illiquid (Soros, 2008:xxi).

Owing to the speedy breakdown of securitised and structured products, banks lost their capacity to move risky assets off their balance-sheets, and were faced with funding and balance-sheet pressures (Geithner, 2008:2). During September 2008, the situation

³⁹ See BBC (2008) for subprime crisis time-line.

⁴⁰ This was the single largest market intervention since the aftermath of the 9/11 attacks on the US (BBC, 2008).

worsened as the failure or near-failure of numerous financial institutions that were deeply rooted in the subprime market caused global financial and credit markets to freeze (Bernanke, 2009:2).

The “unacceptable risk” to the economic system as a result of the potential failure of Fannie Mae and Freddie Mac⁴¹ resulted in a take-over by the US government on 7 September 2008 (BBC, 2008). The first bank failure was that of the fourth largest investment bank in the US, Lehman Brothers (BBC, 2008).⁴² The following day American Insurance Group was bailed out by the US Treasury owing to its large exposures to the CDS market (BBC, 2008). Markets became increasingly risk averse when Washington Mutual, with US\$307 billion in assets, represented the largest failure yet in the US (BBC, 2008).

The banking system was placed under enormous pressure by the failure of these and near failure of other financial institutions (Soros, 2008:xxii). Banks found it difficult to assess the exposure of their own balance sheets, and those of their counterparties, making them reluctant to lend to each other in fear that they might require future liquidity (Soros, 2008:xxii). A brisk and deep contraction in global economic activity was triggered by an unstable global financial system, declining equity values, and tight credit market conditions (Bernanke, 2009:2). The deep-rooted problems in the global financial system soon spread to the real economy as individual countries started to descend into economic recession.

In an attempt to stimulate private-sector borrowing and spending, central banks around the world initiated an aggressive monetary and fiscal policy strategy. The US Federal Open Market Committee (FOMC) reacted to initial signs of economic weakness in September 2007, and by the second quarter of 2008 interest rates were reduced from 5.25 to 2% (Bernanke, 2009:3). The financial crisis deepened because of the September 2008 events and the global economic outlook deteriorated further (Bernanke, 2009:3). By October 2008, the House of Representatives in the US approved a historic US\$700 billion government plan to rescue the US’s financial sector (BBC, 2008). In response to the ongoing economic recession in the US, the FOMC continued to reduce interest rates, and by December 2008 interest rates were set between zero and 0.25% (Bernanke, 2009:3).⁴³

⁴¹ Fannie Mae and Freddie Mac were responsible for nearly half of all outstanding mortgages in the US (BBC, 2008).

⁴² The failure of Lehman Brothers marked a significant shift in the confidence of financial market participants and accelerated negative sentiment towards all international financial markets (BBC, 2008).

⁴³ This was the lowest recorded interest rate level since 1954 (BBC, 2008).

Other countries and regions around the world made similar bold moves in a bid to fight off economic recession; the ECB, for example, reduced rates four times, from 4.25% in September 2008 to 2% by the beginning of 2009 (BBC, 2008). The US Federal Reserve took numerous steps to support the flow of credit, since the subprime crisis threatened to undermine this economic lifeline (Bernanke, 2009:3). It committed short-term credit to sound financial institutions and extended the term of loans to three months (Bernanke, 2009:3). In addition to lowering interest rates to record levels, the Federal Reserve also implemented target lending to free up credit markets outside the banking system, and introduced a system in which the interest rate paid depended on the level of demand from financial institutions (Bernanke, 2009:3). These strategies played an important role in easing tight conditions in financial markets, and increasing the willingness of banks to extend credit (Bernanke, 2009:3).

By the first quarter of 2009, the effect of the financial crisis was evident in the decline of general equity markets. During 2008, London's FTSE 100 closed down 31.3%, and the German DAX and French CAC 40 declined by 40.4 and 42.7%, respectively (BBC, 2008). Many markets around the world reported their worst declines since the 9/11 attacks (Bianco, 2008:19). Although these broad-based market declines were associated with a local housing market problem in the US, this soon transformed into a global financial crisis. Financial innovation acted as the catalyst to declining market confidence, a crippling credit crunch, and ultimately a global economic recessionary environment. A variety of consumer-sensitive industries and economic sectors, such as the motor car industry, were greatly affected by the ensuing global economic crisis (BBC, 2008).

During the first quarter of 2009, a number of quantitative easing strategies were introduced. Germany, Europe's largest economy, unveiled a US\$67 billion package to induce economic growth in the region (BBC, 2008). In the US, Congress passed a US\$787 billion economic stimulus plan (BBC, 2008). The main focus of this stimulus plan was on government spending and social programmes, and the remaining allocations of funds were channelled towards tax cuts (BBC, 2008). During the April 2009 G20 summit in London, the leaders of the world's largest economies introduced US\$1.1 trillion worth of measures to combat the global financial crisis, with the International Monetary Fund (IMF)⁴⁴ receiving US\$500 billion to lend to struggling economies (BBC, 2008).

⁴⁴ The core mission of the IMF is to promote global financial stability.

Despite the responsive measures implemented by numerous governments and regulatory bodies, it appears that financial market participants and financial authorities have been slow to recognise the effects of the subprime crisis on the real economy (Soros, 2008:xxiv) in that they continue to misjudge risk and pursue profits regardless of the risk. The foundations the current financial system is based upon may shed some light on this misconception. The new financial architecture represents these foundations and may demonstrate the fundamental flaws inherent in the functioning of the modern-day financial system, one that is exemplified by a misconception of risk and a quest for maximising profits at all costs.

2.4.3 The new financial architecture

The “new financial architecture” (NFA) is a term that refers to the institutions and practices of today’s lightly regulated financial system (Crotty & Epstein, 2008:3). The subprime financial crisis appears to be the latest chapter in the radical advancement of financial markets, which began during the deregulation process that began in the late 1970s. The advancement of financial markets follows a sequence of events in which deregulation is accompanied by rapid financial innovation, which in turn creates powerful financial booms that end in crises (Crotty & Epstein, 2008). After the occurrence of a crisis, governments respond with bailouts that ultimately fuel the start of new expansions (Crotty & Epstein, 2008:2). Financial markets become larger, less transparent, more complex, and highly leveraged after every bailout (Crotty & Epstein, 2008:7).

Despite this self-destructive evolution, every crisis results in the creation of plans for an NFA, but as the crisis ends, these ideas quickly fade away (Persaud, 2000:233). After the shockwave of emerging-market financial crises during the 1990s in Mexico, East Asia, Russia, Brazil, Turkey and Argentina, it was clear that fundamental reforms were required in the international financial system. In order to strengthen the operation of the global financial system and prevent future crises from occurring, a series of initiatives were launched and these were termed the new international financial architecture (De Beer, 2002:1). Some initiatives under the new international financial architecture highlighted by De Beer (2002:1) are transparency and accountability, the strengthening of financial systems, the detection and monitoring of external vulnerability and private-sector involvement in forecasting and resolving crises. However, the quest for greater international financial stability and the prevention of future systematic risk has demonstrated that the international financial markets themselves may be an important source of financial instability (De Beer, 2002:1).

2.4.3.1 Structural flaws

Crotty and Epstein (2008) identified several structural flaws within the NFA that aided the creation of the subprime crisis. The contention of the neo-classical financial system⁴⁵ led to support for light regulation of commercial and investment banks, as well as very limited regulation of the shadow banking system.⁴⁶ At the root of the NFA lies the assumption that buyers and sellers of financial instruments can make the most advantageous decisions regarding risk. Risk can be transferred only to those individuals who are able to effectively manage the risk, thereby minimising the possibility of financial crises and need for bailouts by government (Crotty & Epstein, 2008:3). The “scientific” foundation of the NFA appears to be weak and its assumptions unrealistic (Crotty & Epstein, 2008:4). Instead of concentrating risk around banks such as in the golden age financial system of the 1950s and 1960s, the integration and globalisation of financial markets across borders has allowed risk to be distributed amongst investors around the world who felt secure with managing their own risk exposure. It was believed that under the NFA system, where markets priced risk accurately, systematic risk would be minimised since investors would have sufficient information to shield themselves from holding unwarranted risk. However, structured financial instruments reconcentrated risk around the world in extremely complex ways. Through securitisation and capital markets around the world acting as the main source of funding, the financial link between the US and the rest of the world became more intertwined as trouble in the US’s subprime mortgage market spread throughout the global economic system (Crotty & Epstein, 2008:5).

Since banks sold loans on to capital markets, according to their originate-to-distribute model, and hedged any remaining risk exposure through CDSs, they were no longer perceived as risky. However, the value of CDSs in 2008 was ten times larger than the available insured debt. This risk-taking behaviour may be attributed to the asymmetric reward structures that were in place. Fundamental personnel in commercial and investment banks, the shadow banking system, insurance companies, and mutual and pension funds were encouraged to take excessive risks. Banks too earned large fees with their originate-to-distribute model, regardless of whether these mortgages defaulted (Crotty & Epstein, 2008:4).

The claim that capital markets price risk optimally does not apply to all securities. The role of financial innovation in the creation of the subprime financial crisis, particularly in the form of structured financial instruments such as mortgage-backed securities and CDOs, has already

⁴⁵ A system in which capital markets price financial instruments accurately according to their risk and return profile (Crotty & Epstein, 2008:2).

⁴⁶ This includes hedge funds, private equity funds and special investment vehicles.

been explained. Since these securities have morphed into such complex instruments, they have become inherently non-transparent. For example, 80% of all derivatives are sold in over the counter (OTC) deals negotiated between an investment bank and a few customers (Crotty & Epstein, 2008:4). The prices of these instruments are determined by investment banks and rating agencies by using statistical models that are easy to manipulate, and these instruments were known to be priced or marked-to-market based on magic or myth (Crotty & Epstein, 2008:5). Liquidity problems have also played a significant role in the subprime crisis and the inherently illiquid OTC instruments were at the root of the problem, as the value of these products plummeted owing to investors and originators having no idea what these instruments were worth (Crotty & Epstein, 2008:5).

This non-transparency may be due to the NFA operating in a very ineffective and only lightly regulatory environment (Crotty & Epstein, 2008:5). The NFA system allowed banks to transfer and hold risky assets by marking them as off-balance-sheet items, thereby reducing their regulatory capital requirements because banks were not required to hold capital to support these off-balance-sheet items. This induced banks to transfer as many of their assets as possible off their balance-sheets (Crotty & Epstein, 2008:4). The result of this behaviour is that neither insiders nor outsiders can accurately evaluate risk, as financial conglomerates are allowed free reign and become large and complex institutions.

The breakdown of the global financial and economic system, as well as the subsequent policy responses implemented and proposed during the outbreak of the subprime financial crisis, has undoubtedly changed the landscape of the NFA. This situation is confirmed through the weakening of and government involvement in investment banks and bank holding companies (Economics of Crisis, 2008:1). At the heart of the changes to the NFA, the focus appears to be on changing the institutional and regulatory structure and increasing government ownership, particularly in the US (Economics of Crisis, 2008:1). The responses by policymakers, done regardless of objections by free-market supporters to increased government participation in the economy, appear to have been the only way to prevent the crisis from deepening even further.

During the rise of the crisis there appears to have been evidence of systematic flaws, particularly in regulation and risk assessment (Economics of Crisis, 2008:1).⁴⁷ However, the focus on strengthening the international financial landscape should not be on changing the rules of the game, but rather on enhancing the players' risk standards and transparent

⁴⁷ See also Crotty and Epstein (2008).

policies (Persuad, 2000:235). The shape of the improved NFA towards a more interventionist or free-roaming system may be a highly contested future topic of debate.

2.4.4 Revelations of the subprime financial crisis

The sentiment shared amongst market participants regarding the role of banks and “moral hazard” in the subprime financial crisis has resulted in a quest to identify responsibility. Since the outbreak of the subprime crisis, market analysts, investors, and academics have sought to determine who is to blame for the crisis. Blame is placed on policymakers, company directors, credit rating agencies, auditors, and greedy investors (Hodge, 2009:28). Despite the interactions and effects that all these participants have on financial markets, banking crises can be compared to viruses, in that they display minute but fundamental transformations on each return (Honohan, 2008a:3). Although every financial crisis is distinctively individual in nature, there appear to be various similarities such as a boom in asset prices, debt accumulation, current account deficits and a lack of risk management (Reinhart & Rogoff, 2008:11).

The subprime financial crisis has once again uncovered a need for risk management and prudential regulation that is less dependent on mechanical risk management models, and instead re-establishes a more flexible and holistic risk management approach (Honohan, 2008b:1). The subprime crisis has highlighted the over-reliance of banks on risk management models and access to readily available liquidity (Honohan, 2008a). The increase of credit standards by banks resulted in broad-based credit contraction and acted as a catalyst for economic recession around the world (Honohan, 2008a). It appears that current risk management and oversight places too much emphasis on idiosyncratic risk that affects an individual company, instead of focusing on systematic factors that could affect the liquidity of the entire market system (Geithner, 2008:5).

After the 1980s savings and loans crisis in the US, the Asian financial crisis and subsequent Russian crisis of 1997/1998, a wave of new risk management policies was introduced and adopted by financial institutions across developed and emerging countries (Honohan, 2008b:2).⁴⁸ Despite policymakers’ best efforts, the rapid increase in the sophistication of the financial market outstripped the pace at which risk management policies evolved (Geithner, 2008:8). With the new banking model environment and practices such as the originate-to-distribute banking model and the use of SPVs to move assets off-balance-sheets, banks

⁴⁸ Examples include the introduction of sophisticated risk management tools under Basel II, and the preparation of regular financial stability reports by financial authorities, such as the IMF.

found a means to escape regulatory capital requirements based on mechanical rules (Honohan, 2008b:3).

The very aim of regulatory capital was undone when financial innovation became a source of systematic risk, as mechanical risk management models allocated inadequate risk capital to hedge against the leveraged risks of structured products used by financial institutions (Honohan, 2008b:6).⁴⁹ The limitations of the current risk management rules have to be recognised, and a risk management process with greater discretion and judgment has to be introduced (Honohan, 2008a:9). This comes in response to the immature reliance on the precision of risk management models, which results in a by-pass of common-sense precautions (Honohan, 2008a:31).

Despite the design of the regulatory framework, financial systems will always be plagued by crises (Geithner, 2008:6). In moving sophisticated risk management processes forward, there seems to be a unified response to the important objectives of the future transformation of the regulatory framework. These are to reduce financial system vulnerability and the need for government interference (Geithner, 2008:7).

2.5 The theories of crisis transmission

The vulnerability of the financial system has undoubtedly been affected by the integration of the global economic system. The strengthening of financial and trade linkages between countries through increased globalisation has resulted in fundamental economic factors being transmitted more rapidly (Chan-Lau *et al.*, 2004:390). This situation has led to an increase of price co-movements and contagion between countries (Chan-Lau *et al.*, 2004:390).

Contagion effects have resulted in local financial markets and economies becoming much more vulnerable to volatility in international financial and economic markets (Khalid & Rajaguru, 2005:8). The correlation between equity markets during periods of financial stability signals interdependence between markets (Daly, 2003:74), while correlation during periods of financial turmoil signals contagion (Bongiglioli & Favero, 2005:1300). Thus, contagion implies that a collapse in one market produces a fall in another market (Gonzalo & Olmo, 2005:5). Interdependence on the other hand, implies that there is a fall in both markets due to the markets being influenced by the same macro-economic factors (Gonzalo & Olmo, 2005:5). In essence then, interdependence implies that there are no significant

⁴⁹ See Honohan (2008b:18) for an example of how vulnerable mechanical risk management tools can be.

changes in cross-market linkages after a financial crisis, while contagion implies a fundamental increase in cross-market linkages after a shock (Daly, 2003:75).

A distinction can be made between contagious and non-contagious crises (Boshoff, 2006:62). As mentioned in Chapter 1, a contagious crisis is an event in a particular country that has a significant and immediate impact on markets in other countries, and a non-contagious crisis is a crisis to which initial outside market reaction is slow and limited, but the impact may be large in the longer term (Kaminsky *et al.*, 2003:2).

As observed in Chapter 1, preliminary research has indicated that there are numerous theories on the channels of crisis transmission. Boshoff (2006:63) organises the numerous transmission channels noted in the literature (some of which were mentioned in Chapter 1)⁵⁰ into three categories. These are theories on *trade linkages*, *financial linkages* and *linkages based on investor behaviour*. The theories of crisis transmission seek to determine the reason that a crisis in one country can affect markets of different sizes and structures around the world.

2.5.1 Trade linkages

The first category of theories concerns trade linkages. Direct real linkages, such as trade in goods and services between different countries, are the easiest way for a shock in one country to be transmitted to others (Pritsker, 2000:8). Financial markets may be related if real linkages exist between countries (Pritsker, 2000:10). This will certainly be the case when asset values are determined by common macro-economic factors (Pritsker, 2000:10). These trading partners may be negatively affected through losses in competitiveness⁵¹ and a decline in demand⁵² from countries experiencing a financial crisis (Van Rijckeghem & Weder, 1999:4). Local demand for imported goods may decline significantly during a domestic financial crisis, which in turn may affect the export performance of the trading partners of the crisis country (Boshoff, 2006:64).

2.5.2 Financial linkages

The second category of theories that seek to explain the transmission of a crisis concerns the linkages created through financial markets. Global financial integration has allowed local financial institutions to invest and intermediate in international financial markets, and as a result has created an additional mechanism by which a financial crisis can be spread from

⁵⁰ See Kaminsky *et al.*, (2003:4) and Forbes (2000:3) on the different categories of crisis transmission channels.

⁵¹ Forbes (2000:4) denotes this as a product competitiveness transmission channel, in which one country gains a competitive advantage when its exports become cheaper than that of its competitors, by devaluing its currency.

⁵² A decline in demand is also referred to as, an income effect (Forbes, 2000:4).

one country to another (Sbracia & Zaghini, 2001:2). In the run-up to the Asian financial crisis, international bank lending in Asian countries grew at a rate of US\$40 billion per year between 1994 and 1997 (Kaminsky *et al.*, 2003:19). This transmission mechanism can be particularly effective when a financial institution's exposure in a crisis country is large, and losses require the readjustment of capital asset ratios and risk exposure (Sbracia & Zaghini, 2001:5).⁵³ Financial linkages may also be effective when the financial institution in question is an important source of credit in the country in which it operates (Sbracia & Zaghini, 2001:5). Finally, limited access to other liquid sources of funding in distressed economies, may explain the success of financial linkages as a transmission mechanism (Sbracia & Zaghini, 2001:5). There are several channels through which financial institutions can transmit a financial crisis between the countries in which they operate.

The first channel is *lending activities*. Since cross-border integration between banks is a common feature of modern finance, a universal lender may end up being the main supplier of funds for numerous countries (Sbracia & Zaghini, 2001:4) – this lender is referred to as a “common-bank lender”. When a financial institution has been lending funds to companies in a crisis country that financial institution may realise a rise in the value of its non-performing loans. This situation may weaken the value-at-risk position of this financial institution, and force capital withdrawals from its operation abroad in order to meet capital adequacy requirements (Sbracia & Zaghini, 2001:3). The financial institution may also be required to meet margin calls and possibly rebalance its portfolios in the specific crisis country (Van Rijckeghem & Weder, 1999:3).⁵⁴ This strategy of decreasing risk exposure in the crisis country can lead to abrupt reductions of credit lines in non-crisis economies and put productive sectors in the non-crisis countries under economic pressure (Sbracia & Zaghini, 2001:4). Similarly, a credit crunch can also be created in a non-crisis country, should the value of borrowers' collateral (such as equity or investment grade bonds) depreciate after a financial crisis (Forbes, 2000:5). Banks operating in numerous jurisdictions may be forced to reduce their amount of outstanding loans in non-crisis countries as a response to the inability of borrowers in the crisis economy to restore the value of their collateral (Sbracia & Zaghini, 2001:5).

The importance of a common-bank lender in the transmission of contagion between countries is observed by Van Rijckeghem and Weder (1999:3), who note that banks were

⁵³ See also Van Rijckeghem and Weder (1999:6) on financial linkages.

⁵⁴ See also Pritsker (2000:9) on how financial institutions are affected by margin calls.

the single largest group of creditors before the Asian financial crisis.⁵⁵ The most volatile component of capital flows during this crisis was centred on bank lending activities (Van Rijckeghem & Weder, 1999:3). After the Asian financial crisis, the capital exposure of international banks, as a result of the crisis, ranged between 20% and 30% for banks from Germany, UK, France and the US (Van Rijckeghem & Weder, 1999:6). The capital exposure of Japanese banks was as high as 70% (Van Rijckeghem & Weder, 1999:6).

The second channel through which financial institutions can transmit a financial crisis between the countries in which they operate is *intermediation*, which is closely related to the first channel (lending activities). Large capital flows were another important feature of the Asian financial crisis and, as mentioned in Section 2.4.1, contributed to the subprime financial crisis. The intermediation activities of banks between foreign investors and domestic ventures result in greater capital inflows, but may also lead to sudden capital withdrawals, since foreign investors are attracted by the short-term maturity assets offered to them by the banking system (Sbracia & Zaghini, 2001:8). The intermediation activities of banks contribute to contagion, as economic shocks are amplified and transmitted to the rest of the economy when risk averse foreign investors withdraw their short-term maturity assets in response to the economic shock experienced by the domestic economy (Sbracia & Zaghini, 2001:8).

Liquidity is another channel of crisis transmission. As emphasised in the section on the subprime financial crisis (Section 2.4), liquidity is a very important factor of the functioning of international financial markets. International and domestic interbank markets allow for efficient financial management by, for example, providing liquidity support to troubled institutions facing individual liquidity problems and reducing the opportunity costs of maintaining liquid reserves (Sbracia & Zaghini, 2001:9). However, as seen with the subprime crisis, the international and domestic interbank market can amplify the weakness of the banking system⁵⁶ during a financial crisis. This is because liquidity shortages of the whole financial sector cannot be met when the entire banking system faces a liquidity squeeze (Sbracia & Zaghini, 2001:9). Through illiquid investments, international interbank linkages can increase the possibility of a co-ordinated failure of the financial system, despite banks being solvent (Sbracia & Zaghini, 2001:9).

⁵⁵ In their investigation of the common-bank lender channel as a means of contagion, Kaminsky and Reinhart (1999) found that in emerging markets the financial transmission mechanism is significantly more important than international trade linkages.

⁵⁶ Indeed a key feature of the subprime crisis was the amplification of this situation throughout the entire international financial system.

Finally, crisis transmission can take place through the *underlying financial instruments* used within international financial markets. The popular use of complex financial instruments and processes, such as sovereign default swaps, hedge fund arbitrage strategies, and securitisation has become an increasingly important financial linkage. Although the creation of complex financial instruments is testimony to the progress of modern finance and its aim to increase efficiency in all financial spheres, the abuse of these complex financial instruments can increase the exposure and vulnerability of financial market participants to different global markets (Chan-Lau *et al.*, 2004:390). Most OTC markets in which these complex financial instruments are traded are characterised by a small number of dealer companies, usually consisting of banks or investment banks. As has been demonstrated by the subprime financial crisis, these highly concentrated markets act as a mechanism through which problems⁵⁷ affecting dealer companies are propagated to the underlying OTC markets, since the same dealer companies operate in both markets (Pritsker, 2000:18).

2.5.3 Linkages based on investor behaviour

The third category of theories is concerned with *changes in investor expectations or sentiments*. Investor's portfolio decisions (as opposed to country characteristics) may help to explain contagion in some instances (Van Rijckeghem & Weder, 1999:3). In response to economic shocks, some investors may be inclined to readjust their hedging strategies in order to protect themselves against changing macro-economic risks. This transmission channel can be referred to as *cross-market hedging*, since an economic shock can be transmitted between countries who do not share common macro-economic risk factors with one another, but share risk factors with a third country (Pritsker, 2000:12).⁵⁸

Similar to financial institutions, individual investors may find it necessary to rebalance their portfolios after experiencing a wealth shock. As investors' risk perceptions change⁵⁹ owing to diminishing wealth, they may become more risk averse and move their portfolios towards less risky assets (Pritsker, 2000:12). After experiencing adverse price movements, leveraged investors may be required to honour margin calls from clearing-houses, and thus be forced to liquidate their asset holdings (Boshoff, 2006:65).⁶⁰ When numerous investors follow this trend, a situation similar to a correlated liquidity shock may be created (Pritsker, 2000:12). Owing to information asymmetries, market participants may not be able to

⁵⁷ Such as liquidity shortages originating in the mortgage market where the same institutions are actively involved.

⁵⁸ A related transmission channel mentioned by Pritsker (2000:12) is contagion due to wealth shocks.

⁵⁹ Forbes (2000:6) refers to this condition as a "wake-up call effect", which involves investors re-evaluating a country's macro-economic fundamentals after the occurrence of a crisis.

⁶⁰ Forbes (2000:5) refers to this situation as a "forced-portfolio recomposition".

distinguish between a crisis country and non-crisis country (Boshoff, 2006:65). This creates a situation in which asset prices in non-crisis countries face downward pressure from a sell-off in perceived risky assets, propagating the initial crisis across markets (Boshoff, 2006:65).

As seen during the build-up of the dotcom bubble, the relationship between the real values of companies can be blurred by investors' feelings on the equity of these companies. This irrational exuberance and similar herding behaviour⁶¹ amongst individual investors may be a source of contagion, as capital flows and financial markets are influenced by mass behaviour that aggravates boom periods and market busts (Kaminsky *et al.*, 2003:4).

The economic literature on contagion focuses mainly on the analyses of the manner in which first moment changes in key variables are transmitted between countries (Edwards, 2000:10). However, Edwards (2000:10) notes that the transmission of changes in second moments, that is, volatility, between countries is of equal importance, since financial volatility influences a variety of economic decisions, such as investment strategies and the pricing of risk. It is thus important to establish whether changes in a volatility system are independent between countries, or whether these changes are the result of the transmission of international financial crises (Edwards, 2000:10). The coming chapters will focus on volatility and its effects on the South African equity market during periods of financial crisis.

2.6 Conclusion

Dramatic changes have occurred in capital markets owing to the forces driving globalisation. The liberalisation of national economies and financial markets created a situation of increased international capital mobility and a greater opportunity for portfolio diversification. However, it can be concluded from the literature review above that globalisation also facilitated increased integration of financial risk between global markets. A central feature of this integration appears to emanate from the underlying market structure that facilitated financial market practices and excesses.

These excesses appear to be a reoccurring phenomenon before the occurrence of each crisis covered within this chapter. A variety of different but interacting market distortions acted as detonators to the bubbles preceding each crisis. Furthermore, it appears that the effects on the global economic environment vary according to the underlying nature of each crisis. The impacts of the Asian financial crisis on investor sentiment towards emerging

⁶¹ Herding behaviour represents a situation where individual investors scrutinise what others ahead of them are doing, and then follow the behaviour of the foregoing investors, even though his or her private information recommends doing something different; amongst investors (Kaminsky *et al.*, 2003:5)

markets, and the far reaching effect of the subprime crisis due to its negative effect on the most influential global economies, are examples of this. The reach and economic recovery after each crisis appears to be evolving as the modern financial world becomes more interconnected. Ultimately, financial market practitioners are undoubtedly aware that no reward can be achieved without risk. However, there appears to be a need for financial market regulators to take into account the complexity of linkages and interactions within the modern financial market system. Together with financial market stability, the importance of successfully managing this risk has repeatedly been highlighted. Finally, although the level of volatility can be quantified within a particular market, there are numerous qualitative factors that interact between financial markets and ultimately drive volatility transmission. Trade, finance and investor behaviour are all elements that propagate volatility between various markets. The individual effects of these factors on volatility transmission are difficult to quantify, but their collective influence should not be underestimated.

In order to successfully manage risk one first needs to identify and measure the underlying risk. Chapter 3 will explain volatility as a measure of risk and the various techniques available to measure volatility.

Chapter 3

Volatility

Financial market volatility is a “live” subject and has many facets driven by political events, macro-economy, and investors’ behaviour

Poon (2005:2).

3.1 Introduction

Financial stability is greatly affected by volatility, and during an international financial crisis, financial stability is of paramount importance not only in the crisis country, but also in countries that have trade relations with the crisis country concerned. Daly (2008:2378) provides several reasons why volatility is a fundamentally important concept in finance. Firstly, investors may lose confidence in capital markets when sharp asset price fluctuations cannot be explained by fundamental economic factors. This situation may result in a reduction of capital flows to equity markets. The effects of financial market volatility through crises, highlighted in Chapter 2, point towards the relation between financial market uncertainty and public confidence.⁶² Secondly, the volatility of a company’s capital structure may provide important information on the probability of default for individual companies. Thirdly, equity market liquidity can be greatly affected by the volatility of equity prices, since volatility is an important element in determining the bid–ask spread of an equity’s price. If the volatility of an individual equity increases, it is more likely that the market maker will increase the spread between the bid and offer prices of that equity. Fourthly, there is a positive relation between volatility and the cost of hedging techniques, such as portfolio insurance. Fifthly, if consumers are naturally risk averse, as proposed by economic and finance theory,⁶³ perceived higher levels of financial market volatility or substantial changes in the volatility of financial market returns may reduce the level of investment participation by consumers. These changes may also influence consumption patterns, leverage decisions, corporate capital investment decisions and macro-economic variables. Finally, a persistent volatile environment may hamper the allocation efficiency of capital, owing to regulatory requirements forcing companies to allocate a larger percentage of capital to cash or equivalent investments as a risk management buffer against the unpredictability inherent in markets.

Given the influence of volatility on financial market stability, it is important to highlight the concepts surrounding volatility. This chapter will commence with an explanation of volatility, specifically with regard to the nature of volatility, the link between volatility and risk in

⁶² See also Yang (2008:4) on this relation.

⁶³ The CAPM proposed by Sharpe (1970:95) for example.

financial markets and the measurement of volatility. Following this introduction to volatility, it will consider interactions between volatility, the general economy and equity prices in Section 3.3. The chapter will then present the model used to measure the degree of volatility transmission in this study in Section 3.4.

3.2 Volatility

Volatility can be described as something that is changeable or varies such as the price or returns of equity over time (Daly, 2008:2378).⁶⁴ Large fluctuations or change over time increases the volatility of the underlying variable. In finance, volatility refers to the variability of returns on an asset (Wuite, 2009:401), that is, the distribution of the rates of return around the average rate of return. Volatility is often associated with unpredictability, uncertainty and risk. Volatility is often perceived by non-market participants as an indicator of market disruption, resulting in financial instruments being unfairly priced and capital markets not functioning properly. For financial market participants, volatility is crucial and is considered in terms of unpredictability and used to describe deviation from an expected value or price (Daly, 2008:2378).

There are a number of variables that can affect the price of an asset as indicated in equation 3.1. In equation 3.1, the price of an asset can be presented by p_t : the present value of expected future cash flows, computed with the appropriate discount factor (BIS, 2006:12):

$$\rho_t = E_t = E_t \sum_{i=1}^T \frac{d_{t+i}}{\prod_{j=1}^i (1+r_{t+j})(1+\pi_{t+j}) + p_{t+i}}, \quad (3.1)$$

where:

d_{t+i} is the nominal payoff of the asset at time $t + i$;

r_{t+j} is the one-year real interest rate;

π_{t+j} is inflation rate;

p_{t+i} is the risk premium at $t + i$;

T represents the maturity date; and

E is the expected value operator.

⁶⁴ See also Yang (2008:2) for a definition of volatility.

Equation 3.1 summarises the variables that influence the price of an asset, and consequently the volatility of an asset (BIS, 2006:12). Ultimately, volatility originates from the discount rate (i.e. bottom part of equation 3.1) and uncertainty over future cash flows (i.e. top part of equation 3.1) (BIS, 2006:12).

Asset price volatility is an unavoidable feature of financial markets. This feature is not necessarily an unwelcome one. It reflects the process of risk pricing and risk transfer according to changing underlying market conditions. This process avoids the misallocation of financial resources due to changing underlying market conditions such as policy changes or even shocks to the financial system. Volatility can however lead to financial market instability, which can impose real costs on the financial system, as seen in the discussion of the financial crises discussed in Chapter 2. The greatest danger to financial market stability does not emanate from sustained high levels of volatility, but rather from sudden increases in volatility (IMF, 2003:62).

These sudden increases in volatility can cause instability in financial markets. Financial instability can be defined as periods of severe market disruptions (IMF, 2003:62). These disruptions have the ability to cause a reduction in real activity through inefficient pricing and transferring of risks, as well as the allocation of liquidity. This definition of financial instability aligns directly with a common definition of systemic risk: the risk of an entire system failing, such as the banking sector (Wuite, 2009:375). As explained in Chapter 1, systemic risk is that element of risk in a security that cannot be diversified away and that influences the entire market (Marx, 2006:34). Such risk can change over time when the macro-economic variables that affect the valuation of all risky assets change (Reilly & Brown, 2003:244). Systemic risk can ultimately lead to instability within the financial system. Financial system instability can in turn lead to the distress of overall liquidity and the functioning of the financial system infrastructure (IMF, 2003:62). Indeed, financial system instability is frequently tied to the failure of important financial institutions (IMF, 2003:62).

Although periods of financial instability are frequently accompanied by higher levels of volatility, market volatility does not necessarily entail financial instability. However, once tail events⁶⁵ occur, volatility becomes a concern as the financial system is placed under strain. The extent to which shocks to the financial system are transmitted across markets is a vital component of financial system instability (IMF, 2003:63). There are a number of factors that

⁶⁵ Tail events occur when the distribution of a time series has a kurtosis larger than three (Yang, 2008:6). High kurtosis implies that more of the variance is due to infrequent extreme deviations as opposed to more frequent modest deviations (Wuite, 2009:224).

can transform volatility, as an innate aspect of a well-functioning financial system, into instability (IMF, 2003:63).

These factors include incentive structures, lack of robust risk management and lack of transparency. The first factor is *incentive structures*. Widely used performance measures such as index tracking,⁶⁶ may encourage herding behaviour amongst institutional investors that can greatly influence price movements. Reward structures based on volume of business rather than risk-adjusted return, for example, can lead to miscalculated long-term risk and the reckless use of leverage.⁶⁷ Higher levels of leverage can magnify a sudden change in the sentiment of the herd, leading to instability as risk pricing becomes difficult (IMF, 2003: 63-64).

The second factor, *lack of robust risk management*, is an important one in the context of minimising the occurrence of future international financial crises. The sensitivity of the financial system to economic downturns and asset price declines is increased through leverage. Extreme price movements together with a sudden appreciation of market and credit risk could result in heavy financial losses and interfere with market efficiency. Sources of unappreciated risk may emanate from exceptional events or changes to a particular regime,⁶⁸ from which the eventual effect may not have been factored into risk measurement models (IMF, 2003:64). Risk management is greatly affected by transparency, as seen in the analysis of international financial crises in Chapter 2.

The third factor that can transform volatility into financial instability is a *lack of transparency*. A lack of transparency or disclosure by individual companies during periods of financial market instability can complicate the risk management process. Insufficient disclosure about the true level of positions or financial conditions can result in sudden changes in market sentiment and extreme price reaction, if large exposures or weaknesses about entities become known. Uncertainty in financial markets regarding the solvency of individual entities affected by common characteristics may impair the distribution of credit and the operation of the payment system (IMF, 2003:64).⁶⁹

These periods of financial stress are usually characterised by extreme financial asset price volatility, but may also be a feature during other times. Market innovation or structural

⁶⁶ Index tracking compares the performances of institutional investors to the performance of the market index (IMF, 2003:63).

⁶⁷ See also BIS (2006:16) on the reckless use of leverage.

⁶⁸ The currency devaluations experienced during the Asian financial crisis are a good example.

⁶⁹ As mentioned in Chapter 2, this situation occurred in the aftermath of the subprime crisis and in light of the current European debt crisis has spread from individual entities to sovereign states.

changes, such as deregulation, can lead to financial bubbles. During the early formation of a bubble, new business opportunities can attract a sudden increase in financial market risk appetite, and lead to increased leverage through either direct borrowing or the use of derivatives. Excessive risk-taking is encouraged by unrealistic expectations about future financial returns, a belief in a fixed market environment and ultimately unsound risk management techniques. The occurrence of an extreme event, which may be the proximate cause but not necessarily the underlying cause of the bubble, may force market participants to re-evaluate their positions and results in the unwinding of financial positions. However, the orderly unwinding of these financial positions by market participants may be hampered due to a rapid decline in risk appetite during a crisis situation, difficulty in estimating the true value of assets, and uncertainties about exposure to counterparties. Asset price volatility is especially high during and after a crisis, which makes the orderly unwinding of positions even more difficult (IMF, 2003:74-75).

It is clear from the discussion above that volatility is a natural part of any financial market. From a financial market participant's view, volatility is not always a negative feature of financial markets because it allows market participants to exploit certain market opportunities. However, a sudden increase in volatility can be disruptive to the efficient functioning of financial markets and result in financial market instability. In order to determine the impact of volatility on a specific market, it is crucial to measure volatility accurately. The next section will explain the measurement of volatility.

3.2.1 Volatility measurement

The techniques used to measure volatility are grouped into time-invariant measures (based on the assumption that volatility is constant over time) and time-variant measures (based on the assumption that volatility changes over time; Daly, 2008:2377). This section will briefly provide some background on the time-invariant measures of volatility, while a more detailed explanation on the time-variant measurements of volatility will be presented in Section 3.4.

The square root of variance is the benchmark definition of time-variant volatility (Sinclair, 2008:16). Variance s^2 can be defined by the following equation (Sinclair, 2008:16):

$$s^2 = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2, \quad (3.2)$$

where:

x_i are the logarithmic return;

$\bar{x}$ is the mean return in the sample; and
 N is the sample size.

Because volatility is an unobserved quantity that can only be estimated, the measurements of volatility are distorted reflections of the true volatility (Sinclair, 2008:21). There are a number of estimators available to measure or estimate historical volatility. Examples include the Parkinson estimator, Garman–Klass estimator, Rogers–Satchell estimator and Yang–Zhang estimator (Sinclair, 2008:26). The most common and basic method for measuring volatility is through the sample standard deviation (Poon, 2005:1). The sample standard deviation is given as follows (Poon, 2005:1):

$$\hat{\sigma} = \sqrt{\frac{1}{T-1} \sum_{t=1}^T (r_t - \mu)^2}, \quad (3.3)$$

where:

r_t is the return on day t ; and

μ is the mean return over the T -day period.

The standard deviation measures the dispersion of returns and it summarises the probability of extreme values of return (Daly, 2008:2380). Thus, a large sample standard deviation implies that a large positive or negative return may occur in future (Daly, 2008:2380).

3.2.2 Volatility as a measure of risk

Volatility is associated with but not necessarily the same as risk (Poon, 2005:1). Volatility is a measure of uncertainty, which could be due to a positive outcome, but risk is necessarily related to an undesirable outcome (Poon, 2005:1). The trade-off between risk and expected return is the core upon which modern finance theory, such as the CAPM, arbitrage pricing theory and portfolio theory, is based. In modern option pricing theory, such as the Black–Scholes model, volatility is paramount in determining the fair value of an option, but is the only variable that is not directly observable (Daly, 2008:2378).

Unlike beta, volatility (most commonly measured by standard deviation) is not a good measure of risk, since it only measures the spread of a distribution, but does not provide information about its shape (Poon, 2005:2). Although volatility is not a good measure of risk,

it is an imperative input in many important finance applications such as portfolio construction, option pricing, hedging and risk management (Poon, 2005:2).

There are a number of historical volatility models, for example the well-known Risk-Metrics equally weighted moving average (EWMA) model of JP Morgan (Poon, 2005:31). The EWMA applies weighting factors that decrease exponentially, thus more importance is given to recent observations but older observations are not abandoned entirely (Yang, 2008:6). The EWMA model is given by equation 3.4 (Yang, 2008:7):

$$\sigma_n^2 = \lambda \sigma_{n-1}^2 + (1 - \lambda) u_{n-1}^2, \quad (3.4)$$

where:

$$0 < \lambda < 1;$$

σ_n is the volatility on day n ; and

u_i is the daily return for a specific day.

Historical volatility models such as the EWMA model do not separate volatility from volatility shocks and some of the models do not incorporate volatility mean reversion (Poon, 2005:44). In financial or economic data, high volatility is likely to be followed by periods of lower volatility while low volatility is likely to be followed by periods of higher volatility. In the EWMA forecast, this feature of financial data is ignored, since the forecast variance for tomorrow is the same as the forecast variance for the day after and all the days after that (Sinclair, 2008:34). The GARCH model that will be presented in Section 3.4 addresses this feature of financial data by adding a long-term average variance that represents the level to which variance will revert. Thus, if the current variance is high, the expectation may be for it to remain high, but to revert ultimately to familiar levels (Sinclair, 2008:34).

The prediction of volatility has an important implication for risk averse investors, as they can alter their portfolio exposures according to the predicted increase in asset volatility (risk) (Daly, 2008:2381). When predicting or measuring volatility, time series statistics are used because this allows one to determine whether new information is more important than older information and to determine the speed of information decay (Daly, 2008:2381). Furthermore, when using the appropriate model such as an E-GARCH model, time series data allows one to establish whether volatility is equally sensitive to positive market moves as it is to negative moves, and if the size of previous returns are relative to the level of the volatility experienced today (Daly, 2008:2381). Volatility has many components that are

driven by political events, the macro-economy, and investor behaviour (Poon, 2005:2). The following section will consider these interactions.

3.3 Volatility interactions

There are three main factors that influence the variables that determine the level of asset prices and ultimately their level of volatility. Firstly, from a *macro-economic perspective*, GDP can be a fairly accurate measure of cash flows in that changes in the volatility of GDP result in changes to the volatility of asset prices such as equities *ceteris paribus* (BIS, 2006:12). Secondly, *economic uncertainty* can transform financial market volatility into financial market instability. Economic uncertainty, in the form of real interest rates, the level of the risk premium and the expected level of inflation, may also influence the level of asset prices. In this regard, *monetary policy* is a very important factor that may affect volatility through its impact on the level of inflation, interest rates and economic activity (BIS, 2006:12). Finally, the *structure of financial markets*, in particular market liquidity, financial innovation and financial market integration, plays an important role in determining financial market volatility (BIS, 2006:12).

3.3.1 Volatility and the macro-economy

Prior to the outbreak of the subprime financial crisis in August 2007, a particular economic phenomenon attracted the attention of financial regulators, academics and market participants. This phenomenon became known as the “great moderation” and was manifested in the form of low macro-economic volatility (Barnett & Chauvet, 2008:1). Since the early 1980s the volatility of growth in real GDP has declined by 50% and inflation volatility declined by 70% (Blanchard & Simon, 2001:134). The great moderation became apparent in the US, as well as other G7 countries, between two and three decades ago (Stock & Watson, 2003:1).⁷⁰ In the literature it is generally agreed that the start of the great moderation in the US was in the first quarter of 1984.⁷¹ Although a variety of sources have been suggested as responsible for the reduction in volatility by numerous studies, economic structural changes, improved policy framework, and the absence of significant shocks to the financial system as a whole appear to be the most common.

⁷⁰ See also Stock and Watson (2003), Clark (2009:29), Blanchard and Simon (2001) and Campbell (2005) on the great moderation.

⁷¹ See McConnell and Perez-Quiros (2000) and Kim and Nelson (1999) for an elaboration on the start of the great moderation.

3.3.1.1 Economic structural changes

Despite a decline in the volatility of government spending in the US after the post-war period, output volatility in the US declined (Blanchard & Simon, 2001:137). This may be attributed to a decrease in consumption and investment volatility, as a result of improvements in financial markets, and a shift in the inventory behaviour of companies from pro-cyclical towards countercyclical investment behaviour. Increased labour market and product competition, economic structural changes in the form of a shift from manufacturing to services, better inventory management and financial market innovation – focusing on better risk diversification and smoothing consumer spending regardless of income or wealth shocks –⁷² contribute to the persistence of the great moderation (Bean, 2009:4).

3.3.1.2 Improved policy framework

The brief increase in the level of inflation during the 1970s and early 1980s was a result of a correlation with the temporary increase of inflation volatility during this period, and since there appeared to be a relationship between the inflation volatility and output volatility, the decline in inflation volatility in the 1980s appears to have resulted in the decline of output volatility (Blanchard & Simon, 2001:155). This decline in inflation volatility is attributed to improved monetary policy regimes implemented by policymakers at the time. In the US, for example, monetary policy in the 1960s and 1970s was viewed as being too accommodative. However, during 1979 and through to the 1990s the US Federal Reserve⁷³ demonstrated a commitment to counteracting inflation (Stock & Watson, 2003:1), resulting in better output stabilisation (Blanchard & Simon, 2001:163). But improved monetary policy appears to explain only a small part of the reduction of output volatility in the US, when comparing the pre-1984 period with the post-1984 period (Stock & Watson, 2003:3).⁷⁴ The quest of inflation targeting and macro-economic stability by central banks appeared to have been successful in securing inflation expectations (Bean, 2009:4). This situation may have resulted in economies moving closer to the Taylor frontier mentioned by Stock and Watson (2003:2), where the relationship between inflation volatility and GDP volatility is plotted. There appears to be a trend amongst central banks of increased gradualism in their policy response to keeping inflation at bay, greater transparency, and improved communication about their intentions and future outlook, which has resulted in greater central bank transparency, creating an environment for more stable inflation expectations by market participants, and thus lowering volatility (BIS, 2006:2).

⁷² Clark (2009:15) notes that the increased availability of credit to households and companies through innovations such as securitisation has helped to smooth out the business cycle.

⁷³ See Bernanke (2004) for an explanation of the important role of monetary policy in the great moderation.

⁷⁴ For alternative views on the role of monetary policy, see Barnett and Chauvet (2008:3; 2008:43).

3.3.1.3 “Good luck” hypothesis

Half or more of the great moderation could have been temporary, which suggests that the absence of common international macro-economic shocks or structural changes in the economy may have resulted in decreasing output volatility (Stock & Watson, 2003:3). Smaller economic shocks⁷⁵ also seem to have been responsible for the decline in output volatility (Blanchard & Simon, 2001:139). However, many studies use small or univariate models to estimate shocks and this may lead to incorrect estimates of structural shocks, since these models do not reflect information generated by markets and central banks accurately. The distinction between economic shocks and transmission depends on the form of the information set used in the estimating model. Results pointing towards the “good luck” hypothesis as an explanation of the great moderation should not be taken too seriously, as the models implemented to obtain these results may have been misspecified (Giannone *et al.*, 2008:10-11). By employing a large model to evaluate the role of shocks in explaining a decline in output volatility over the pre-great moderation period and the great moderation period, Giannone *et al.*, (2008:14) found that the transmission, rather than the change in shock volatility, is a more relevant explanation of the great moderation. A reoccurrence of a shock, as large as that experienced during the 1970s, may lead to a turnaround in the favourable volatility experienced over the last two to three decades (Stock & Watson, 2003:40). The good luck component, as an explanation of the great moderation, should not be expected to be permanent, as good luck can quickly transform into bad luck (Clark, 2009:26). The subprime crisis is a case in point.

Much research on the great moderation focuses on the US, but as this study focuses on South Africa, it is relevant to consider local research too. Burger (2008:335) examines whether South Africa experienced similar reductions in volatility. Data for the period 1960 to 2006 is utilised (Burger, 2008:336), and the study concludes that volatility declined significantly in the period between the second quarter of 1994 and fourth quarter of 2006, when compared with the period between the third quarter of 1976 and the first quarter of 1994 (Burger, 2008:353). This reduction can be attributed to a decrease in the size of shocks affecting the South African economy at the time (Burger, 2008:343).⁷⁶ In comparison with the findings of other studies mentioned within this section, Burger (2008) highlights similar reasons for the reduction in overall volatility. Better monetary policy and improvements in the financial sector appear to have been the main catalysts for the reduction in South African macro-economic volatility (Burger, 2008:354). Contrary to what was expected, better inventory management had no effect on reducing real GDP volatility

⁷⁵ Hence the term “good luck” hypothesis.

⁷⁶ Most notably, shocks of a political nature such as the Soweto uprising (Burger, 2008:337).

(Burger, 2008:354). Despite the reduction in macro-economic volatility experienced by the South African economy, macro-economic volatility still appears to influence equity market volatility (Chinzara, 2011:27).⁷⁷ Macro-economic variables such as short term interest rates, the exchange rate and the gold price were found to have positive volatility transmission effects on equity market volatility (Chinzara, 2011:46).

3.3.2 Volatility and financial market stability

Regardless of the real cause of the great moderation, which is beyond the scope of this study, it is important to highlight the connection of this economic phenomenon to one of the most severe financial crises of our time: the subprime crisis. A decline in output volatility is associated with the reduction in the frequency and severity of economic recessions, as low output volatility brings about more stable employment and reduced economic uncertainty, whereas lower inflation volatility improves economic planning, market operation and the management of inflation risk (Bernanke, 2004:1). The persistence of macro-economic stability or lack of real volatility resulted in markets becoming convinced of the permanence of the great moderation (Bean, 2009:1). This situation convinced market participants to adopt a more relaxed approach towards risk because risk premiums became excessively low (Bean, 2009:1).⁷⁸ As financial institutions underestimated the risk inherent in the economy, they may have overestimated the amount of leverage that they could manage successfully.⁷⁹

Accompanied by the global macro-economic imbalances mentioned in Section 2.4.2, these interactions played an important role in the creation of global financial sector losses throughout the subprime crisis. Market participants tend to underestimate future risks during periods of favourable economic performance and over-rely on the ability of policymakers to maintain this real economic growth (Bean, 2009:5).

Although numerous negative shocks⁸⁰ plagued the global financial system between the 1990s and the mid-2000s, as the evidence suggests, their severity and frequency does not appear to have increased volatility much. Barnett and Chauvet (2008) and Clark (2009) try to establish whether the great moderation is over due to the occurrence of the subprime crisis.

⁷⁷ See also Diebold and Yilmaz (2007) for evidence on how macro-volatility appears to influence equity market volatility.

⁷⁸ See also Barnett and Chauvet (2008:1) on the apparent permanence of the great moderation.

⁷⁹ See BIS (2006:19) for evidence of increased risk-taking by market participants.

⁸⁰ Examples include the Russian and Asian financial crises, the dotcom bubble, international terrorism (including the 9/11 attacks) and political uncertainty in the Middle East (BIS, 2006:24).

The economic recession in the US following the subprime crisis has resulted in GDP growth levels similar to those experienced in the 1960s and 1970s, suggesting a rise in volatility to the levels experienced prior to the great moderation (Clark, 2009:6-7).⁸¹ The volatility of output growth in the US during the second quarter of 2009 was roughly equal to its 1983 level. However, although it appears that output volatility reversed the gains made during the great moderation, the rise in volatility has not been as extensive as the rise during the great moderation (Clark, 2009:9-10). A sudden change in the prevailing inventory management regime, a relaxation of structural changes in financial markets, and alterations to the monetary policy framework seem unlikely to account for the reversal of macro-economic volatility (Clark, 2009:17). The empirical evaluations suggest that larger shocks to oil prices⁸² and financial markets may be responsible for most of the rise in volatility (Clark, 2009:15). These shocks include the rise in oil prices from US\$54 a barrel in January 2007 to US\$134 a barrel in June 2008, a 50% decline in US residential investment from the fourth quarter of 2005 to the second quarter of 2009, and the credit crunch and its effects on the functioning of the economy after August 2007 (Clark, 2009:18).

Table 3.1 indicates the contribution of each shock to the increase in macro-economic volatility in the US between the first quarter of 1985 and the second quarter of 2009 (Clark, 2009:20).

Table 3.1 Impact of shocks on macro-economic volatility

Macro-economic variable	<i>Financial shock</i>	<i>Oil shock</i>
GDP growth, excl. residential investment	36.50%	33.10%
Inflation	10.10%	14.80%
Federal funds rate	23.20%	32.20%

Source: Adapted from Clark (2009:24)

The rise in volatility emanates from specific shocks only affecting certain parts of the economy, and macro-economic volatility is likely to decline once the current crisis settles down (Clark, 2009:27). It can be concluded that even though macro-economic volatility is likely to alter between high and low levels, low volatility is likely to prevail (Clark, 2009:28).

3.3.3 Volatility transmission

Although an inevitable link between the macro-economy and financial markets might be expected, there appears to be a weak relationship between macro-economic volatility and financial market volatility. The volatility of short-term and long-term interest rates, exchange

⁸¹ A similar situation is revealed in other G7 countries (Clark, 2009:7).

⁸² See also Herrera and Pesavento (2009:131) on how oil price shocks affect macro-economic volatility.

rates, corporate spreads and equities in developed and emerging economies was lower over the period between mid-2004 and March 2006 when compared to the previous decade (BIS, 2006:1). The sustained economic expansion experienced during this period, lower global inflation levels, improvements in the profitability expectations and balance-sheet conditions of companies, better monetary policy framework, and greater financial market progress are amongst the causes of the reduction in financial market volatility (BIS, 2006:2).

The great moderation is unlikely to explain the low levels of financial market volatility experienced during this period, since it occurred before the decline materialised between 2004 and 2006 (BIS, 2006:2). However, even if this contribution was modest at best, output volatility and inflation volatility may have declined further since 2004, and contributed to the decline in financial market volatility (BIS, 2006:2-14).

As mentioned earlier, numerous improvements have been made by financial markets in recent years. Examples include improvements to market liquidity through increased transaction volumes, growth in markets for risk transferring products, the greater role of well-informed institutional investors who are able to better manage risk and a decline in hedging-related volatility owing to changes in the market for mortgage-backed securities (BIS, 2006:2).⁸³ However, these improvements appear to be at the heart of the subprime crisis. All these developments were intended to help market participants avoid or better manage shocks. This was not the case in the recent subprime crisis, where the importance of the level of financial market volatility was determined by its influence on the willingness and ability of banks to extend credit, and the corporate sector's investment decisions (BIS, 2006:3). The excessive risk-taking prior to the subprime crisis was the result of a misperception amongst market participants of recurring systematic risk (Barnett & Chauvet, 2008:44). Although risk management practices, financial market developments and improved monetary policy frameworks have evolved to improve the overall stability of financial markets during recent decades, the subprime crisis has highlighted the need for improving the ability of financial institutions to ease the adverse effects of financial market volatility (BIS, 2006:3).

The long-term volatility of macro-economic components, such as output growth, inflation, and interest rates, are all important descriptive variables that influence volatility in equity markets (Engle & Rangel, 2005:26). However, the weak relation between macro-economic volatility and financial market volatility may be the result of offsetting factors being at work

⁸³ These changes include an increase in the use of CDSs and adjustable-rate mortgages.

during the great moderation period (BIS, 2006:13).⁸⁴ Financial market volatility has generally been much higher since the 1970s, which may have been due to the effect of oil shocks on inflation during this period, whereas the level of volatility during the 1980s and 1990s may have been influenced by global deregulation and liberalisation of financial markets and capital flows (BIS, 2006:11). In his analysis of the effects of the great moderation on equity market volatility in the US over the period of 1970 to 2005, Campbell (2005:1) decomposed real equity returns into a news component that reflected future fundamentals such as earnings and dividends and a component that reflected future returns. Since the first quarter of 1981 fundamental news volatility declined by 50% and there appeared to be a positive relationship between the fundamental news component and macro-economic volatility (Campbell, 2005:2). However, the volatility of the return news component was unaffected by the decline in macro-economic volatility, and thus macro-economic volatility had no significant effect on the volatility of the equity market over the period studied (Campbell, 2005:36).

3.4 The ARCH and GARCH models

The most important source of market price changes is news about an asset's fundamental value. The swift sequence of news feeds about a particular asset will result in high frequency data exhibiting volatility clustering from its returns. Macro-economic and institutional changes are the most likely source of volatility in lower frequency data, whereas trading pressure and turbulence induce volatility in high frequency data (Daly, 2008:2379).

There are a number of factors associated with volatility changes. Firstly, large volatility changes are likely to be followed by large positive or negative changes, whereas small changes tend to be followed by small changes. This is known as positive serial correlation. Secondly, a number of studies have investigated the day-of-the-week effect on volatility.⁸⁵ These studies conclude that trading and non-trading days contribute to market volatility through the arrival of information. Thirdly, the returns volatility of a company usually increases when it becomes more leveraged in response to a fall in its equity price. Leverage effects may thus explain some of the market volatility changes. Fourthly, corporate leverage is one of the most important long-term influences on volatility, and short-term volatility influences include trading volume, contrarian trade, and the introduction of futures and options (Daly, 2008:2379). Finally, there appears to be a positive relationship between high market volatility and economic recessions, financial crises and high nominal interest rates

⁸⁴ See also Blanchard and Simon (2001:164) on the offsetting factors influencing volatility.

⁸⁵ See Athanassakos and Robinson (1994) and Berument and Kiymaz (2001) on the day-of-the-week effect.

(Daly, 2008:2379). Analysing and modelling financial market volatility is thus indispensable in understanding its effects on the greater economy and individual markets.

The ARCH model introduced by Engle (1982) has been the most important development in modelling volatility. This is partially due to the versatility of the ARCH model in capturing important stylised facts of economic and financial data. These facts include the presence of thick tails in unconditional distributions, variance changes over time and positive serial correlation. In an attempt to develop hedging strategies and analyse investment opportunities, ARCH models have been applied to examine information flows across countries, markets and assets. They have also been applied to wider economic fields by, for example, modelling the relationship between the time-varying conditional variance and risk premium in the term structure of interest rates, measuring inflation and describing the relationship between the macro-economy and equity markets (Daly, 2008:2381).

ARCH models do not make use of past standard deviations, but formulate the conditional variance of asset returns (h_t) through maximum likelihood estimation (Poon, 2005:37). Information from the previous period is utilised by the conditional mean and is a random variable in most cases, and takes the following form (Daly, 2008:2382):

$$m_t \equiv E[y_t | F_{t-1}] \equiv E_{t-1}[y_t], \quad (3.5)$$

where:

y_t is the rate of return for a particular equity from time $t-1$ to t ;

F_{t-1} is the past information set for all relevant variables up to time $t-1$; and

E is the expectations operator.

Investors know the realised values of all the relevant variables (F_{t-1}) when making their investment decisions at time t . Investors' expectations in terms of return and volatility are given by the conditional expected value of y_t in equation 3.5, and the conditional variance of y_t , given F_{t-1} , is summarised in equation 3.6 (Daly, 2008:2382):

$$\sigma_t^2 \equiv E_{t-1}[y_t - m_t]^2, \quad (3.6)$$

Using the conditional variance σ_t^2 , investors will be able make more accurate forecasts on the variability of returns (Daly, 2008:2382).

3.4.1 Autoregressive Conditional Heteroskedasticity (ARCH)

The empirical study of this dissertation focused on the ARCH family of models, which make it possible to model the attitude of investors not only towards expected returns, but also towards risk or uncertainty. These models are able to process the volatility (variance) of a series. Under conventional econometric analysis, the variance of the error terms is viewed as being homoskedastic or constant. Since financial data exhibits periods of unusually high volatility followed by low volatility, it is preferable to examine the conditional volatility of the series, as it will aid an investor or policymaker in estimating the riskiness of an asset at a certain period of time (Asteriou & Hall, 2007:250).

Following the ARCH literature, $\sigma_t^2 = h_t$, and returns are given as $r_t = u + \varepsilon_t$ and $\varepsilon_t = \sqrt{h_t} z_t$, where $z_t \sim D(0,1)$ is white noise (Poon, 2005:37). The process z_t is scaled by the conditional variance h_t (Poon, 2005:37). The ARCH (q) process proposed by Engle (1982) takes the following form:

$$h_t = \omega + \sum_{j=1}^q \alpha_j \varepsilon_{t-j}^2, \quad (3.7)$$

with $\omega > 0$ and $\alpha_j \geq 0$ to ensure that h_t is a strictly positive variance process (Poon, 2005:38).

Owing to the occurrence of volatility persistence in financial markets, q is usually of high order (Poon, 2005:38). In equation 3.7, h_t is known at time $t-1$, which means that the one-step-ahead forecast is readily available (Poon, 2005:38). The multistep-ahead forecast can be formulated by assuming that $E[\varepsilon_{t+\tau}^2] = h_{t+\tau}$. The unconditional variance of r_t is (Poon, 2005:38):

$$\sigma^2 = \frac{\omega}{1 - \sum_{j=1}^q \alpha_j}. \quad (3.8)$$

The ARCH (q) model is covariance stationary only when the sum of the autoregressive parameters is less than one (Poon, 2005:38).

3.4.2 Generalised Autoregressive Conditional Heteroskedasticity (GARCH)

One of the drawbacks of the ARCH model is that it appears to be a moving average specification rather than an autoregression (Asteriou & Hall, 2007:260). A new model, GARCH, which includes the lagged conditional variance terms as autoregressive terms was developed by Tim Bollerslev in 1986 (Asteriou & Hall, 2007:260). Bollerslev's (1986) GARCH model builds on the original ARCH model introduced by Engle (1982).⁸⁶ Bollerslev (1986) made the variance parameter (σ_t^2) linear in lagged values of the error term $\varepsilon_t^2 = \sigma_t^2 z_t^2$. This GARCH model is given by (Nelson, 1991:348):

$$\sigma_t^2 = \omega + \sum_{i=1}^q \beta_i \sigma_{t-i}^2 + \sum_{j=1}^p \alpha_j z_{t-j}^2 \sigma_{t-j}^2, \quad (3.9)$$

where ω, α_j and β_i are non-negative.

For a GARCH (1, 1) model, $\alpha_1 \geq 0$ and $\beta_1 \geq 0$ are required to ensure that h_t is strictly positive (Poon, 2005:38). The unconditional variance is:

$$\sigma^2 = \frac{\omega}{1 - \sum_{i=1}^p \beta_i - \sum_{j=1}^q \alpha_j}. \quad (3.10)$$

The GARCH (p, q) model is covariance stationary only when $\sum_{i=1}^p \beta_i + \sum_{j=1}^q \alpha_j < 1$ (Poon, 2005:38).

3.4.3 Exponential Generalised Autoregressive Conditional Heteroskedasticity (E-GARCH)

Unconditional price or equity returns have a tendency to display fatter tails than a normal distribution, in the form of skewness, but more pronounced in terms of excess kurtosis (Daly, 2008:2384). The E-GARCH model proposed by Nelson (1991:350) is one of the more successful attempts to model excess conditional kurtosis in equity returns based on a generalised exponential distribution (Daly, 2008:2394). Despite being very successful models, ARCH and GARCH models are unable to capture some important features of financial and economic data, the most fascinating of which is the leverage or asymmetric effect (Daly, 2008:2384). Nelson's E-GARCH model aims to eliminate some of the restrictive

⁸⁶ See Nelson (1991:348) for a derivation of the original model introduced by Engle (1982).

features of the more common GARCH model. Bollerslev's GARCH model (equation 3.9 above) can be improved in order to eliminate the original model's shortcomings in explaining changes in the volatility of equity market returns (Nelson, 1991:347).

Researchers have successfully applied the new ARCH methodology to asset pricing models (Nelson, 1991:348).⁸⁷ By substituting recursively for the $\beta_i \sigma_{t-i}^2$ terms, equation 3.9 can be rewritten as:

$$\sigma_t^2 = \omega^* + \sum_{k=1}^{\infty} \phi_k z_{t-k}^2 \sigma_{t-k}^2 . \quad (3.11)$$

If ω, α_j and β_i are non-negative, ω^* and ϕ_k are non-negative too. In setting the conditional variance equal to a constant plus a weighted average (with positive weights) of past squared residuals, GARCH models elegantly capture the volatility clustering of asset returns (Nelson, 1991:349). This feature of GARCH models makes it perfect for testing market volatility patterns (Nelson, 1991:349).

This integrated model structure still imposes significant limitations on GARCH models (Nelson, 1991:349). There are two main differences between the E-GARCH model and the standard GARCH model. Firstly, the GARCH model assumes that good news and bad news of similar magnitudes have the same influence on the level of volatility, whereas the E-GARCH model allows good news and bad news to have a different impact on volatility (Daly, 2008:2385). The reason for the limitations of the GARCH model is that the model assumes that only the magnitude and not the positivity or negativity of unpredicted excess returns determines feature σ_t^2 (Nelson, 1991:349). A model in which σ_t^2 responds asymmetrically to positive and negative residuals⁸⁸ might be preferable for asset pricing applications (Nelson, 1991:349).

A second limitation of GARCH models emanates from the non-negative constraints on ω^* and the ϕ_k in equation 3.11, which are imposed to ensure that σ_t^2 remains non-negative for all t with probability 1 (Nelson, 1991:349). These constraints imply that increasing z_t^2 in any period increases σ_{t+m}^2 for all $m \geq 1$, ruling out random oscillatory behaviour in the σ_t^2 process

⁸⁷ See Bollerslev *et al.*, (1988) on the application of ARCH methodology on asset pricing.

⁸⁸ That is, both the size and the sign of lagged residuals determine conditional variance.

(Nelson, 1991:349). These non-negative constraints can furthermore create difficulties in estimating GARCH models (Nelson, 1991:349).

A third limitation of GARCH modelling is the interpretation of the persistence of shocks to conditional variance (Nelson, 1991:349). Should volatility shocks endure indefinitely, they may move the whole term structure of risk premiums and are likely to have a significant impact on investment in long-lived capital goods (Nelson, 1991:349). In GARCH (1, 1) models, shocks may persist in one form and die out in another, which may result in the conditional moments of GARCH (1, 1) exploding even when the process itself is strictly stationary (Nelson, 1991:350).

If σ_t^2 is to be the conditional variance of ε_t given information at time t , it must be non-negative with probability 1 (Nelson, 1991:350). As mentioned earlier, GARCH models achieve this by making σ_t^2 a linear combination (with positive weights) of positive random variables (Nelson, 1991:350). Nelson (1991:350) adopted another natural device for ensuring that σ_t^2 remains non-negative, by making $\ln(\sigma_t^2)$ linear in some function of time and lagged z_t 's for some suitable function g . This can be depicted as follows (Nelson, 1991:350):

$$\ln(\sigma_t^2) = \alpha_t + \sum_{k=1}^{\infty} \beta_k g(z_{t-k}), \quad \beta_1 \equiv 1, \quad (3.12)$$

where $\{\alpha_t\}_{t=-\infty, \infty}$ and $\{\beta_k\}_{k=1, \infty}$ are real, non-stochastic, scalar sequences. In order to accommodate the asymmetric relation between equity returns and volatility changes, the value of $g(z_t)$ must be a function of both the magnitude and the sign of z_t . This is achieved by making $g(z_t)$ a linear combination of z_t and $|z_t|$ (Nelson, 1991:351):

$$g(z_t) \equiv \theta z_t + \gamma [|z_t| - E|z_t|], \quad (3.13)$$

$$z_t = \varepsilon_t / \sqrt{\sigma_t}, \quad (3.14)$$

where θz_t and $\gamma [|z_t| - E|z_t|]$, each has a mean of zero (Nelson, 1991:351). The term θz_t determines the sign effect and the term $\gamma [|z_t| - E|z_t|]$ determines the size effect of

innovations. If the distribution of z_t is symmetric, these two components are statistically significant (Nelson, 1991:351). Over the range $0 < z_t < \infty$, $g(z_t)$ is linear in z_t with slope $\theta + \gamma$, and over the range $-\infty < z_t \leq 0$, $g(z_t)$ is linear with slope $\theta - \gamma$. Thus, $g(z_t)$ allows the conditional variance process $\{\sigma_t^2\}$ to respond asymmetrically to rises and falls in equity price. If it is assumed that $\gamma > 0$ and $\theta = 0$, the innovation in $\ln(\sigma_{t+1}^2)$ would be positive (negative) when the magnitude of z_t is larger (smaller) than its expected value. Alternatively, if $\gamma = 0$ and $\theta < 0$, the innovation in conditional variance would be positive (negative) when returns innovations are negative (positive) (Nelson, 1991:351).

Regarding the limitations of the GARCH model mentioned earlier, the exponential form of GARCH provides a solution to the inability of the GARCH (1, 1) model to explain positive and negative unexpected excess returns. With regard to the second limitation of the GARCH model, there are no inequality constraints in equations 3.12 and 3.13. The β_k terms can be both negative and positive (Nelson, 1991:351).

The E-GARCH model is superior to the standard ARCH model, since it makes the conditional volatility a function of both the magnitude and direction of innovations (good news and bad news) (Samouilhan, 2006:250). The third limitation of GARCH, it being difficult to evaluate whether shocks to variance persist (Nelson, 1991:349). In the exponential GARCH model, $\ln(\sigma_t^2)$ is a linear process and it is easy to verify whether it is stationary (covariance or strict) and ergodic (Nelson, 1991:351). If the shocks to $\ln(\sigma^2)$ die out quickly enough and if the deterministic component α_t is removed, then $\ln(\sigma_t^2)$ will be strictly stationary and ergodic (Nelson, 1991:351). These stationarity and ergodicity criteria are the same as for a general linear process with finite innovations variance (Nelson, 1991:352).

To conduct the econometric study of this dissertation, an E-GARCH model (Nelson, 1991) is employed within an AS model framework.⁸⁹ By modelling the returns of the markets simultaneously, problems associated with the univariate E-GARCH model can be eliminated (Koutmos & Booth, 1995:749). Firstly, problems with estimated regressors can be avoided, as the two-step procedure can be eliminated. Secondly, the efficiency and power of the tests for cross-market transmissions can be improved. Thirdly, own market and cross-market

⁸⁹ A detailed description of the AS model will follow in Chapter 4.

innovations (news) are allowed to exert an asymmetric impact on the volatility in a given market.

3.5 Conclusion

Asset price volatility is an unavoidable feature of financial markets and is often associated with unpredictability, uncertainty and risk. The interactions between the various economic components, such as GDP volatility, economic uncertainty, and the structure of financial markets need to be considered before identifying the sources of financial market volatility. Economic prosperity is linked to financial market stability. The greatest threat to financial market stability is uncertainty or market volatility. Therefore, the ability to identify, measure and manage this financial market phenomenon is of importance to market participants. Volatility can be measured by both time-invariant measures and time-variant measures. Empirical evidence has demonstrated that the behaviour of asset returns in the real world changes randomly over time. This study implements a time-variant measure of volatility in the form of an E-GARCH model as the nature of financial market volatility indicates that time-variant models are more appropriate in assessing the level of volatility transmission between markets.

Chapter 4 will explore the characteristics of volatility transmission from international financial markets to the South African equity market. After a brief introduction on previous volatility transmission studies, section 4.3 will present the data and research methodology implemented to perform the empirical study. The empirical results will be presented in section 4.4 before briefly highlighting the characteristics of the evolving global financial system in section 4.5. Due to the ever evolving nature of financial markets, section 4.6 will briefly present the future structure and regulatory framework of the global financial system. Chapter 4 will be concluded with a few policy recommendations in section 4.7.

Chapter 4

Volatility transmission

4.1 Introduction

The volatility transmission phenomenon is central to the diffusion of international financial crises. An increase in globalisation, owing to the deregulation of markets and the free flow of funds between capital markets, has affected the relationships amongst price movements across markets. Trade and investment have been the main interdependent factors between major world economies. Trade and investment has resulted in news about economic fundamentals in a particular country holding implications for equity prices in other countries (Tanizaki & Hamori, 2009:27-28).

An overview of the evolution of the most prominent studies regarding volatility transmission will be presented in Section 4.2. Thereafter, the data and research methodology of the current study will be presented in Section 4.3. The results of this empirical study will be presented in Section 4.4. After examining the empirical findings, the focus will shift (in Section 4.5) towards the fundamental factors that influence the current and future financial system. A brief highlight of the regulatory environment shaped by past and current financial crises and how these regulations will alter the future structure of financial markets and their functioning will be provided in Section 4.6. The focus of section 4.5 and section 4.6 compliments the overall aim of the study, since it allows for a better overall understanding of the internal functioning of the South African financial markets and where they are heading. Concluding remarks will be provided in section 4.7.

4.2 An overview of volatility transmission

Data on the volatility of returns in financial markets offers supplementary information to data on returns alone (Tanizaki & Hamori, 2009:28). This has been proven by Ross (1989), who demonstrates that returns volatility provides useful data on the flow of information and suggests that price volatility has important implications for linkages between markets. Volatility of prices in an arbitrage-free economy was found to be directly related to the rate information flow to the market (Ross, 1989:16). There has since been a growing interest in studying the linkages between conditional variances across financial markets and their implications for information transmission mechanisms (Tanizaki & Hamori, 2009:28). An overview of previous volatility transmission studies related to this study will be provided in this section.

4.2.1 Hamao et al. (1990)

In their study, Hamao *et al.*, (1990) explore the short-term interdependence of prices and price volatility across three major international markets. They analysed the pricing relationships between New York, London and Tokyo using a GARCH-M statistical model.⁹⁰ There are two main points of interest in this study: firstly, the degree to which equity price changes in one market influences the opening prices of the next market to trade and, secondly, whether changes in the price volatility of one market are related to the observed price volatility changes in the next market to trade. The study found that the volatility transmission effects between New York and London are weaker than the transmission effects between New York and the Japanese market (Hamao *et al.*, 1990:281, 282, 306).

4.2.2 Lin et al. (1994)

In their study of the relationship between financial markets, suggest that financial interdependence and contagion are two factors that have resulted in financial markets becoming more integrated. Numerous studies have focused on the international transmission of equity returns and volatility and have found several common observations.⁹¹ Firstly, equity price volatility is time varying. Secondly, high levels of volatility usually result in highly correlated price changes in major markets. Thirdly, price and volatility correlations from the US to other countries appear to be of a casual nature. Finally, there is evidence of lagged price and volatility transmission effects between major markets (Lin *et al.*, 1994:508).

Lin *et al.*, (1994:507, 511) focuses on how returns volatilities of equity indices are correlated between Tokyo and New York and analyses the international transmission mechanism by describing two ways in which investors can learn from overnight information stemming from a foreign market. The first model they used considered the influence of intra-day equity price movements across markets on each other. Because of non-synchronised trading hours between these markets, the flow of news between Tokyo and New York is very important. Within the current globalised economy, it is difficult for investors in the other country to distinguish between global and local factors.

Lin *et al.*, (1994:509) overcome this problem by designing their econometric framework to separate the global factors from a local factor. Following the signal-extraction approach of

⁹⁰ The GARCH-M model was found to be an attractive representation of daily equity returns behaviour in the US (Hamao *et al.*, 1990:283).

⁹¹ See Hamao *et al.*, (1990), King and Wadhwani (1990), Schwert (1990), Susmel and Engle (1990), Neumark *et al.*, (1991) and Becker *et al.*, (1992) on the international transmission of equity returns and volatility.

King and Wadhwani (1990),⁹² Lin *et al.*, (1994:510) adopted the original approach of King and Wadhwani (1990) by decomposing close-to-close returns into daytime and overnight returns, and permitting time-varying volatility during signal extraction. Several reasons have been identified as to the inclusion of time-varying equity returns volatility in the original approach of King and Wadhwani (1990). Firstly, as mentioned in Chapter 3, equity price volatility is “clustered”. Secondly, as shown by Ross (1989), because volatility is related to the rate of information flow, its predictability can be due to the arrival rate of information being correlated over time. Thirdly, the arrival of new information, given different prior beliefs about news, provides an incentive to trade and leads to price changes (Lin *et al.*, 1994:510). The process of probing for the equilibrium price in response to the arrival of new information may contribute to volatility clustering.

The second model they used to analyse the international transmission mechanism was an Aggregate Shock (AS) model. In the AS model, domestic overnight returns are specified as a function of the preceding domestic return, a Monday or post-holiday dummy, and foreign market influences (Lin *et al.*, 1994:513). Thus, in the AS model, it is assumed that investors use returns surprises from foreign markets to set opening prices. From behaviour finance theory, that is, the efficient-market hypothesis, the opening prices in a domestic market should fully reflect foreign news if the market is efficient.

Volatility correlations across markets are important when examining the speed at which the market adjusts to new information. To examine the reaction speed of domestic equity prices to overnight foreign news as the domestic market re-opens, Lin *et al.*, (1994:510) use tests for lagged returns and volatility. In modelling the international transmission of equity returns and volatility, they also test whether the Aggregate Shock (AS) model and Signal Extraction (SE) model are better than the GARCH-M model used by Hamao *et al.*, (1990) for characterising investor behaviour.

Lin *et al.*, (1994:536) draw the following conclusions from their study. Firstly, they find that foreign daytime returns can significantly influence domestic overnight returns and that cross-market interdependency in returns and volatilities between New York and Tokyo is generally bidirectional. Secondly, in terms of the Schwarz criterion (SC), no strong evidence is found that the SE model characterises the behaviour of traders in Tokyo better than other models.

⁹² In the SE problem, it is assumed that investors extract the global factor from observed price changes in the foreign market by taking a fraction of the foreign price change. This fraction is an estimate of the portion of the total variance of returns that results from the global factor (Lin *et al.*, 1994:510).

Finally, they conclude that there is limited evidence to suggest lagged return transmission from New York to Tokyo.

4.2.3 Koutmos and Booth (1995)

Koutmos and Booth (1995) investigate the transmission mechanism with regard to the price and volatility transmission across the equity markets of New York, Tokyo and London. Koutmos and Booth did the same study as Hamao *et al.*, (1990; discussed in Section 4.2.1) but instead of using a GARCH-M model, they utilised an extended multivariate E-GARCH model. Before Koutmos and Booth (1995), no studies had investigated the possibility that the quantity and quality of news may be important determinants of the degree of volatility transmission between markets (Koutmos & Booth, 1995:748). The development of a model by Nelson (1991) to capture the asymmetric impact of shocks on volatility created the opportunity to conduct this type of study.⁹³ Koutmos and Booth (1995:749) note that by using a multivariate extension of Nelson's (1991) univariate model, problems associated with the latter model will be eliminated. Firstly, problems with estimated regressors will be avoided because the two-step procedure will be eliminated. Secondly, the efficiency and power of the tests for cross-market transmissions will be improved. Thirdly, the multivariate E-GARCH model allows own market and cross-market innovations (news) to exert an asymmetric impact on the volatility in a given market.

Taking potential asymmetries in volatility transmission into account, Koutmos and Booth (1995:759) found evidence of price transmission from New York to Tokyo and London, and from Tokyo to London. However, they note that the second moment interactions are more widespread and common, resulting in significant volatility transmission between all the markets investigated. This suggests that volatility transmission is asymmetric; that is, equity markets are more sensitive to bad news originating in other markets than good news (Koutmos & Booth, 1995:760). Another important finding is that the linkages and interactions between the observed equity markets increased substantially after the October 1987 crash,⁹⁴ which points towards greater interdependence amongst international markets when compared with the pre-crisis period (Koutmos & Booth, 1995:747).

4.2.4 Kanas (1998)

In a similar study to Koutmos and Booth (1995), Kanas (1998) examines the volatility transmission between the three largest European equity markets. The potential

⁹³ For a review of the E-GARCH model, refer to Chapter 3 of this study.

⁹⁴ Also known as "Black Monday".

asymmetrical effect of innovations (news) on volatility between London, Frankfurt and Paris was captured by an E-GARCH model. For the period studied, common transmissions were found to exist between Paris and Frankfurt and between London and Paris, and unidirectional transmissions were present between London and Frankfurt (Kanas, 1998:245). The study found that London, the largest by market capitalisation of the three markets studied, exercised the greatest influence on the other markets, but received the weakest influence (Kanas, 1998:251). Similar to Koutmos and Booth (1995), Kanas (1998) provides an analysis of the pre-1987 crash and post-1987 crash, although this time from a European perspective. Statistically significant transmissions were found between Paris and Frankfurt, but no transmissions from London to Paris or Frankfurt during the pre-crash period were found. In contrast to this finding, the post-crash period revealed significant transmissions from London to Paris and Frankfurt, as well as common transmissions between Frankfurt and Paris. The latter pattern is similar to the one identified during the entire period. Kanas (1998:253-254) deduces two major conclusions from these results. Firstly, corresponding to the findings of Koutmos and Booth (1995), there were a greater number of transmissions during the post-crash period than during the pre-crash period.⁹⁵ This finding indicates once again that these European markets became more interdependent after the market crash (Kanas, 1998:254). This market feature was attributed to the increased deregulation of European markets that started in the late 1980s and the introduction of new automated trading systems in all three markets during the late 1980s and early 1990s (Kanas, 1998). Secondly, during the post-crash period, London emerged as the more influential market with regard to volatility transmission.

4.2.5 Ramchand and Susmel (1998)

The study conducted by Ramchand and Susmel (1998) examines the relationship between correlation and volatility within a conditional time- and state-varying framework. In light of previous studies that found evidence in favour of increased contagion or transmission during volatile market movements,⁹⁶ Ramchand and Susmel (1998:4) investigate whether there is a change in market correlations across variance regimes. More specifically, the study investigates the relationship between time- and state-varying volatility and correlation between the equity market of the US and four Organisation for Economic Co-operation and Development equity markets (Japan, the UK, Germany and Canada), with the use of a switching ARCH (SWARCH) technique (Ramchand & Susmel, 1998:4). The SWARCH technique allows one to model volatility/variance as state varying, whereas the bivariate

⁹⁵ The transmission coefficients from Frankfurt to Paris and from Paris to Frankfurt, for example, doubled from the pre-crash period to the post-crash period (Kanas, 1998:254).

⁹⁶ See King and Wadhwani (1990) for evidence on increased contagion during volatile market moves.

SWARCH model makes it possible to switch from conditional variance to state-varying covariance and correlations. This makes it possible to test for changes in correlations across variance states (Ramchand & Susmel, 1998:1). The results obtained indicate that correlation between the US and other world markets is 2 to 3.5 times higher on average when the equity market in the US is experiencing a high variance state (Ramchand & Susmel, 1998:5). Based on these results, Ramchand and Susmel (1998) conclude that during periods of high market volatility in the US, correlations between foreign markets and the US tend to increase.

4.2.6 Ng (2000)

In this study, Ng (2000) investigates the extent to which volatility within the Pacific-Basin region⁹⁷ was influenced by a global factor and how much is explained by a regional factor. In order to achieve this, Ng (2000:207) constructed a volatility transmission model that allows for modelling local idiosyncratic shocks, regional shocks from Japan and global shocks from the US to drive the unexpected returns of any particular Pacific-Basin market. A bivariate GARCH (1, 1) model was used for the Japanese and US returns, and the maximum likelihood technique was used to estimate the bivariate system (Ng, 2000:212). Three important findings with regard to the investigation into the magnitude and changing nature of return and volatility transmissions from Japan, the US and Pacific-Basin are made. Firstly, although global and regional factors are important for market volatility within the Pacific-Basin region, the influence of the world market tended to be greater. Secondly, factors such as market liberalisation, currency return fluctuations, and the size of trade influenced the relative importance of global and regional market factors that affect volatility. Finally, the magnitudes of the Pacific-Basin market volatility explained by global and regional factors appeared to be small. Equities in Japan and the US, for example, accounted for less than 10% of the weekly variance in returns in four of the six Pacific-Basin countries studied (Ng, 2000:230).

4.2.7 Baele (2003)

The study by Baele (2003) may be viewed as an expansion on the one conducted by Ng (2000). Baele (2003) created a regime-switching volatility transmission model to quantify the magnitudes and time-varying nature of volatility transmission from aggregate European markets and the US market to thirteen Western European equity markets (Baele, 2003:1).⁹⁸

⁹⁷ Six Pacific-Basin countries are examined in this study: Hong Kong, Korea, Malaysia, Singapore, Taiwan and Thailand (Ng, 2000).

⁹⁸ The markets studied included eight Economic and Monetary Union countries (Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands and Spain), three EU but non-Economic and Monetary Union countries

The model aimed to decompose Western European unexpected returns into a country specific shock, a regional European shock and a global shock stemming from the US. Significant increases in the probability of high transmission intensities were found during the last two decades for both the EU and the US. This intensity appears to be larger for the EU during the latter part of the 1980s and early 1990s (Baele, 2003:31). Interestingly, it was found that after the introduction of a single monetary unit, most countries experienced a significant drop in their sensitivities to EU and US shocks. Over the sample period of January 1980 to August 2001, Baele (2003:31) found that on average shocks originating in the EU explained approximately 15% of the local variance, and shocks originating from the US explained 20% of the variance. Although this finding highlights the influence of the US on the European market, Baele (2003:31) notes that the importance of the regional European market is substantially increasing whereas countries with an open economy, low inflation and well-developed financial markets share more information with the regional European market. Finally, statistically significant correlation was found between the residuals of the US market and local residuals during a crisis period, but no significant evidence of contagion was found between the regional European markets and their respective local equity markets (Baele, 2003:32).

4.2.8 Collins and Biekpe (2003)

Up until now, all the studies in the overview of volatility transmission have centred upon international markets and their level of integration. With Collins and Biekpe (2003), contagion and volatility transmission are considered a bit closer to the local market. They aim to test the extent of contagion between African equity markets and the equity markets of international emerging countries and to investigate the relationship between the returns of African equity markets. The adjusted correlation coefficient was used to measure contagion and existing interdependencies with the international markets, and Granger causality tests were implemented to understand the casual relationships between African equity markets. Collins and Biekpe (2003:193) found evidence of contagion between international emerging-market crises and the largest, most traded African markets only Egypt and South Africa out of the eight African markets studied. The study highlights the isolation of most African markets, as there appeared to be no causal relationship between African markets in general. Fundamental trade and economic links present between regional African markets were found to be responsible for the inter-relationships between African equity markets.⁹⁹ With

(the UK, Denmark and Sweden), two non-EU countries (Norway and Sweden) and two regional markets (the US and an aggregate European market).

⁹⁹ The alternative explanation for the relationship between African equity markets is investor behaviour (Collins & Biekpe, 2003:193).

regard to contagion effects, fundamental influences appear to have no effect on how Egypt and South Africa are influenced by international financial events (Collins & Biekpe, 2003:193).¹⁰⁰

4.2.9 Piesse and Hearn (2005)

The final study presented in this overview measured the transmission of volatility returns across a sample of sub-Saharan Africa countries.¹⁰¹ A univariate E-GARCH model was applied to the African equity markets, owing to the model's ability to model asymmetric effects of good news and bad news on volatility successfully and accurately. The study found that the South African and Nigerian markets transmit their volatility to other local markets, and that this effect is particularly strong when trade linkages or shared trading mechanisms between markets exist. The asymmetric relationship between volatility and returns indicates that volatility tends to increase when returns surprises are positive in Botswana and Nigeria, whereas in South Africa volatility tends to increase when returns surprises are negative.¹⁰² This finding indicates that volatility in the South African market is affected more by bad news than good news. Finally, volatility was persistent for Botswana, Kenya and South Africa throughout the study period (1993–2000) (Piesse & Hearn, 2005:42, 49, 52).

A clear pattern emerges with every new addition to of the study of volatility transmission: the most superior econometric model available at that particular time is utilised in the quest to understand the complex relationships of volatility transmission. Thus, this overview of these past studies has provided a summary of the evolution of statistical models and their application to the study volatility transmission. These studies have also provided an opportunity to compare the latest findings within this study, with those mentioned above.

4.3 Data and research methodology

This section begins with an exposition of the data utilised within the empirical study. The data was tested for the periods before, during, and after the occurrence of each financial crisis with respect to the directly affected region as discussed in Chapter 2 of this study. The statistical model implemented in section 4.3.2 was derived from the discussion in Chapter 3, the articles discussed above, as well as several statistical procedures in EViews 7.

¹⁰⁰ In this study, the crash of the Hong Kong equity market after the 1997 Asian financial crisis was used to test for international contagion effects (Collins & Biekpe, 2003:186).

¹⁰¹ The ten countries that make up the region are Botswana, Ghana, Kenya, Malawi, Mauritius, Namibia, Nigeria, South Africa, Zambia and Zimbabwe (Piesse & Hearn, 2005:41).

¹⁰² No statistically significant evidence was found for the other countries studied (Piesse & Hearn, 2005:49).

4.3.1 Data

Data for the returns of the JSE, HSI, DJIA and FTSE 100 were statistically tested to establish the volatility transmission effects between these exchanges according to the respective financial crisis emanating from these regions. International financial markets do not trade during the same trading hours and differences in opening and closing times between these interacting international financial markets may lead to spurious casual relationships (Cheung *et al.*, 2010:88). In order to avoid the overlapping and non-synchronous trading problem,¹⁰³ weekly index returns¹⁰⁴ were employed. Since data of a higher frequency (for example, intra-day or daily) contains too much noise and lower frequency data (for example, monthly) would have made it more difficult to capture changes in information, the use of weekly data is further justified. The periods studied vary according to the financial crisis being studied. The data periods used in the empirical study are summarised in Table 4.1.

Table 4.1 Summary of the empirical study data

Financial crisis	Originating country	Indices	Crisis period	Data period
Asian financial crisis	South Africa compared to Asia	JSE vs. HIS	1997–1998	03/01/1995–29/12/2000
Dotcom bubble	South Africa compared to the US	JSE vs. DJIA	2000–2001	05/01/1998–31/12/2002
9/11 attacks	South Africa compared to the US	JSE vs. DJIA	2001	05/01/1998–31/12/2002
Subprime financial crisis	South Africa compared to the EU & the US	JSE vs. FTSE 100 vs. DJIA	2007–2009	02/01/2003–31/07/2010

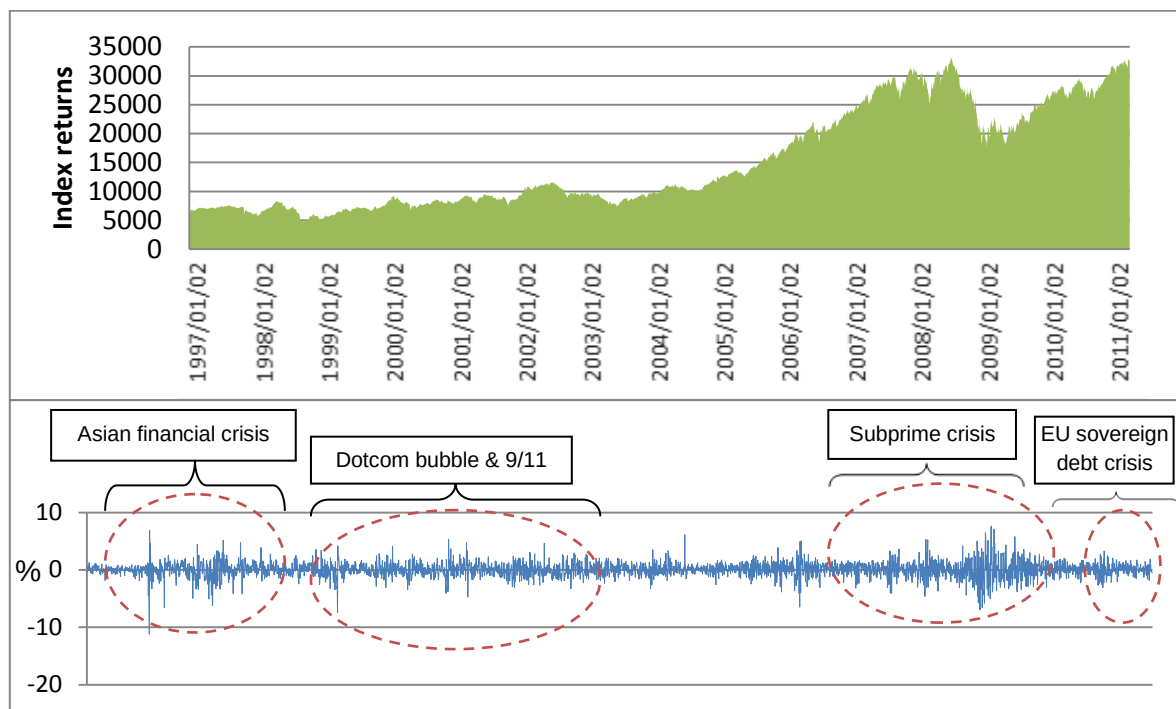
Source: Compiled by the author

The following figures represent the daily index returns and daily percentage change from 01/02/1997 to 10/02/2011 for the JSE, HSI, DJIA and FTSE 100. The vertical and horizontal axes indicate index returns and time, respectively. The data was taken from Google Finance (Google, 2011).

¹⁰³ See Cheung *et al.*, (2010:88) and Hung and Cheung (1995:282) for more on the non-synchronous trading problem.

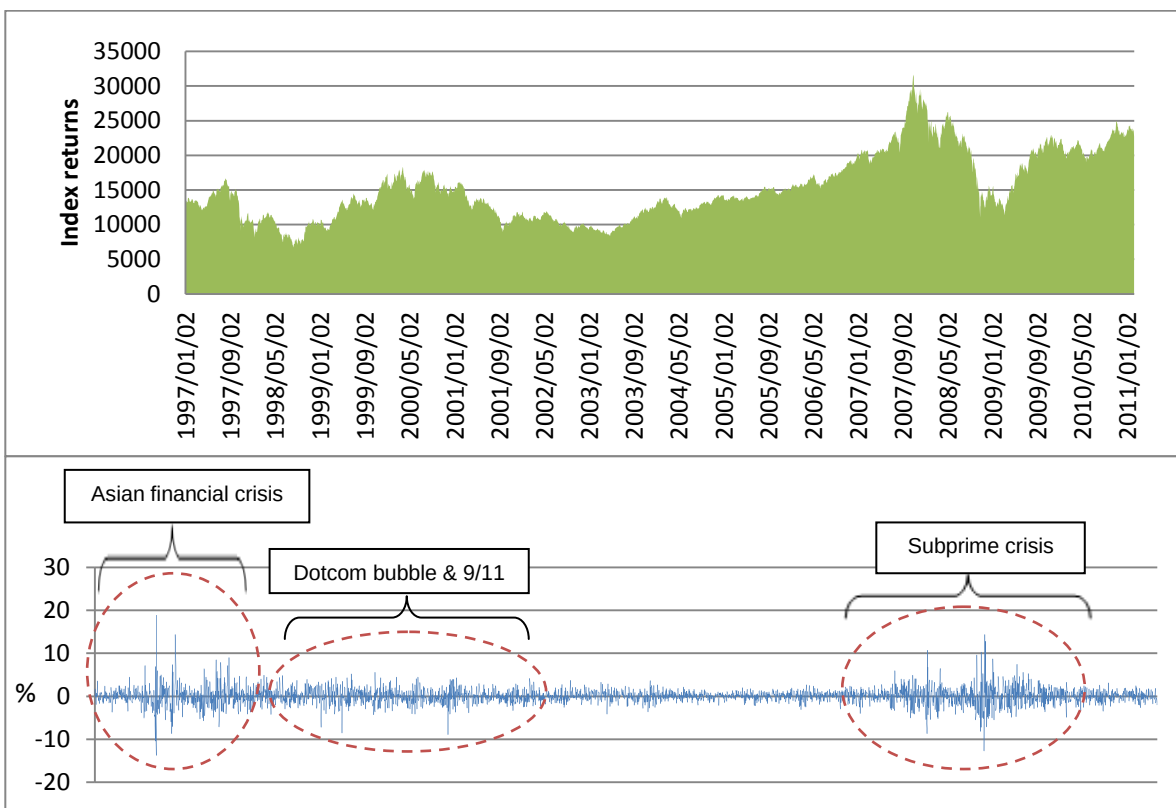
¹⁰⁴ The index returns are in local currency.

Figure 4.1 The daily JSE returns and daily percentage change



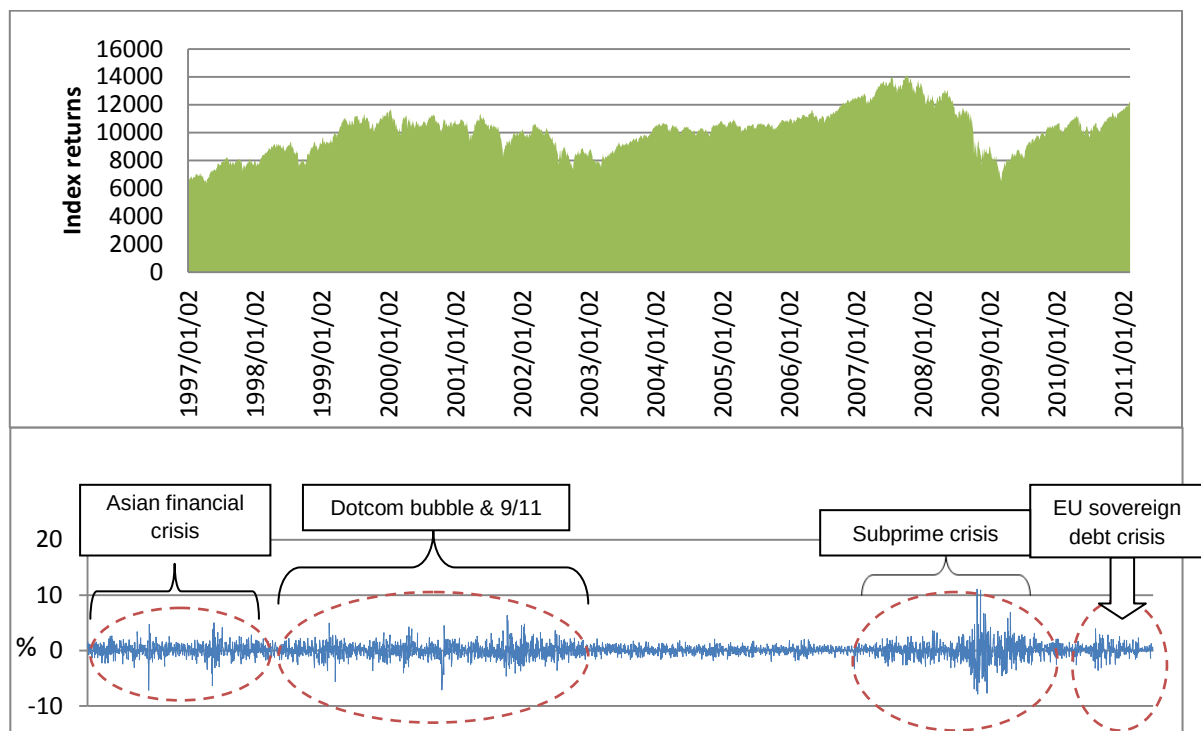
Source: Compiled by the author

Figure 4.2 The daily HSI returns and daily percentage change



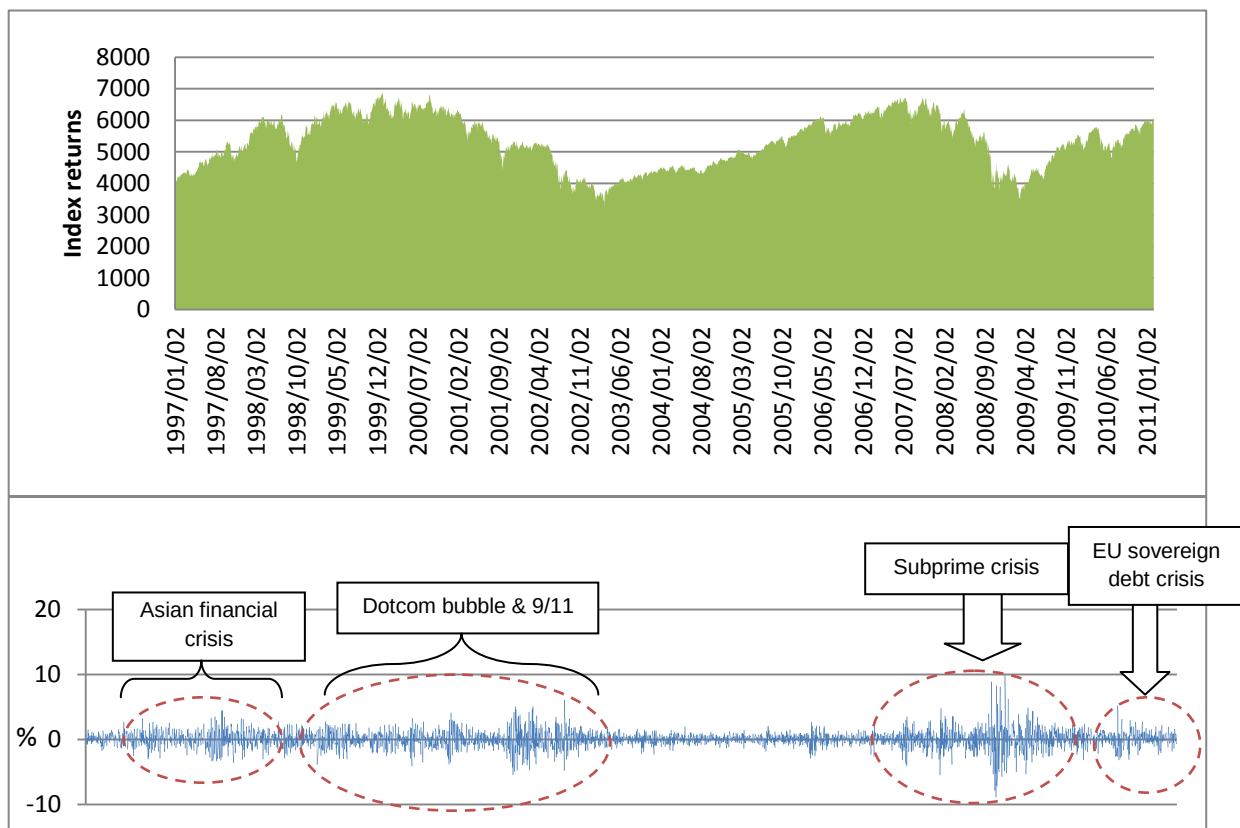
Source: Compiled by the author

Figure 4.3 The daily DJIA returns and daily percentage change



Source: Compiled by the author

Figure 4.4 The daily FTSE 100 returns and daily percentage change



Source: Compiled by the author

Figures 4.1 to 4.4 depict the daily percentage change in the index returns and provide a snapshot of the volatility in returns at its highest. The crises pertaining to this study have all been highlighted in these figures. It can be seen from the figures that the degree of volatility in each market varies according its country/region of origin. For example, the daily volatility in returns around the period of the Asian financial crisis is higher on the HSI relative to the FTSE 100, whereas the volatility as a result of the EU sovereign debt crisis is clearly visible on the FTSE 100 but does not even appear to have affected the HSI in any significant manner. As this study investigates international financial market integration and volatility transmission, it is relevant to note that all the indices exhibit heightened levels of stress during the underlying crisis periods. Although the figures demonstrate unsurprising results and are a crude measurement, they provide evidence of an integrated international financial market system. The characteristics of this integration and how they change as a result of a financial crisis were investigated.

A number of statistical inference procedures are first presented before describing the empirical methods employed within this study and presenting their results.

Tables 4.2 to 4.4 provide an overview of the descriptive statistics for the various data sets. These include mean, median, minimum and maximum values, standard deviation, skewness and kurtosis of the returns.

Table 4.2 Summary statistics for the Asian financial crisis period

Exchange	Obs.	Mean	Maximum	Minimum	Std. dev.	Skewness	Kurtosis
JSE	312	-0.13983	0.186494	-0.071921	0.028859	-0.613124	13.5907
HSI	312	0.001386	0.129340	-0.168645	0.036789	-0.567162	5.364921
FTSE 100	312	0.002125	0.055497	-0.059526	0.017568	-0.300363	3.666002
DJIA	312	0.003137	0.065945	-0.089390	0.018290	-0.688836	5.472157

Source: Compiled by the author

Table 4.3 Summary statistics for the dotcom bubble and the 9/11 attacks period

Exchange	Obs.	Mean	Maximum	Minimum	Std. dev.	Skewness	Kurtosis
JSE	260	0.001239	0.064520	-0.135655	0.028739	-1.014810	6.255994
HSI	260	-0.000753	0.129340	-0.105174	0.035736	0.167561	3.765894
FTSE 100	260	-0.001378	0.070335	-0.071921	0.022111	-0.106510	3.583232
DJIA	260	-3.62E-05	0.077802	-0.111871	0.023369	-0.454357	5.432913

Source: Compiled by the author

Table 4.4 Summary statistics for the subprime financial crisis period

Exchange	Obs.	Mean	Maximum	Minimum	Std. dev.	Skewness	Kurtosis
JSE	423	0.002679	0.097471	-0.093164	0.024067	-0.446264	4.413247
HSI	423	0.001729	0.109175	-0.124827	0.028506	-0.525053	5.832158
FTSE 100	423	0.000797	0.079275	-0.124937	0.020370	-1.030839	7.939038
DJIA	423	0.000688	0.067732	-0.156799	0.019157	-1.652988	14.79408

Source: Compiled by the author

It can be seen from the tables that the maximum and minimum values highlight the high level of volatility in returns. Under the period reviewed for the subprime crisis, for example, the JSE returns moved between a weekly minimum value of approximately -0.093164 and a maximum value of 0.097471. The same trend can be seen for the DJIA between this period, with a fluctuation between -0.156799 and 0.067732. With regard to standard deviation, a widely used statistic to capture volatility, the JSE exhibited its highest volatility during the dotcom crisis and 9/11 attacks, and its lowest variation in returns occurred during the subprime financial crisis. Finally, all the kurtosis statistics are larger than 3, which indicate that returns are more peaked and have fatter tails than normal distributions.¹⁰⁵

Stationarity is an important concept with regard to time series processes (Asteriou & Hall, 2007:231). When a variable is non-stationary, incorrect conclusions can easily be made since the assumptions of the classical linear regression model are violated, and therefore any t-test, F-test and R-squared values become unreliable (Asteriou & Hall, 2007:295). The order of integration of a time series reveals more information about its stationarity. A series y_t is integrated to the order of one and contains a unit root, if y_t is non-stationary and Δy_t is stationary (Asteriou & Hall 2007:290). A non-stationary time series y_t might need to be differenced more than once to make it stationary (Asteriou & Hall, 2007:291).

An Augmented Dickey–Fuller test (ADF) was utilised to test the stationarity of each data variable. The results obtained from performing the ADF test on all the study's data sets indicated that the null hypothesis of a unit root could be rejected, as the probability of the t-statistic was smaller than 0.05 ($p < 0.05$). This confirmed that no unit root is present in any of the data sets and that the data is stationary. Accordingly, the data sets did not need to be differenced in order to induce stationarity.

4.3.2 Research methodology and empirical results

After the ADF test, the presence of heteroskedasticity was tested for. Heteroskedasticity is an important statistical inference measure, since it affects the distribution of the parameter

¹⁰⁵ This is referred to as a leptokurtic distribution as these distributions have excess kurtosis.

estimators, and makes the estimators of the ordinary least squares (OLS) inefficient (Asteriou & Hall, 2007:116). Heteroskedasticity also impacts hypothesis testing in that neither the t-statistic nor the F-statistic is reliable in its presence (Asteriou & Hall, 2007:116). After obtaining OLS results, White's test was used to test for heteroskedasticity. The null hypothesis of heteroskedasticity was rejected, as all of the p-values were significantly lower than the 5% level of statistical significance.

As mentioned in Chapter 1, this study aimed to determine how the relationship, in terms of market efficiency, information flows and market integration between the South African equity market and global equity markets evolves as a result of the occurrence of a financial crisis. The latest crisis that originated in the US has had widespread effects on global markets and provides a unique opportunity to gather new insights into the ever-changing global market interdependence and transmission effects of financial risk.¹⁰⁶

The empirical study will be divided into two parts. The first part will focus on the nature of influence between the afore-mentioned markets by implementing Granger causality tests on the respective market indices. The second part of the empirical study will focus on establishing the level of volatility transmission between the respective indices. The level of volatility transmission was investigated by applying an AS model to each crisis period. This study employed a similar methodology to the one used by Lin *et al.*, (1994) and Samouilhan (2006) with regard to the use of an AS model.

4.3.2.1 Granger causality

Most early studies on market interdependencies and contagion effects relied on upon testing market indices with the Granger causality methodology. However, this approach only captures the unidirectional transmission (mean returns) from larger markets to smaller markets. In contrast to this, and as seen in section 4.2, advances in ARCH and GARCH models have made it possible to study the conditional volatility of equity markets and determine the future volatility of equity returns based on the provision of past volatilities and returns shocks (Worthington & Higgs, 2004:2). Nevertheless, the Granger causality test facilitates a greater understanding of the direction in and speed at (number of days) which one market affects the other, and is therefore be used to establish the level of market integration between the markets studied.

¹⁰⁶ This includes market risk, credit risk, liquidity risk, operational risk, reputation risk, volatility risk, settlement risk and profit risk, which ultimately leads to systemic risk.

A time series X is said to Granger-cause Y , if it can be shown that those X values provide statistically significant information about future values of Y . Conventionally, the Granger causality test involves the testing of the null hypothesis that x_t does not cause y_t , by constructing the following two regressions (Asteriou & Hall, 2007:285):

$$\Delta y = \sum_{i=1}^m a_i y_{t-i} + \sum_{j=1}^n b_j x_{t-j} + e_t, \quad (4.1)$$

$$y = \sum_{i=1}^m a_i y_{t-i} + e_t. \quad (4.2)$$

where testing $b_i = 0$ for every i , and the assumption is that the disturbances are uncorrelated. The unidirectional causality from international markets (HSI, DJIA, and FTSE 100) to the South African market (JSE) was tested. For international markets to Granger-cause the JSE, the estimated coefficients on the lagged international indices' values must be statistically different from zero, and the estimated coefficients on the lagged JSE values must not be statistically different from zero (Gujarati, 2003:697). The results of the Granger causality test are presented in Tables 4.5 and 4.8. The period under review is the same as presented in Table 4.1.

Table 4.5 Granger causality between the HSI and JSE

Null hypothesis	Obs.	F-statistic	Prob.
HSI returns did not Granger-cause JSE returns	310	0.69689	0.499
JSE returns did not Granger-cause HSI returns		0.29514	0.745

Source: Compiled by the author

Table 4.5 indicates the causality between the HSI and the JSE for the period studied under the Asian financial crisis. The results presented above demonstrate that the null hypothesis must be accepted at the 5% level of statistical significance. This means that there was no Granger causality from the JSE to the HSI for the period before, during or after the Asian financial crisis.¹⁰⁷

Table 4.6 Granger causality between the DJIA and JSE

Null hypothesis	Obs.	F-statistic	Prob.
DJIA returns did not Granger-cause JSE returns	258	0.18058	0.835
JSE returns did not Granger-cause DJIA returns		0.45088	0.638

Source: Compiled by the author

¹⁰⁷ Granger causality tests were also conducted on both the FTSE 100 and DJIA for the same period. The null hypotheses of no Granger causality were not rejected at the 5% level of significance.

Table 4.6 indicates very similar results for Granger causality between the DJIA and the JSE during the dotcom bubble and 9/11 attacks.¹⁰⁸ The number of lags according to the SC dropped from two to one. Since weekly data was used in this study, this can be interpreted as a greater speed (one week as opposed to two weeks) of transmission between the JSE and DJIA.

Table 4.7 Granger causality between the FTSE 100 and JSE

Null hypothesis	Obs.	F-statistic	Prob.
FTSE 100 returns did not Granger-cause JSE returns	421	1.45309	0.235
JSE returns did not Granger-cause FTSE 100 returns		0.38457	0.681

Source: Compiled by the author

Table 4.7 shows the results for Granger causality between the FTSE 100 and JSE for the subprime financial crisis period. It demonstrates that the null hypothesis for Granger causality tests conducted on both the FTSE 100 and JSE could not be rejected at the 5% level of statistical significance. Thus, the FTSE 100 did not Granger-cause the JSE after one week. The JSE also did not Granger-cause the FTSE 100 since the probability of the f-statistic is larger than the 5% level of statistical significance.

Table 4.8 Granger causality between the DJIA and JSE

Null hypothesis	Obs.	F-statistic	Prob.
DJIA returns do not Granger-cause JSE returns	421	4.14843	0.016
JSE returns do not Granger-cause DJIA returns		1.66651	0.190

Source: Compiled by the author

The results of the Granger causality test between the DJIA and the JSE for the subprime crisis period differ from that for the periods of the dotcom bubble and 9/11 attacks. Although there was still no Granger causality from the JSE to the DJIA, the DJIA did Granger-cause the JSE at the 5% level of statistical significance.

In summarising the results of the Granger causality tests and in anticipation of the E-GARCH volatility transmission results, it can already be concluded that there was a greater level of market integration during the subprime crisis from both the US and London, as opposed to earlier crisis periods such as the Asian financial crisis and the dotcom bubble.¹⁰⁹ Given this, the following section will focus on volatility and its transmission characteristics before, during and after the occurrence of international financial crises.

¹⁰⁸ The null hypotheses were accepted at the 5% level of significance for Granger causality tests conducted on both the HSI and FTSE 100 for the same period.

¹⁰⁹ Once again, the benchmark being the South African equity market (JSE).

4.3.2.2 The Aggregate Shock (AS) model

The AS model follows a two-step procedure through which the fitted values of e_t and σ_t^2 in equations 4.3 and 4.5, respectively, are obtained. These fitted values are then substituted into equations 4.4 and 4.6, respectively, before presenting and interpreting the estimated equations. In the AS model, the foreign weekly returns on a foreign market is specified as:

$$FWR_t = \alpha_1 + \beta_1 FWR_{t-1} + e_t, \quad (4.3)$$

where FWR is the foreign weekly return for period t , and e_t captures the factors that affect returns that are unexplained by the autocorrelation of the current weekly returns with the previous weekly returns (persistence). Unlike Lin *et al.*, (1994) and Samouilhan (2006), no Monday/holiday dummy was used since weekly data was employed in this study. Thus, it was assumed that efficient markets e_t represents that part of returns that cannot be anticipated based on available public information when equity trading is initiated at the start of each week.

Domestic weekly returns on the JSE for the same period t can be modelled as:

$$JWR_t = \alpha_2 + \beta_2 JWR_{t-1} + \phi e_t + \mu_t. \quad (4.4)$$

Equation 4.4 includes a coefficient ϕ , which represents the relationship between the foreign returns and the JSE returns. The error term e_t now represents the unexplained returns on the foreign equity market for period t . An E-GARCH (p, q) process was used in order to determine the level of volatility transmission between a foreign equity market and the JSE. It was assumed that the error term e_t in equation 4.3 is normally distributed with a mean of zero and a variance that follows an E-GARCH (p, q) process:

$$\ln \sigma_{f,t}^2 = \varpi_1 + \beta_3 \ln \sigma_{f,t-1}^2 + \gamma_1 \frac{e_{f,t-1}}{\sigma_{f,t-1}} + \alpha_1 \frac{|e_{f,t-1}|}{\sigma_{f,t-1}}, \quad (4.5)$$

where the natural log of the conditional variance for e_t for period t is a function of the time-invariable mean reversion value, ϖ , the natural log of the past conditional variance, $\sigma_{f,t-1}^2$,

the level of the standardised residuals, $\frac{e_{f,t-1}}{\sigma_{f,t-1}}$, and absolute value of the standardised residuals, $\frac{|e_{f,t-1}|}{\sigma_{f,t-1}}$. The subscript f denotes foreign.¹¹⁰

Finally, it was assumed that the error term of the JSE weekly returns μ_t is also normally distributed with a mean of zero and a variance that follows an E-GARCH (p, q) process:

$$\ln \sigma_{j,t}^2 = \varpi_2 + \beta_4 \ln \sigma_{j,t-1}^2 + \gamma_2 \frac{e_{j,t-1}}{\sigma_{j,t-1}} + \alpha_2 \frac{|e_{j,t-1}|}{\sigma_{j,t-1}} + \kappa_i \sigma_{f,t}^2. \quad (4.6)$$

The model specification of the variance of the JSE in equation 4.6 includes a foreign measure, $\sigma_{f,t}^2$, which allows for testing of the relation between local volatility and foreign volatility. The $\kappa_i \sigma_{f,t}^2$ term in equation 4.6 is the foreign conditional variance term, and denotes the relation between local volatility and foreign volatility. The inclusion of the terms $\frac{e_{j,t-1}}{\sigma_{j,t-1}}$ and $\frac{|e_{j,t-1}|}{\sigma_{j,t-1}}$ makes it possible to model the asymmetric volatility to past shocks as long as $\gamma_2 \neq 0$. If $\gamma_2 < 0$ then negative shocks (bad news/negative past errors) will have a greater effect on volatility than positive shocks (good news/positive past errors). When $\gamma_2 > 0$ the opposite is true.

Different lag specification models were estimated for each data set and the appropriate lag specification for the E-GARCH (p, q) term was chosen, where the Akaike information criterion (AIC) and SC values were minimised. The AIC is computed as (QMS, 2009):

$$AIC = -2 \frac{l}{T} + 2 \frac{k}{T} \quad (4.7)$$

The SC is an alternative to the AIC and imposes a larger penalty for additional coefficients (QMS, 2009):

¹¹⁰ That is HSI, DJIA and FTSE 100.

$$SC = -2 \frac{l}{T} + \frac{k \log T}{T}, \quad (4.8)$$

where:

l is the value of the log likelihood function;

T is the number of observations; and

k is the number of parameters.

The various information criteria are all based on -2 times the average log likelihood function, adjusted by a penalty function.

The AS model presented above allowed the testing of the relationship between both returns (price) and volatility on the JSE and a foreign equity market. The results are presented in Tables 4.9 to 4.11.

Table 4.9 Aggregate Shock (AS) model: Asian financial crisis

Mean equation						
		Variable	Coefficient	AIC	SC	
Pre-crisis	HSI	JSER_LAG1	0.115057 ⁺	-5.394843	-5.139044	
		HS_Resid	0.116428 ⁺			
	FTSE 100	JSER_LAG1	0.173575	-5.774960	-5.544741	
		FTSE_Resid	0.295083 ⁺			
	DJIA	JSER_LAG1	0.268958 ⁺	-5.741285	-5.511066	
		DJIA_Resid	0.108428			
Crisis	HSI	JSER_LAG1	0.325771 ⁺	-4.665154	-4.407803	
		HS_Resid	0.308893 ⁺			
	FTSE 100	JSER_LAG1	0.316962 ⁺	-4.532848	-4.301233	
		FTSE_Resid	0.565967 ⁺			
	DJIA	JSER_LAG1	0.280279 ⁺	-4.786115	-4.580235	
		DJIA_Resid	0.772546 ⁺			
Post-crisis	HSI	JSER_LAG1	0.179751 ⁺	-5.164878	-4.933263	
		HS_Resid	0.240596 ⁺			
	FTSE 100	JSER_LAG1	0.396402 ⁺	-5.068214	-4.836599	
		FTSE_Resid	0.639708 ⁺			
	DJIA	JSER_LAG1	0.348039 ⁺	-5.221857	-4.990242	
		DJIA_Resid	0.668734 ⁺			
Variance equation						
		ϖ_2	α_2	γ_2	β_4	K
Pre-crisis	HSI	-3.188005 ⁺	0.858207 ⁺	-0.224185 ⁺	-0.609476 ⁺	0.129670
	FTSE 100	-12.73294	0.118036	-0.021304	-0.912926 ⁺	-1.169959
	DJIA	-1.125422 ⁺	-0.673511 ⁺	-0.130911	0.799676 ⁺	0.016340 ⁺

Crisis	HSI	-2.783223 ⁺	0.416242 ⁺	0.033207	-0.935809 ⁺	0.452934 ⁺
	FTSE 100	-3.576616	0.133048	0.220867 ⁺	-0.904542 ⁺	1.904123 ⁺
	DJIA	0.409028	-0.882990 ⁺	-0.267214 ⁺	0.690756 ⁺	0.266102 ⁺
Post-crisis	HSI	-13.36954 ⁺	0.865809 ⁺	-0.208204	0.251737	-0.358347
	FTSE 100	0.298028	0.830331 ⁺	-0.225958	-0.148103	1.298376
	DJIA	-1.373688	0.410986	-0.155554	0.905456 ⁺	-0.031653

_RESID → is the relationship between foreign equity market returns and JSE returns; ϖ_2 is the invariable mean reversion value; α_2 indicates the past conditional variance; γ_2 captures the asymmetric function of volatility; β_4 indicates the volatility persistence; κ^* captures the level of volatility transmission; ⁺ signifies that the particular coefficient is statistically significant at the 5% level.

Source: Compiled by the author

From the mean equation results in Table 4.9, it is evident that the effect of weekly international returns on the JSE was positive during all periods (pre-crisis, crisis and post-crisis) of the Asian financial crisis.¹¹¹ This positive association indicates that positive returns on the foreign exchanges were related to positive returns on the JSE and negative foreign returns with negative returns on the JSE for the specific periods under review. During the pre-crisis period, a 1% increase in the weekly HSI returns was followed by a 0.116% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns resulted in a 0.295% increase in the weekly JSE returns, and the returns transmission from the DJIA was not statistically significant from zero. During the crisis period, a 1% increase in the weekly HSI returns led to a 0.309% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns resulted in a 0.566% increase in the weekly JSE returns, and the weekly returns on the JSE rose by 0.773%, following a 1% rise in the weekly DJIA returns. During the post-crisis period, a 1% increase in the weekly HSI returns led to a 0.241 increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns led to a 0.640% rise in the weekly JSE returns, and a 1% rise in the weekly DJIA returns was associated with a 0.669% increase in the weekly JSE returns. It is evident that the returns association between the foreign markets and the JSE increases from the pre-crisis period to the crisis period, before decreasing to lower levels during the post-crisis period. The only exception is the increase in the strength of the relationship between the FTSE 100 and the JSE throughout the full period. The reason for this increase in co-movement between the FTSE 100 and the JSE might be explained by the strong trade relations between the two markets.

By making use of the E-GARCH model, it was also possible to measure the volatility characteristics of the JSE in terms of the influence of foreign markets on the local equity

¹¹¹ The only exception was the returns transmission of the DJIA during the pre-crisis period.

exchange. The γ_2 parameter in the E-GARCH model measures the asymmetry or the leverage effect of volatility. Only three statistically significant volatility leverage effects were measured during the Asian financial crisis. During the pre-crisis period, the volatility on the HSI had a negative asymmetric effect on the JSE, suggesting that negative returns on the HSI had a greater effect on the degree of current JSE volatility. Thus, volatility on the HSI and JSE showed a greater reaction to negative shocks (bad news) than to positive shocks (good news). The FTSE 100 had the opposite effect on the JSE during the crisis period, with positive returns on the FTSE 100 having a greater effect on the magnitude of current volatility when compared with negative past errors. Thus, positive shocks (good news) have a greater impact on the volatility of the markets than negative shocks (bad news). The DJIA returns displayed a negative asymmetric effect on its own volatility and that of the JSE during the Asian financial crisis.

The β_4 coefficient indicates the degree of volatility persistence. The majority of volatility persistence coefficients were significant during the Asian financial crisis period.¹¹² All the coefficients were found to be smaller than one, which according to Xu and Fung (2005) is a requirement for the volatility persistence terms to be stable. A high level of volatility persistence implies that fluctuations will remain in the markets for an extended period. This will lead to greater uncertainty amongst market participants.

A heightened level of uncertainty has important consequences for risk management resulting in higher volatility of equity returns, since investor decisions are based on expectations. During the pre-crisis period, the coefficients were significantly different from zero in all the cases. The FTSE 100 exhibited the highest level of volatility persistence, whereas the HSI demonstrated the lowest volatility persistence. During the crisis period, the coefficients were all statistically significant. The HSI exhibited the highest level of volatility persistence,¹¹³ followed closely by the FTSE 100 and the DJIA. During the post-crisis period, the DJIA had the only statistically significant volatility persistence coefficient. This implies that post-Asian financial crisis market participants became less uncertain, which resulted in lower levels of volatility. This was confirmed by the results obtained for the volatility transmission effects.

During the build-up to the Asian financial crisis there was only one statistically significant instance of volatility transmission from foreign markets to the JSE. The DJIA transmitted an

¹¹² Exceptions occurred after the crisis period, when the HSI and FTSE 100 results were not statistically different from zero.

¹¹³ This is not surprising because one expects the country in which a crisis originates to have the greatest direct impact on foreign markets.

increase of 0.016 units in weekly volatility to the JSE for every unit increase in the weekly volatility experienced on the DJIA. This relatively calm period was reversed during the height of the crisis. The estimated volatility transmission between all the foreign markets studied and the JSE was positive. Thus, higher volatility on the HSI, FTSE 100 and DJIA was associated with higher levels of volatility on the JSE, whereas the opposite was true for lower levels of volatility. The volatility on the JSE increased by 0.453 units for every unit increase in the current week's volatility on the HSI. The FTSE 100, in contrast, had an even greater effect on the JSE with regard to volatility transmission. An increase of 1 unit in volatility on the FTSE 100 resulted in an increase of 1.90 units in volatility on the JSE during the same trading week. This is more than four times the amount of transmission compared with the HSI during the same period. As mentioned under the analysis of the returns transmission, this may be attributable to the strong trade relations between the UK and South African markets. The DJIA appeared to have had the smallest volatility transmission effect. An increase of 1 unit in the level of weekly volatility on the DJIA resulted in an increase of 0.266 units in the weekly volatility of the JSE.

The results from the AS model on both the dotcom bubble and 9/11 attacks will now be presented in table 4.10.

Table 4.10 Aggregate Shock (AS) model: Dotcom bubble and 9/11 attacks

Mean equation					
		Variable	Coefficient	AIC	SC
Pre-crisis	HSI	JSER_LAG1	0.361609 [†]	-4.774859	-4.568979
		HS_Resid	0.319801 [†]		
	FTSE 100	JSER_LAG1	0.465179 [†]	-4.864175	-4.606825
		FTSE_Resid	0.484040 [†]		
	DJIA	JSER_LAG1	0.361009 [†]	-4.824082	-4.592467
		DJIA_Resid	0.720080 [†]		
Crisis	HSI	JSER_LAG1	0.224175 [†]	-4.851133	-4.646494
		HS_Resid	0.467684 [†]		
	FTSE 100	JSER_LAG1	0.289610 [†]	-5.116471	-4.886252
		FTSE_Resid	0.828935 [†]		
	DJIA	JSER_LAG1	0.211744 [†]	-5.086827	-4.882188
		DJIA_Resid	0.770123 [†]		
Post-crisis	HSI	JSER_LAG1	-0.009624	-5.340837	-5.034913
		HS_Resid	0.447205 [†]		
	FTSE 100	JSER_LAG1	-0.095398	-5.272295	-4.928131
		FTSE_Resid	0.445093 [†]		
	DJIA	JSER_LAG1	-0.124157	-5.063228	-4.719063
		DJIA_Resid	0.364311 [†]		

		Variance equation				
		ϖ_2	α_2	γ_2	β_4	κ
Pre-crisis	HSI	0.044523 ⁺	-0.343006 ⁺	-0.199718 ⁺	0.877760 ⁺	0.113255 ⁺
	FTSE 100	-1.108305 ⁺	0.279982 ⁺	-0.016988	-0.964468 ⁺	0.159347 ⁺
	DJIA	-2.320788	-0.965949 ⁺	-0.229532	0.564753 ⁺	0.148709
Crisis	HSI	-6.191407 ⁺	0.309562	-0.081476	0.698898 ⁺	-0.508712
	FTSE 100	-0.186970	0.663289 ⁺	-0.045922	0.857691 ⁺	0.169092
	DJIA	-1.437978	0.426708	-0.113700	0.877750 ⁺	-0.015597
Post-crisis	HSI	-2.450434	-1.161065	-0.580848 ⁺	0.628073 ⁺	-0.035282
	FTSE 100	-1.457877 ⁺	-0.779706	-0.504668 ⁺	0.630484 ⁺	0.095643
	DJIA	-2.174746 ⁺	-1.114500 ⁺	-0.641931 ⁺	0.440437 ⁺	-0.016537

_RESID → is the relationship between foreign equity market returns and JSE returns; ϖ_2 is the invariable mean reversion value; α_2 indicates the past conditional variance; γ_2 captures the asymmetric function of volatility; β_4 indicates the volatility persistence; κ captures the level of volatility transmission; ⁺ signifies that the particular coefficient is statistically significant at the 5% level.

Source: Compiled by the author

From the results presented in Table 4.10, it can be concluded that there was a positive association in terms of the effect of weekly international returns on the JSE during the dotcom bubble and 9/11 attacks. As mentioned earlier, positive returns on the foreign exchanges were related with positive returns on the JSE, and negative foreign returns with negative returns on the JSE for the specific periods under review. During the pre-crisis period, a 1% increase in the weekly HSI returns was followed by a 0.32% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns led to a 0.484% increase in the weekly JSE returns, and a 1% increase in the weekly DJIA returns resulted in a 0.72% rise in the weekly JSE returns. During the crisis period, a 1% increase in the weekly HSI returns resulted in a 0.468% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns led to a 0.829% rise in the weekly JSE returns, and a 1% increase in the DJIA weekly returns was followed by a 0.770% rise in the weekly JSE returns. Once again, during the post-crisis period, there was a decline in the returns transmission between the foreign markets and the South African market. However, the returns transmission is still higher than the pre-crisis period. This demonstrates that the level of market integration in terms of the returns effect between the markets studied changed before, during and after the occurrence of the dotcom bubble and 9/11 attacks. During the post-crisis period, a 1% increase in the weekly HSI returns was followed by a 0.447 increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns led to a 0.445% rise in the weekly JSE returns, and a 1% rise in the weekly DJIA returns resulted in a 0.364% increase the weekly JSE returns.

In terms of the leverage effect regarding volatility during the dotcom bubble and 9/11 attacks, there were only four instances in which the coefficients were statistically different from zero. In all these instances, $\gamma_2 < 0$, which indicates that negative shocks (bad news) generated more volatility than positive shocks (good news). The HSI had a negative asymmetric effect on the JSE during the pre-crisis period, which suggests that negative returns on the HSI had a greater effect on the degree of current JSE volatility than positive HSI returns. There was no statistically significant leverage effect emanating from any foreign market during the crisis period. After the occurrence of the crisis, negative returns on the HSI, FTSE 100 and DJIA had a greater effect on the magnitude of volatility compared with positive past errors.

The volatility persistence coefficients were all statistically significant for the entire period under review. Once again all the coefficients were found to be smaller than one, and thus stable (Xu & Fung, 2005). For the pre-crisis period, the HSI had the highest level of volatility persistence, whereas the FTSE 100 exhibited the lowest level of volatility persistence. During the crisis period, however, the FTSE 100 became the market with highest level of volatility persistence. As expected, the DJIA exhibited its highest level of volatility persistence during the dotcom crisis and 9/11 attacks. This implies that market participants became more uncertain with regard to their returns expectations on the DJIA,¹¹⁴ which resulted in higher levels of volatility. The uncertainty appeared to subside once the crisis had passed. All the markets displayed lower levels of persistence after the crisis than during the crisis period. This was confirmed by the results obtained for the volatility transmission effects.

There was little evidence of volatility transmission from the foreign markets to the JSE for period studied. Only the HSI and FTSE 100 exhibited statistically significant volatility transmission effects and only during the pre-crisis period. Again, the estimated volatility association between these foreign markets and the JSE was positive, with higher volatility on the HSI and FTSE 100 being associated with higher levels of volatility on the JSE. For every increase of 1 unit in the current week's volatility on the HSI, volatility on the JSE increased by 0.113 units. An increase of 1 unit in the weekly volatility of the FTSE 100 resulted in an increase of 0.159 units in the level of volatility on the JSE. Contrary to what was expected, there were no statistically significant transmission effects other than those displayed during the pre-crisis period. The evolving nature of the financial crises could be a possible explanation for this. Sections 4.5 and 4.6 will explore this explanation.

¹¹⁴ The US was the country of origin for the crises considered under this period.

Table 4.11 Aggregate Shock (AS) model: Subprime financial crisis

Mean equation						
		Variable	Coefficient	AIC	SC	
Pre-crisis	HIS	JSER_LAG1	0.150512 [†]	-5.413724	-5.293769	
		HS_Resid	0.634137 [†]			
	FTSE 100	JSER_LAG1	0.154587 [†]	-5.553061	-5.418111	
		FTSE_Resid	0.809065 [†]			
	DJIA	JSER_LAG1	0.313844 [†]	-5.505182	-5.355238	
		DJIA_Resid	0.848428 [†]			
Crisis	HIS	JSER_LAG1	0.091556	-4.575435	-4.369554	
		HS_Resid	0.505593 [†]			
	FTSE 100	JSER_LAG1	0.185535 [†]	-4.885811	-4.628461	
		FTSE_Resid	0.926402 [†]			
	DJIA	JSER_LAG1	0.082779	-4.649164	-4.443283	
		DJIA_Resid	0.949747 [†]			
Post-crisis	HIS	JSER_LAG1	0.001427	-5.594491	-5.312791	
		HS_Resid	0.682467 [†]			
	FTSE 100	JSER_LAG1	0.138798 [†]	-6.254104	-5.937191	
		FTSE_Resid	0.797100 [†]			
	DJIA	JSER_LAG1	0.117936 [†]	-6.200731	-5.919031	
		DJIA_Resid	0.959037 [†]			
Variance equation						
		ϖ_2	α_2	γ_2	β_4	$\mathcal{K}$
Pre-crisis	HIS	-0.13885	0.124647	-0.267279 [†]	0.814653 [†]	0.183990
	FTSE 100	-1.500617	0.191373 [†]	-0.175871 [†]	0.803277	0.119694
	DJIA	-1.700118	-0.125481	-0.146392	0.825084 [†]	0.049000
Crisis	HIS	-2.029136	0.443367	-0.220249	0.619170	0.189579
	FTSE 100	-1.090671	-0.342205	0.177139	0.712848 [†]	0.404097 [†]
	DJIA	-7.566540 [†]	-0.503650	-0.361794	-0.266195	0.224039
Post-crisis	HIS	0.109226	0.622599	0.150565	-0.880100 [†]	2.168421
	FTSE 100	-1.199483	1.056827	-0.010911	0.820789 [†]	0.124944
	DJIA	-14.32175 [†]	0.199259	-0.120371	-1.005560 [†]	0.606586

$\text{_RESID} \rightarrow$ is the relationship between foreign equity market returns and JSE returns; ϖ_2 is the invariable mean reversion value; α_2 indicates the past conditional variance; γ_2 captures the asymmetric function of volatility; β_4 indicates the volatility persistence; κ captures the level of volatility transmission; [†] signifies that the particular coefficient is statistically significant at the 5% level.

Source: Compiled by the author

From the results of the AS model for the subprime crisis presented in Table 4.11, it is clear that once again there was a positive association with regard to the weekly international returns, where positive returns on the foreign exchanges were related to positive returns on the JSE and negative foreign returns were related to negative returns on the JSE. During the

pre-crisis period, a 1% increase in the weekly HSI returns resulted in a 0.634% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns was followed by a 0.809% increase in the weekly JSE returns, and a 0.848% rise in the weekly JSE returns was preceded by a 1% rise in the weekly DJIA returns. During the crisis period, a 1% increase in the weekly HSI returns led to a 0.506% increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns resulted in a 0.926% increase in the weekly JSE returns, and a 1% increase in the weekly DJIA returns weekly returns was followed by a 0.950% rise in the weekly JSE returns. After the crisis period, a 1% increase in the weekly HSI returns was followed by a 0.682 increase in the weekly JSE returns, a 1% increase in the weekly FTSE 100 returns resulted in a 0.797% rise in the weekly JSE returns, and a 1% rise in the weekly DJIA returns led to a 0.960% increase in the weekly JSE returns.

From the results on the returns transmission, it is apparent that during the post-crisis period there were still very high levels of transmission in returns from the foreign markets to the South African market. Although there was a decrease in returns transmission from the FTSE 100 compared with the crisis period, returns transmission from the HSI and the DJIA increased during the post-crisis period. A possible explanation may be that the post-subprime crisis period of one year may not be sufficient time for the markets to return to their mean transmission value. However, this period was deliberately selected in order to eliminate any impeding and on-going negative effects caused by the European sovereign debt crisis, as well as problems related to the downgrading of US treasury ratings.

With regard to the leverage effect of volatility during the subprime crisis, only the HSI and FTSE 100 were statistically different from zero. This was recorded during the pre-crisis period and in both instances, $\gamma_2 < 0$, which indicated that negative shocks (bad news) generated more volatility than positive shocks (good news).

Volatility transmission from the foreign markets to the JSE was less prevalent during the whole period of the subprime crisis studied compared to earlier crises. Only the FTSE 100 exhibited statistically significant volatility transmission to the JSE during the crisis period. The estimated volatility association between the FTSE 100 and the JSE was positive, with higher volatility on the FTSE 100 being associated with higher levels of volatility on the JSE. An increase of 1 unit in the weekly volatility of the FTSE 100 was associated with an increase of 0.404 units in the weekly level of volatility on the JSE.

4.3.2.3 Discussion of main findings of the empirical study

As mentioned previously, the objective of this study was to determine returns and volatility transmission effects from international markets to South Africa in order to acquire a better understanding of how the South African equity market (JSE) reacts to international financial crises through price and volatility transmission. It was thus important to interpret the results obtained from the empirical study in terms of crisis transmission theories, and to establish whether the interaction between the international equity markets studied and the JSE are of an interdependent or contagious nature. Increased correlation between equity markets during periods of financial turmoil signifies contagion (Bongiglioli & Favero, 2005:1300), whereas correlation between equity markets during periods of financial stability signifies interdependence between markets (Daly, 2003:74). Fundamental economic factors are transmitted more rapidly between countries owing to stronger financial and trade linkages between countries, and this has led to an increase in price co-movements and contagion between countries (Chan-Lau *et al.*, 2004:390). The US and the UK are consistently within the top three of South Africa's main trading partners by value (SARS, 2010). Between 1998 and 2008, a number of EU members were ranked within the top ten trading partners of South Africa. During this same period Japan and China were South Africa's main trading partners from the Asian region. From a financial linkage perspective, foreigners are actively involved in South African financial markets through direct participation in the equity and bond market, amongst others.¹¹⁵ A large percentage of the top forty companies listed on the JSE are also listed and actively traded on international equity markets.¹¹⁶ This market feature has resulted in a greater co-movement in returns between these markets.

During the Asian financial crisis, there was an increase in returns transmission between international equity markets and the JSE during the pre-crisis period compared with both the crisis and post-crisis periods. The returns transmission from the FTSE 100 increased after the crisis period. In terms of volatility transmission, only the HSI and FTSE 100 exhibited statistically significant volatility transmission. This occurred during the crisis period, which makes it possible to conclude that there was a significant contagion effect from the crisis country to the South African equity market. As is the case with the FTSE 100, it appears that the hypothesis of trade and financial linkages may be accepted in explaining the contagion and transmission effect. Investor behaviour with regard to risk aversion during the crisis period and negative emerging-market sentiment after the crisis period, may further explain the nature of the contagion effects present during the Asian financial crisis. With regard to the nature of the volatility transmission experienced, all statistically significant transmissions

¹¹⁵ In 2010, foreigners were net purchasers of R36 billion in equities and R58 billion in bonds (JSE, 2011).

¹¹⁶ Examples include Old Mutual, Anglo American, BHP Billiton, Sasol and Investec.

were asymmetric. Thus, negative shocks (bad news) had a greater impact on volatility than positive shocks (good news).

The results on the returns transmission during the dotcom bubble and 9/11 attacks indicate the presence of contagion effects between the international equity markets and the JSE. Returns transmission was highest during the crisis period compared with the pre- and post-crisis periods. Although there was an increase in transmission from all the markets, the returns transmission from the FTSE 100 to the JSE nearly doubled after the pre-crisis period. All the markets studied reveal statistically significant volatility transmission to the JSE during the pre-crisis period, with only the DJIA transmitting its volatility during the crisis period. Compared with the pre-crisis period the volatility transmission, from the DJIA to the JSE, increased significantly. This could be due to the originating country¹¹⁷ experiencing both a financial crisis and a political crisis during this crisis period. Unfortunately, it is difficult to measure the impact of the 9/11 attacks in terms of price and volatility transmission in isolation because of its timing.¹¹⁸ Once again, all the theories of crisis transmission hold between the JSE and the FTSE 100 with regard to returns transmission and between the JSE and the DJIA in terms of volatility transmission. In the latter case, investor behaviour might have been influenced not by a negative emerging-market sentiment as experienced during the Asian financial crisis, but rather a general flight to more secure asset classes. Such herding behaviour appears to be a likely explanation for investor behaviour during the 9/11 attacks. This assumption was confirmed by the results on the nature of the volatility transmission. The transmission from the DJIA is asymmetric, which, as previously mentioned, indicates that negative shocks (bad news) have a greater impact on volatility than positive shocks (good news).

The analysis of the subprime crisis period revealed contagion effects in returns transmission from the FTSE 100 and DJIA to the JSE compared with the pre-crisis period. The HSI only exhibited a contagion effect during the post-crisis period, when the returns transmission from the FTSE 100 declined towards pre-crisis levels. The returns transmission from the DJIA, however, remained very close to the level experienced during the period. The latter may be due to the crisis originating in the US, even though its reach, through financial innovation, was widespread. The results on volatility transmission however indicate that there was no direct statistically significant effect on the South African equity market from the originating crisis country. The only statistically significant volatility transmission, which occurred during

¹¹⁷ In this case, the US.

¹¹⁸ In their study of volatility transmission patterns and terrorist attacks, Chulia *et al.*, (2008) found volatility transmission between the US and Eurozone equity markets, but noted that the 9/11 attacks occurred during a severe economic downturn.

the crisis period, was from the FTSE 100. This observation may once again be attributed to the historical trade ties that exist between South Africa and the EU. For this reason, it can be assumed that trade and indeed financial linkages were the main causes of the volatility transmission between the FTSE 100 and JSE.¹¹⁹ Naturally, investor behaviour as mentioned in the context of the Asian financial crisis would have been a contributing factor, as investors tried to shield themselves from excessive losses. Once again, the volatility exhibited an asymmetric effect during the subprime crisis. The only statistically significant cases were recorded during the pre-crisis period and were from the HSI and FTSE 100.

Given the main findings from studying the price and volatility transmission during three international financial crises, the following assertions can be made:

- During the manifestation of an international financial crisis, the JSE was directly affected through contagion effects inherent in the returns of the originating crisis country.
- Trade and financial linkages and linkages related to investor behaviour were the main causes of the transmission of contagion effects during a financial crisis.
- Volatility transmissions appear to have only arisen directly from the originating crisis country or region during the Asian financial crisis.
- The FTSE 100 was the main exporter of price and volatility transmission to the JSE.
- When comparing the magnitude of the volatility transmission from the FTSE 100 experienced during the Asian financial crisis with the magnitude experienced during the subprime crisis, there appears to have been a decrease compared to the initial transmission.
- Although the composition of the Asian financial crisis and the subprime crisis may not be identical, these crises share many similarities.¹²⁰ This may indicate a positive evolution in terms of the regulation of the South African financial markets in protecting the financial system from instability originating outside the borders of South Africa.

The following sections will shift the focus towards the fundamental factors that influence the current and future financial system. A brief discussion of the regulatory environment shaped by past and current financial crises will be given in Section 4.5, and the sections thereafter

¹¹⁹ In 2007, foreigners were net sellers of R5.5 billion in equities and R841 million in bonds. This sell-off by foreigners continued during 2008, with net sell-offs of R429 million in equities and R1.6 billion in bonds (JSE, 2011). It is evident that there was an initial flight from equities at the onset of the crisis, and a reversal into bonds a year later.

¹²⁰ A real estate bubble at the heart of each crisis is one example.

will provide an indication of how these regulations will alter the future structure of financial markets and their functioning.

4.4 The evolving global financial system

The financial crisis that originated in the US's subprime mortgage market in 2007 quickly evolved into a global financial crisis after spreading to Europe. The financial turmoil affected the economic activity and financial systems in nearly all countries around the globe. Understanding the volatility transmission of equities across countries is essential for a number of reasons. Portfolio management activities, such as asset allocation and equity selection, may be greatly improved through greater knowledge about return transmission effects that result from transmission mechanisms. Profitable trading strategies may result from the existence of transmission effects in returns, and may indicate evidence against market efficiency. It may thus be possible to learn more about the efficiency of a particular market through transmission mechanisms. For example, it is not possible to forecast the returns of an individual company's equity with the lagged returns of another company's equity when the specific market is efficient and without a time-varying risk premium. Information about the effects of volatility transmission is valuable to financial market practitioners, particularly those who rely on conditional volatility estimates (Ogum, 2010:3).¹²¹ Information about how a preceding crisis evolved may also be of great assistance to financial market participants, since risk management can be improved in anticipation of future crises.

Five distinct stages can be identified during the period preceding a crisis and its eventual bust (De Haan *et al.*, 2009:339):

- credit expansion, characterised by rising assets prices;
- euphoria, characterised by overtrading;
- distress, characterised by unexpected failures;
- discredit, characterised by liquidation; and
- panic, characterised by a flight for cash.

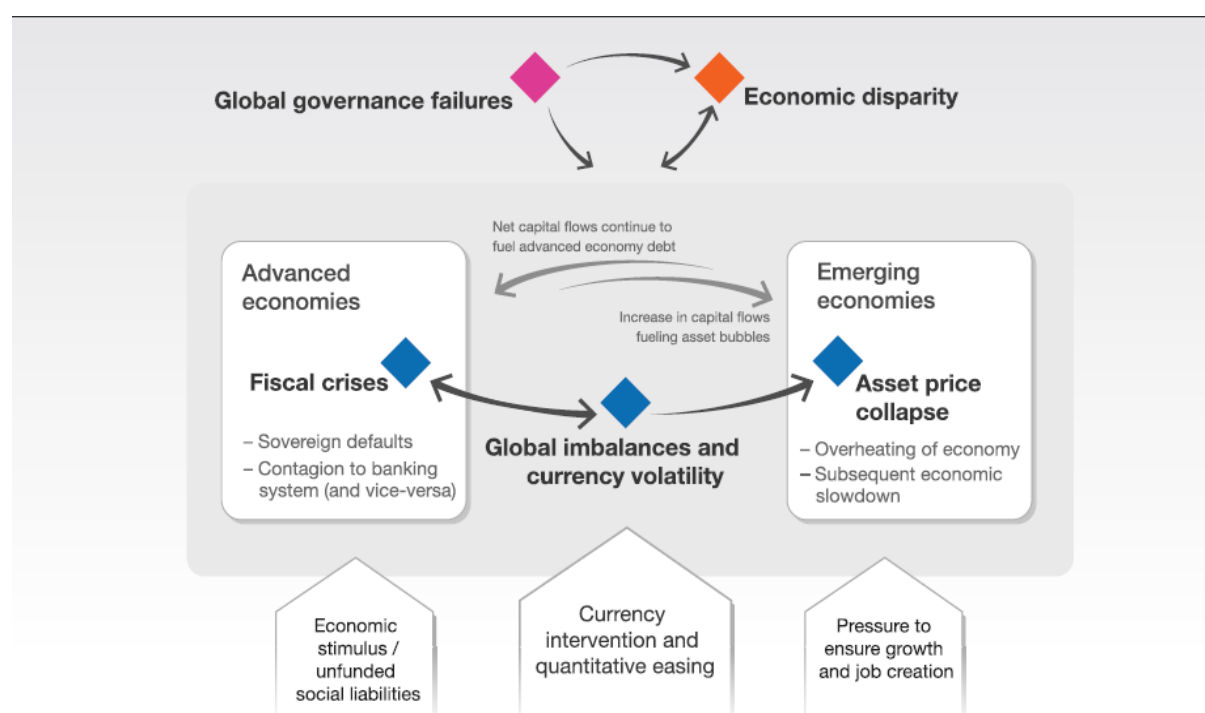
Financial systems (especially the banking sector) exhibit certain characteristics that make them prone to systemic risk (De Haan *et al.*, 2009:339). The economic activities of banks with regard to the maturity mismatches between their assets (loans) and liabilities (deposits), the interconnectedness of financial institutions and markets, and the information intensity of

¹²¹ These include portfolio optimisation, the pricing of options, and Value at Risk and hedging functions.

financial contracts and credibility problems, are all characteristics that make the financial system more susceptible to systemic risk.

In a macro-economic environment, systemic risk refers to a situation in which certain events trigger a loss of economic value or confidence in the financial system, which may result in substantial adverse effects on the real economy (De Haan *et al.*, 2009:334). Figure 4.5 presents three current economic risks identified in the “Global Risks 2011” report of the World Economic Forum (WEF, 2011). Global imbalances and currency volatility, fiscal crises and asset price collapse are all results of internal and external imbalances. External imbalances include the carry-trade for example where a quest for higher yields by countries with high savings rate creates a distortion in the flow of money around global financial systems (see section 2.4.1). Internal imbalances (within a specific country) are created by a variety of factors, which include government policies and the behaviour of the private sector (WEF, 2011:14).

Figure 4.5 Risks associated with macro-economic imbalances

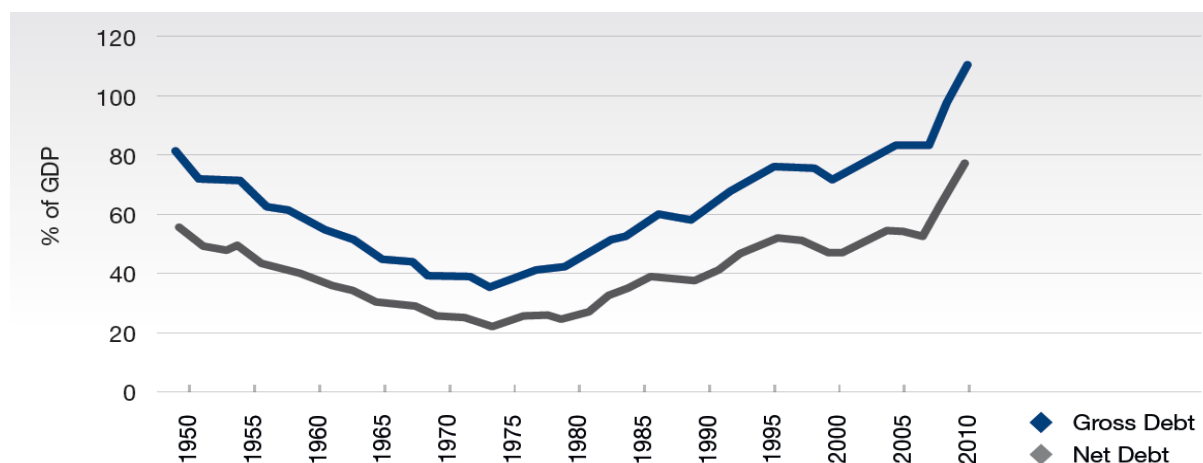


Source: World Economic Forum (2011:15)

Fiscal imbalances are an example of internal risks faced by certain economies currently and are a result of the extravagant spending by their respective governments in response to economic threats faced as a consequence of the global financial crisis. Large bailout packages for banks, efforts to stabilise the financial sector, and unprecedented fiscal

stimulation to alleviate the impact of a contracting economy have ensured expanding deficits and escalating debt-to-GDP ratios, shown in Figure 4.6.

Figure 4.6 The average government debt-to-GDP ratios in the G7 economies (purchasing power parity weighted)



Source: World Economic Forum (2011:16)

From figure 4.6, there appears to have been a substantial increase in government debt levels since the year 2000 which evidently coincides with the occurrence of the subprime financial crisis presented in this study. There are distinct debt-to-GDP thresholds at which debt growth becomes non-linear (Reinhart & Rogoff, 2010:1). The threshold for public debt held by developed and emerging economies is approximately 90%; thereafter, the debt burden reduces average GDP growth by more than one percentage point (Reinhart & Rogoff, 2010). Financial markets have recently been plagued by risk and uncertainty regarding spiralling government debt levels, particularly within the EU,¹²² affecting economic growth through increased borrowing costs and a need for fiscal austerity (WEF, 2011:17).

Apart from the imbalances within developed economies, external imbalances between countries are also creating some uncertainties, such as a mismatch between savings and investment.¹²³ This situation should not be too much of a concern especially in a globalised world, as capital is supposed to flow to the most productive economic use, including often problematic¹²⁴ cross-border capital flows (WEF, 2011:14). However, as mentioned in

¹²² Portugal, Ireland, Greece and Spain (collectively referred to in the financial media as “the PIGS”) have experienced soaring public debt levels and have subsequently placed the Economic and Monetary Union of the EU under severe financial pressure. Debt-to-GDP ratios for these troubled economies vary between 142% of GDP for Greece and 60% of GDP for Spain (CNN, 2011).

¹²³ This mismatch is that deficit countries save less than their investment requirements, and surplus countries have trouble investing their high savings.

¹²⁴ Especially for the economies of emerging countries, since these capital flows can have negative effects on the economy when there is a sudden reversal in the flow of capital, as seen during the Asian financial crisis.

Chapter 2, external imbalances become problematic once they contribute to an unsustainable accumulation of debt or foreign reserves. Slow growth and an increasing accumulation of debt and fiscal pressures have the ability to create risks of sovereign defaults and destabilise the global financial system.

In response to the global economic slowdown that followed the defaults in US subprime mortgages, there has been a noticeable unwinding in leverage or global imbalances¹²⁵ that were built up over the past twenty years (WEF, 2009:8). Inevitably, this unwinding has introduced a new era in the global financial system, which is characterised by the following factors: de-leveraging and a global economic slowdown, increased government intervention and a possible reversal in the pace of globalisation.

The noticeable price decline in credit and equity markets followed from the de-leveraging actions of bankers and investors, and greater risk aversion and increased credit standard requirements made it more difficult for companies to finance their operations. Even with the introduction of various fiscal packages by governments of industrialised countries, a shift from excessive consumption towards increased private savings, rising default rates and declining house prices resulted in a slowdown in economic growth. Other government interventions in response to the global financial crisis included emergency lines of credit, short-term liquidity injections, government guarantees on interbank loans, negotiated bank acquisitions and in some cases nationalisations. The ultimate outcome of these actions is that governments continue to require significantly increased levels of financial regulation and oversight in exchange for the risk undertaken from their national banking sectors (WEF, 2009:17).

However, the attempts of central banks to recapitalise national banking systems and replace liquidity in the financial system in effect transferred most of the leverage and financial risk to their respective national balance-sheets (WEF, 2009:17). The substantial scale of intervention by central banks made it necessary for governments to provide special financing packages, which led to strained national fiscal positions, and raised the threat of sovereign defaults and intervention by the IMF (WEF, 2009:18). Furthermore, as the financial crisis spreads towards recently opened economies and new risks emerge from current shifts in economic balances,¹²⁶ interventions such as capital controls and regulating the flow of

¹²⁵ These include excessive financial deregulation, expansionary monetary and fiscal policies, and disproportionate credit utilisation.

¹²⁶ In the current economic environment, which is characterised by, for example, low interest rates in Western developed countries, capital flows are being driven towards higher-yielding emerging market countries, resulting

money may limit growth and investment opportunities for financial institutions, and increase the cost of debt (WEF, 2009:19).

4.5 The future structure and regulatory framework of the financial system

The main concern for financial market policymakers is maintaining financial market stability. The expansion and liberalisation of financial systems in recent decades has resulted in financial stability receiving greater prominence than before (De Haan *et al.*, 2009:334). This expansion and liberalisation of financial systems can be summarised as three distinct issues. Firstly, the growth of financial systems outpaced the growth of the real economy, subsequently increasing the importance of financial markets to the real economy. Since the total financial assets in a country generally represent a fraction of GDP, a financial crisis has the potential to create substantial fiscal costs and output losses. Apart from direct losses to shareholders, creditors, insurance funds, employees and uninsured depositors, a banking crisis may force a government to undertake major and expensive restructuring of its banking system (De Haan *et al.*, 2009:341). Economic activity may also be further depressed when a banking crisis leads to a credit crunch. Secondly, the increasing complexity of financial systems has made it more difficult to assess the underlying financial risks and vulnerabilities inherent in the financial system (De Haan *et al.*, 2009: 334). Such an example is the subprime crisis, during which market participants found it difficult to assess the true distribution of financial risks. Finally, greater cross-border integration and the amalgamation of financial intermediaries have resulted in financial markets and participants becoming increasingly interlinked (De Haan *et al.*, 2009:334).

A typical response to any crisis and indeed the current international financial crisis is minimising the probability of a similar crisis occurring in the future. By analysing the chain of events and factors that led up to the creation of a particular crisis, policymakers aim to understand and avert the creation of another crisis. The main tool through which policymakers avert another crisis is regulation. The most recent examples of these are the Volcker Rule¹²⁷ and Dodd-Frank Wall Street Reform and Consumer Protection Act.¹²⁸ These regulations were set in place in response to events during the subprime crisis to better

in the possible risk of a sudden reversal in capital flows. This is similar to the situation that occurred during the Asian financial and subprime crises.

¹²⁷ The Volcker Rule is legislation aimed at protecting individuals, by increasing the transparency of financial markets. The Volcker Rule places trading restrictions on financial institutions by separating the investment banking, private equity, and hedge fund functions from their consumer services business.

¹²⁸ The Dodd-Frank Act was drafted to prevent the collapse of major financial institutions, such as happened with Lehman Brothers at the peak of the subprime crisis. This is to be achieved by increasing government oversight of trading in complex financial instruments. The reform act also establishes government agencies to number banking practices of troubled financial institutions, in an attempt to protect unsuspecting borrowers against unfair lending and mortgage practices.

govern financial markets and in particular the less regulated shadow activities of banks and other financial institutions that formed part of the creation of the subprime crisis fallout.¹²⁹ As financial markets evolve and become more complex, the regulations governing these market activities also need to evolve, and be ahead of the evolutionary curve. There are a number of future regulatory proposals that will likely alter the future structure of the financial system, the most prominent of which is Basel III.

The proposed Basel III regulations, which are expected to be enforced by 2019, seek to achieve greater supervision of the liquidity risks faced by financial institutions and, in particular, banks. Initially, banks will be required to hold common equity to the value of 4.5% of their risk weighted assets (RWA) by the start of 2015. Thereafter (by 2019), banks will need to hold a 2.5% capital conservation buffer of common equity for use in periods of financial stress.

A second proposal, a “new Bretton Woods” system, is also being investigated (Boughton, 2009:44). Regulatory authorities have proposed a change to the current international financial architecture by enhancing the role of the IMF, improving surveillance of complex financial markets and helping to prevent excesses being built up in the future.

A further proposal is the merger between the Bank for International Settlements (BIS), the IMF and the Financial Stability Board (FSB) to create the International Financial Stability Fund. This supranational regulator would facilitate co-ordination amongst international regulators based on the principles of risk management, transparency, and stronger crisis resolution mechanisms.

Finally, there appears to be a move towards unifying a fragmented financial market regulatory and supervisory system. The de Larosière report (de Larosière, 2009) proposes the formation of a new European framework for safeguarding financial stability from a regulatory and supervisory perspective. The proposal of the de Larosière report centres on establishing an oversight system that encompasses the macro-prudential and micro-prudential assessment of the financial system into a central European Systemic Risk Council (de Larosière, 2009:46).

¹²⁹ It should be noted that these regulations were drawn up at the height of the subprime crisis and it may be argued that they were set in place to calm market jitters rather than improve the overall governance of financial markets. At the time of writing, these regulatory measures were limited to the US financial market. Nevertheless, since these regulations have been implemented their impact on the future structure of financial markets is evident.

With regard to the local financial system, South Africa's sound regulatory system played an important role in limiting the effects of the subprime crisis on the local financial system (IMF, 2010:1). Factors that contributed to shielding the local financial system from instability were a well-capitalised financial sector and limited exposure of domestic financial institutions to risky foreign assets such as subprime asset-backed securities and CDSs (IMF, 2010:5). In order to ensure the future stability of the South African financial system, the South African government has proposed the Financial Markets Bill (Cobbett, 2010). The Bill proposes a broad reform of rules and regulations in the financial sector aimed at increasing the stability of banks and insurers, and at improving under-regulated products and institutions such as OTC derivatives and hedge funds, under a single Financial Markets Bill.

The most noteworthy proposals to be presented for public comment under the Bill are (Cobbett, 2010):

- focus on the entire system – Reserve Bank to implement a macro-prudential approach, rather than focus only on the risks of individual institutions;
- establish a Council for Financial Regulators, jointly chaired by the Minister of Finance and the Reserve Bank Governor, that would oversee all regulatory agencies in the financial sector;
- ensure prudential regulation of banking and insurance – institute stricter financial regulation requirements (capital requirements, liquidity and leverage ratios);
- promote greater regulator independence;
- hedge fund and derivatives brokers – proposed replacement of the existing Securities Services Act with the Financial Markets Bill, and the introduction of a Credit Rating Services Bill, aimed at under-regulated products and institutions such as OTC derivatives and hedge funds.

In summary, from an international and South African perspective, there appears to be a shift towards greater interventionist regulatory frameworks. These frameworks place emphasis on restructuring the under-regulated financial market sector and requiring banks to move away from complex shadow banking systems towards a more transparent banking model. The main aim by financial market authorities appears to be the facilitation of easier regulation, oversight and protection.¹³⁰ Ultimately, the increased level of regulation is aimed at reducing financial market uncertainties and thus volatility.

¹³⁰ In response to an increasing international trend regarding the safekeeping of investors' securities ownership, the South African Central Securities Depository (STRATE) created a segregated depository account to increase client and investor protection in the event of default by one of its participants (STRATE, 2011:4).

4.6 Conclusion

This chapter detailed the analysis of the nature of price and volatility transmission experienced by the South African equity market. Firstly a short overview of the most prominent studies on volatility transmission was presented. This provided an opportunity to trace the evolution of the study of volatility transmission and provide a background to the research methodology followed within this study. Weekly returns data for each of the respected markets and studied periods was employed. The required statistical inference was completed before commencing with the empirical analysis. The Aggregate shock (AS) model was presented under the research methodology before presenting the final empirical results.

The FTSE 100 appears to have had the biggest influence on price and volatility transmission to the JSE. It was found that the South African equity market experienced contagion effects during the crisis periods studied. These effects came directly from but were not limited to the countries in which the particular crisis originated. The price and volatility transmissions were found to have spread as a result of trade and financial linkages, and investor behaviour intensified the effects across borders.

The future structure of financial markets and their functioning was highlighted. The remaining sections focused on the fundamental factors that influence the current and future financial system by providing a brief overview of the regulatory environment shaped by past and current financial crises. Finally, it was found that South African regulators were successful in shielding the local financial system from direct instability caused by international financial crises studied.

Chapter 5

Study conclusion

5.1 Introduction

Financial crises offer a practical situation for the study of volatility characteristics because the variation of equity market returns differ significantly during crisis periods relative to a stable equity market environment. This study examined the volatility effects of three international equity markets and the South African equity market during three financial crises spanning different periods in order to determine how the relationship, in terms of market efficiency, information flows and market integration between these equity markets and the South African equity market evolved as a result of the occurrence of a financial crisis.

Chapter 5 will present a brief review of the three main subjects of this study. Firstly, a general background of each financial crisis studied will be provided in Section 5.2 with regard to underlying causes, general effects and transmission channels. Thereafter, the focus will shift towards volatility in Section 5.3. This will be followed by the study's empirical findings in section 5.4. Section 5.5 will present a summary of the future structure of financial markets, given current and proposed regulation in response to recent market turmoil. This study will conclude with suggestions for future research in Section 5.6.

5.2 Study review: Financial crisis

Disruptions to the efficient functioning of financial markets can result in the increased cost of financial intermediation, curb the availability of an economic lifeline in the form of credit restrain activity in the real sector of the economy, and eventually expose a country to periods of low growth and/or economic recession. The study of financial crises has revealed an analogous and reoccurring trend: a variety of different but interacting market distortions acted as detonators to each bubble. The effects on the global economic environment appeared to vary according to the underlying nature of each crisis. Although financial crises are distinctively individual in nature, there appears to be various similarities in characteristics, such as a boom in asset prices, debt accumulation, current account deficits and a lack of risk management. However, the reach and economic recovery after each crisis, appears to be evolving as the modern financial world becomes more interconnected. This interconnectedness results in crisis transmission between the country in which the crisis originated and international markets. Three main categories of crisis transmission channels were discussed: trade linkages, financial linkages and linkages based on investor behaviour.

5.3 Study review: Volatility

Financial stability is greatly affected by volatility, and during an international financial crisis, financial stability is of paramount importance not only in the particular crisis country, but also in countries that have trade relations with the crisis country concerned. Investor confidence, the capital structure of companies, liquidity of equity markets, the cost of hedging, and efficient capital allocation are all factors affected by the volatility of financial markets. Asset price volatility reflects the process of risk pricing and risk transfer according to changes in the underlying market conditions. Volatility can lead to financial market instability, which can result in real costs to the financial system when sudden increases in volatility, rather than sustained high levels of volatility, are a feature of a particular financial market.

Economic uncertainty in the form of real interest rates, the level of the risk premium and the expected level of inflation may influence the level of asset prices and transform financial market volatility into financial market instability. The structure of financial markets, in particular market liquidity, financial innovation and financial market integration, plays an important role in determining financial market volatility. Measuring the level of financial market volatility is another essential component in managing volatility risk. The ARCH family of models provide a measure of volatility that can be implemented in financial decisions pertaining to risk analysis, portfolio selection and derivative pricing.

5.4 Study review: Volatility transmission

Data on the volatility of returns in financial markets offer supplementary information to data on returns alone. Returns volatility provides useful data on information flow and suggests that price volatility has important implications for information linkages between markets. Investors base their decisions on information and their behaviour may cause an economic shock to be transmitted between countries that do not share common macro-economic risk factors. Apart from information linkages, which are of significant importance to financial market participants, trade and financial linkages are essential in transmitting fundamental economic factors across borders. These linkages have a direct impact on the co-movements of returns and spread contagion between countries. In this study, price and volatility transmissions were found to spread as a result of trade and financial linkages.

5.5 Summary of results

The aim of this study was to contribute to the improved understanding of how the South African equity market interacts with international equity markets, by identifying the degree of

price and volatility transmission before, during, and after an international financial crisis. The possibility of changes in the nature of price and volatility transmissions as a result of these crises was at the centre of this study. An AS model, that incorporated an E-GARCH (p, q) process to determine the level of volatility transmission between a foreign equity market and the JSE, was applied in seeking to achieve the study's objective.

The main findings from studying the price and volatility transmission during three international financial crises can be summarised as follows. There was an increase in returns transmission between international equity markets and the JSE during the pre-Asian financial crisis period compared with both the Asian financial crisis and post-Asian financial crisis periods. The returns transmission from the FTSE 100 increased after the crisis period. The HSI and FTSE 100 were the only markets that exhibited statistically significant volatility transmission. This occurred during the crisis period, which makes it possible to conclude that there was a significant contagion effect from the crisis country to the South African equity market.

The returns transmission during the dotcom bubble and 9/11 attacks indicated the presence of contagion effects between the international equity markets and the JSE. In comparison to the pre- and post-crisis periods, returns transmission was highest during the crisis period. Although there was an increase in transmission from all the markets studied, the returns transmission from the FTSE 100 to the JSE nearly doubled during the crisis period compared with the pre-crisis period. All the markets revealed statistically significant volatility transmission to the JSE during the pre-crisis period, but only the DJIA transmitted its volatility during the crisis period. The volatility transmission from the DJIA to the JSE increased 16-fold compared with the pre-crisis period.

The study of markets during the subprime crisis period revealed increased returns transmission effects to the JSE from both the FTSE 100 and DJIA. The HSI only exhibited an increased contagion effect during the post-crisis period, when the returns transmission from the FTSE 100 declined towards pre-crisis levels. In contrast, the returns transmission from the DJIA remained very close to the level observed during the crisis period. No direct statistically significant volatility transmission was found between the South African equity market and the originating crisis country. The FTSE 100 was the only market to exhibit statistically significant volatility transmission to the JSE during the crisis period.

In summary, it was found that the South African equity market experienced contagion effects, inherent in the returns of the originating crisis country, during the crisis periods

studied. Volatility transmissions during the international financial crises studied arose directly from the originating crisis country. The FTSE 100 was the main exporter of price and volatility transmission to the JSE.

There appears to be a positive evolution in terms of the regulation of the South African financial markets in protecting the financial system from instability originating outside the borders of South Africa. With regard to the future regulatory environment, from an international and South African perspective, there appears to be a shift towards greater interventionist regulatory framework. This will place emphasis on the restructuring of the alternative financial market sector and require banks to move away from complex shadow banking systems towards a more transparent banking model that facilitates easier regulation and oversight.

5.6 Recommendations for future research

Although the intention has been to provide a study of the South African equity market that is as up to date and relevant as possible, there are additional avenues that fall beyond the scope of this particular study that can be recommended for future research. These are:

- A detailed study of the effect of international financial crises on other South African financial markets, for example the bond market, foreign exchange market and money market, could be conducted.
- A hypothetical but realistic mix of portfolios that combine different financial instruments could be compiled in order to assess which combination of financial instruments is the most suitable for investors to hold in times of heightened financial stress.
- The policy and regulatory structure of the South African financial market could be compared to that of other international markets.
- Finally, alternative methods for testing price and volatility transmission could be pursued, and compared with these findings. The biggest limitation of this study is centred on the empirical methodology implemented which cannot distinguish with certainty whether volatility is influenced by financial or political factors. Alternative testing methods might provide useful insight in this regard.

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