Liberalisation of capital controls: A review of South African exchange controls and their impact on exchange rate stability

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by

Tendai Ndemera

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Supervised by: Professor Nicholas Biekpe
Co-Supervised by: Valeri Sokolovski

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Abstract

The 2007/08 global financial crisis, including pre- and post-crisis reform, led economies to re-examine the concept of capital controls. Theoretical and empirical literature has been divided regarding their effectiveness. This research paper assesses the impact of capital controls on exchange rate stability in South Africa (particularly exchange restrictions[1] used to insulate economies from excessive currency volatility) using time series analysis and employs event study methodology (Kothari & Warner, 2006; MacKinlay, 1997) to measure the impact of the capital control actions. More specifically, this research paper evaluates the impact of capital controls on (a) exchange rate returns, (b) volatility and (c) liquidity in South Africa for the period commencing 1 January 1999 to 31 December 2014 including the period during the 2007/08 financial crisis. The research paper applies methodology from empirical research on capital controls and currency stability (Pandey, Pasricha, Patnaik, & Shah, 2015), volatility using standard deviation and the GARCH (1,1) model (Abdalla, 2012; Bollerslev, 1986; Farrell, 2001) and liquidity (Karnaukh, Ranaldo, & Söderlind, 2015). In addition, it attempts to determine the effect on exchange rate movements directly attributable to capital controls i.e., the local factors, by removing the dollar risk factor that constitute a significant portion of exchange rate time series as noted by Verdelhan (2015), which serves as the base model for the event study. The research paper finds that overall the key capital controls selected do not have a significant impact on the ZAR/USD exchange rate with limited evidence of an effect on returns, volatility and liquidity.

[1] As indicated in the International Monetary Fund (IMF) Annual report on exchange arrangements and exchange restrictions (AREAER), October 2014

CHAPTER 1: INTRODUCTION

1.1. BACKGROUND

Numerous emerging economies utilise capital controls to protect themselves from the negative effects of external shocks. However, financial liberalisation seeks to lessen or remove these controls and allow for the market mechanism to function effectively without undue government or regulatory intervention. Similar to the view by Abdalla (2012), the reserve bank, by announcing or implementing changes such as capital controls which impact the currency can change aspects such as the returns or volatility of the exchange rate through this intervention. Various financial crises present evidence that some regulation is required, especially when markets fail or as a tool to rectify crises[2] (Edison & Reinhart, 2000). This allows for the regulators to rectify market imperfections (Krugman, 1998). Studies on capital controls, exchange rate volatility and the corresponding reduction in vulnerability to external shocks by Edwards & Rigobon (2009) concluded that restrictions on inflows depreciate exchange rates and increase exchange rate volatility. However, the exchange rate becomes less sensitive to external shocks.

This research paper evaluates the impact of capital controls on exchange rate returns, volatility and liquidity in South Africa for the period commencing 1 January 1999 to 31 December 2014 including the period during the 2007/08 financial crisis. The year 2009[3] was included as part of the financial crisis period for the analysis as the effects of the crisis were still prevalent. In addition, policy modifications to address the effect of the crisis were in progress during this period (Čihák, Demirgüç-Kunt, Peria, Martinez, & Mohseni-Cheraghlou, 2012; International Monetary Fund, 2011; Motsi, 2015). It should be noted that the South African Rand had collapsed in 2001[4], thus the 2002 – 2006 period coincides with a period where South African authorities deemed capital controls particularly necessary and implemented them, contrary to the opposing views by some authors (Gidlow, 2005). The period 2007 - 2009 was used as a

[2] Financial and currency crises

[3] The year 2009 was included as part of the sudden stop for the analysis as the crisis spilled over into this year and the effects of it were still highly prevalent (Čihák et al., 2012; International Monetary Fund, 2011). The intention was to remove any effects it would have to skew the results of the analysis. See IMF AREAER, October 2014 for sudden stops and Mendoza (2010) for more insights on Sudden Stops, Financial Crises, and Leverage

[4] The Myburgh Commission had been investigating the fall of the rand in 2001 with emphasis on the exchange control system and how it could be effectively administered owing to the removal or relaxation of exchange control regulations. Republic of South Africa, Myburgh Commission of Inquiry into the fall of the rand, Pretoria, 2002

sudden stop phase and reference point to test the effectiveness of capital controls on exchange rate volatility, i.e., effects before and after a crisis to test the robustness of these controls in response to a major external shock. Event study methodology (Kothari & Warner, 2006; MacKinlay, 1997), recent literature on the carry and dollar factor (Verdelhan, 2015), exchange rate volatility (Abdalla, 2012; Bollerslev, 1986; Dukich, Kim, & Lin, 2010; Farrell, 2001; Nelson, 1992; Nelson & Foster, 1994; Ross, 2013) and liquidity (Bangia, Diebold, Schuermann, & Stroughair, 2002; Karnaukh et al., 2015; Mancini, Ranaldo, & Wrampelmeyer, 2013) were used to further refine the approach.

1.2. PROBLEM DEFINITION

Most studies on capital controls in developing or emerging economies tended to focus on the following:

a. As noted by Glick & Hutchison (2005, 2011) and Gross (2008), numerous empirical studies assess the impact of capital controls on economic variables (e.g. interest differentials, growth, inflation, capital flows and output). Limited research has been performed to assess the effects of capital controls on exchange rate stability or currency volatility for developing countries (Abdalla, 2012), let alone a large sub-Saharan economy that has experienced gradual and sequenced easing of capital controls;
b. Capital controls on inflows as the economies intended to stabilise a countries currency to attract foreign direct investment (FDI) and much needed funds that would enhance growth. As such, there was less focus on outflows or net flows in general. FDI is an important element of the South African government's economic policy (Chowdhury & Wheeler, 2008; Mohamed, 2006); and
c. Finally, the empirical studies lacked a common methodology and approach in terms of variables and their measurement and placed significant emphasis on a few country instances (mostly Chile and Malaysia). This is one of the four problems[5] of capital control literature noted by Magud et al. (2005, 2011) and a view shared by Gross (Gross, 2008, p.

[5] The four problems that complicate the comparison across empirical and theoretical research are mentioned in the articles by Magud et al. (2005, 2011) are as follows: (1) the is no universally adopted theoretical approach to assess the impact of controls; (2) the empirical studies lacked a common methodology and tended to place significant emphasis on a few country instances (Malaysia and Chile for the most part); (3) the distinct dissimilarities through time and cross country for the capital-flow management measures applied are substantial; and (4) there are various explanations about what is deemed effective.

11). The authors contend that another serious problem is that there is no universally adopted theoretical approach to assess the impact of controls (Magud et al., 2005, 2011). In addition, although liquidity is an essential element in asset markets, the assessment of liquidity effects in general is limited, if not omitted in the analysis of foreign exchange markets (Karnaukh et al., 2015). This applies equally to how liquidity is impacted upon by capital controls.

The three aspects present a problem as they firstly do not focus on restrictions on outflows or controls on gross flows in general (this paper aims to focus on controls on outflows as well, as is the case for South Africa) and secondly illustrate the inadequacy of literature estimating the impact on the exchange rate returns and associated variability, including liquidity. Finally, sufficient work has not been performed on other important economies such as South Africa.

1.2.1. Research question

Do capital controls contribute to exchange rate stability?

1.3. STATEMENT OF RESEARCH OBJECTIVES

1.3.1. Measuring the effect of the capital control events on exchange rate stability

The first objective involves assessing the return, volatility and liquidity effects of capital control actions or events on the exchange rate during the period under study. The effect of capital controls will be evaluated using event study methodology around 8 periods of the capital control events to determine whether the capital controls enhanced exchange rate stability. The event and direction criterion (Fratzscher, 2005) will be used to measure effectiveness or success.

1.3.2. Adding insight to existing literature

As indicated by Glick and Hutchison (2005, 2011), there are few empirical studies modelling capital control impact on exchange rate stability in developing nations, let alone a large economy such as South Africa, given the importance of capital flows at a macroeconomic level. This illustrated inadequacy of empirical literature estimating the impact on the exchange rate and associated variability will be addressed with the motive of adding new insights to the current debate on capital controls effectiveness. To the best of the author's knowledge, prior studies on the link between exchange controls and exchange rate stability in developing

countries (Glick & Hutchison, 2005) are limited in comparison to those for developed countries. In addition, event study methodology has not, to the best of the author's knowledge, been extensively applied to time series analysis for South Africa.

Secondly, Pandey et al. (2015) allude to literature and state that as soon as a country has an open capital account, occasional implementation of capital controls might not yield the desired benefits. This would suggest that for capital controls to be effective, "this has to be done in the context of a comprehensive administrative system for capital controls, where the government has the ability to interfere in all cross-border transactions" (Pandey et al., 2015, p. iv). India and China are the only two main emerging market economies that have these comprehensive systems which would be a reason to question whether the use of capital controls in South Africa (which does not fit the criteria of these two nations) is needed.

Thirdly, Karnaukh et al. (2015) assert that the assessment of liquidity effects in foreign exchange markets is limited and this research paper attempts to add onto this clearly omitted area and augment the approach by looking at the impact that capital control actions have on liquidity.

Finally, this research aims to resolve some of the issues noted by Magud et al. (2005, 2011) by contributing to the construction of the universally adopted methodology to assess the impact of capital controls, build onto scholarly articles that aimed to evaluate the impact using time series data which would ultimately enhance the ability to apply the approach across time and any country even in the presence of vast dissimilarities. This research paper intends to achieve this by assessing the impact on returns, volatility and liquidity.

1.4. JUSTIFICATION OF RESEARCH TOPIC

The primary motivation for this research is size and sophistication of the South African economy and its importance to emerging markets (including relevance for BRICs). With a GDP of approximately US$ 314 billion in 2015[6], this accounts for more than 20% of Africa's total GDP. Being a relatively open economy, it is exposed to the effects of globalisation which have made it easier for individuals and institutions to circumvent these controls (Edwards, 1999; Glick & Hutchison, 2011) therefore further undermining the effectiveness of capital controls.

[6] World Development Indicators (WDI), 2015

South Africa has for a number of years consistently run a current account deficit. Capital (or financial) flows, which are constituents of the capital account, are used to fund the current account deficit. This financing of the deficit through the financial account demonstrates the importance of capital flows because of the finite nature of official reserves and therefore the need to balance these with capital controls as this ensures that the deficit does not become a burden to the economy. Abedian, Wet, & Pitso (2006) indicate that this deficit financing can continue for an extended length of time without the need for exchange rate adjustments by policymakers. In addition, the authors highlight the importance of capital flows and how capital controls as well as financing concerns would have impeded the ability to ensure the maintenance of such high deficits[7].

The importance of the capital controls on the exchange rate as well as on economic fundamentals (such as interest differentials, inflation, capital flows and output mentioned in the problem definition) is highly significant. South Africa's share of the foreign currency market and derivatives in foreign currency is substantial with an average daily turnover of around $60 billion in 2013 [with averages of $12bn in 2001, $14bn in 2004, $30bn in 2007 and $29bn in 2012 (Bank of International Settlements, 2013)], and given the liquidity in this market, volatility in the exchange rate has a significant effect on the returns. The average daily trading turnover of this market was around $5 trillion in 2013 which indicates the magnitude of its importance (Bank of International Settlements, 2013). As indicated in the Triennial Central Bank Survey by the Bank for International Settlements (Bank of International Settlements, 2013), the South African Rand is deemed to be one of the most significant emerging market currencies, ranking in the top 20 of the daily average turnover of currency trades. As mentioned before and stated by Karnaukh et al. (2015), the assessment of liquidity effects in foreign exchange markets is limited and the reasons for liquidity imbalances are unclear therefore a study on the influence of capital controls on the foreign exchange market could provide policymakers with a different perspective around the issue of capital controls, their effectiveness and the greater market effect.

Another crucial factor motivating for this research was the desire to contribute to the current debate on financial regulation implemented after the global financial crisis, in particular capital

[7] The authors specify that in the past, the movement of goods and services between countries occurred more rapidly than the movement of capital and as such the deficit, indicating an excess of import over exports, would be difficult to withstand for lengthy periods.

controls and their impact on exchange rate volatility as existing literature on developing countries is limited. This will be achieved using event study methodology on time series data for South Africa.

The previous studies conducted have not performed a comparison of these aspects immediately before and after the 2007/08 financial crisis. Exchange control limits not only have an effect on the amount of money that can be taken abroad but also have an administrative burden (Glick, Guo, & Hutchison, 2006) on individuals and financial institutions alike. For instance, investment management companies are required to adhere to these limits which is not only costly to implement controls and monitor adherence, but also results in fines and penalties if these limits are breached.

As the domestic markets become saturated, investors will have limited savings and investment choices. Limits on the amounts invested abroad could result in missed investment opportunities, especially with globalisation and integration of financial markets. Most of the funds invested by investment managers are in the form of pension fund income and limiting these would result in decreased returns for retiring pensioners. Kwaku (2007) in his paper on the investment climate and choices for pension funds in Africa indicates that reforms which lead to market harmonisation would lead to an increase in the investment opportunities available to these institutional investors. This apparent "forced" lack of diversification brought about by capital controls could result in welfare loss to society.

Motelle (2014) emphasised that it is an appropriate combination of sound financial liberalisation policies, competition policies, macroeconomic policies and regulatory and supervisory policies that is required to ensure that financial stability is not affected by the adverse effects of relaxation of capital controls. In South Africa, the adoption of the Financial Sector Regulation Bill (Twin Peaks[8]) and the ensuing approach should enhance efforts to achieve these objectives.

[8] Twin peaks: Regulation – has it gone too far? KPMG 2013

1.5. BENEFITS OF RESEARCH

In summary, the research assignment is relevant for the following reasons:

- It provides empirical evidence of the extent to which capital controls contribute towards currency stability and the related question on whether the removal of capital controls post-independence (or other elements of the transition to democracy) changed the dynamics (caused a structural break) around the determinants of the real exchange rate (J. Frankel, 2007);
- It corroborates the outcomes of prior empirical testing and contributes towards the current debate on capital control effectiveness; and
- It helps policymakers determine whether the controls in place are resulting in excessive administrative burden resulting in unproductive activities (such as circumvention) which do not benefit society at large. This research assignment intends to suggest pragmatic policy implications and meaningful recommendations for economic development.

1.6. CHAPTER OUTLINE

This section provides a high level overview of the focus areas in the research assignment. The thesis is divided into 5 sections.

Chapter 2 provides an overview of applicable literature and the history of capital controls in our economy. It reviews the theoretical and empirical literature connecting capital controls and currency stability, presents the concept of event studies as applied to return analysis, outlines the research on volatility and liquidity as well as developing the hypothesis for testing.

Chapter 3 outlines the specific research methodology.

Chapter 4 discusses and analyses the research findings including a comparison of conclusions from existing literature.

Chapter 5 summarises the findings, provides conclusions including policy implications and provides pragmatic recommendations for future research.

CHAPTER 2: OVERVIEW OF APPLICABLE LITERATURE

2.1. THEORETICAL BACKGROUND

Capital controls are actions or restrictions imposed by the government, central banks or other regulatory institutions in either quantitative (taxes, exchange rate controls, tariffs) or qualitative forms (legislative). These can be on exchange rates, interest rates, lending or even on movement of capital (regulations affecting both capital inflows and outflows[9]) across national borders and investment limits imposed on individuals and entities, and a variety of asset classes such as equities and derivative instruments. Edison and Reinhart (2000) stipulate that these controls can occur in a varierty of methods such as restrictions on capital account transactions including taxes on funds remitted abroad, prohibiting transfers of funds or cross-border movement and dual exchange rates. The intention of all this would be to reduce the depletion of international reserves while providing regulatory authorities with ample to rectify distortions by implementing appropriate policy tools.

Farrell and Todani (2006) in an article focussing on South Africa, interpret these as constraints that impact capital account transactions such as portfolio investments. Prates and Fritz (2013) present a toolkit for capital controls (refer to Figure 1 below) and resort to the definition provided by Neely (1999) which states that capital controls relate to "*measures that manage the volume, composition, or allocation of international private capital flows*" (Prates & Fritz, 2013, p. 7).

Figure 1 - Financial regulation toolkit

Regulation		**Agents**		**Market (spot vs. derivatives)**
		Financial vs. non-financial	Resident vs. non-resident	
Prudential regulation		Financial institutions	Resident	Spot and derivatives
FX derivatives regulation		Both	Both	Derivatives
Capital controls	Portfolio and FDI	Both	Non-resident	Spot
	Foreign loans	Both	Resident	Spot

Source: (Prates & Fritz, 2013)

[9] IMF AREAER, October 2014 – As indicated in the AREAER, (page 77) "*controls on capital transactions include prohibitions; need for prior approval, authorization, and notification; dual and multiple exchange rates; discriminatory taxes; and reserve requirements or interest penalties imposed by the authorities that regulate the conclusion or execution of transactions or transfers and the holding of assets at home by non-residents and abroad by residents.*"

Financial liberalisation is an aspect of the Washington Consensus of 1990 relating to the modification of the financial markets to become less stringent thus enabling them to be a true reflection of the conditions in the market. Williams (2004) states that it is the freeing up of financial markets usually to respond to price incentives. The International Financial Services London (IFSL, 2003) asserts that liberalisation is achieved in a number of ways, for example when individual countries initiate their own reforms or if a region requires that member nations reform as part of their trading arrangement.

McKinnon (1973) and Shaw (1973) scrutinised the argument in favour of financial liberalisation. They stressed the importance of financial deepening and the growth of the money economy and concluded that when the market is fully liberalised such that it is at its equilibrium clearing interest rate, credit rationing will disappear as investments and savings will be optimal. However, McKinnon (1973) stressed that relaxing the capital account by removing capital controls should be postponed until such a time when free trade in goods had been cemented and stabilised. Any attempts to alter the sequence, i.e., amending the capital controls first, would lead to significant real appreciate of the currency thereby limiting the opening up of trade in goods.

Theories supporting competition are associated with the neoclassical view and approximate perfect competition (Robinson, 1934; Stigler, 1957). In a competitive model, where perfect information and complete markets exist, the welfare advantages of free capital flow are the same as those from free trade of goods (Farrell & Todani, 2006). Edwards (1999) phrases this as a question around whether the theory applicable to gains from free trade in goods can be similarly applied to free trade in financial capital. Obstfeld & Rogoff (1996) argued at a theoretical level to back the existence of gains from intertemporal trade via a free international securities market. According to Dooley (1996) and further expanded on by Farrell and Todani (2006), free capital flow will allocate capital where it is most useful among nations thereby allowing citizens in various countries to participate in welfare enhancing "intertemporal consumption smoothing" (Farrell & Todani, 2006, p. 2). This is in line with the theory of comparative advantage (Hunt & Morgan, 1995). Following from these analyses, a relaxation of controls (or complete removal) could result in a more productive global economy as capital moves to those areas where it could be employed in a more productive or efficient manner.

The theory behind capital controls, which is still contentious, stems to a certain extent from economic theory on free trade of goods. The theory of perfect competition is idealistic and at

best only creates a benchmark upon which to develop liberalisation policies. Dooley (1996) goes on to state that economic theory suggests that exceptions to such perfect competition are indeed possible where markets fail or pre-existing distortions violate the assumptions of a "first best" competitive equilibrium. These "second best" arguments envision a setting where the economy suffers from one distortion, and an introduction of another distortion, i.e., capital controls, improves the welfare of society.

Bhagwati (1998) contends that the logic of free trade does not apply to financial goods, particularly currency convertibility, as manifested by the Asian currency crisis. Cooper (1998) attempts to address the question on whether universal capital account convertibility is a good idea and finds that the answer is that it is not (i.e., it is either negative or in doubt) and might not lead to an efficient allocation of capital. Edwards (1999) notes that Bhagwati (1998) and Cooper (1998) contend that the mere existence of imperfect information would mean that "free capital mobility is likely to amplify existing distortions, create situations of moral hazard, encourage excessive risk taking, and generate major and costly crises" (Edwards, 1999, p. 66). Edwards (1999) further contends that controls may be ineffective and can be evaded with ease by domestic and foreign participants, as well as leading to costly distortions and government corruption that could augment economic instability. The evidence presented by the authors is akin to irrational behaviour by market participants which in most cases increases when economies are liberalised without the appropriate institutions or remedies for these counterproductive activities. This is in line with the assertions by Glick and Hutchison (2011) around the ease with which circumvention of controls occurs in a global economy. As such, although the controls themselves might be justified and given time could work, competing forces noted above would result in the ineffectiveness of these controls.

2.2. EMPIRICAL LITERATURE – INCLUDING THE LINK BETWEEN CAPITAL CONTROLS AND EXCHANGE RATES

2.2.1. General studies on capital controls

Reasons for capital controls include controlling increased capital flight especially during crises, preventing scenarios that could adversely affect the country's exchange rate, avoiding speculative activities that are undesirable and volatile investments. In some instances they are used to prevent money laundering and investment losses from being magnified, as well as

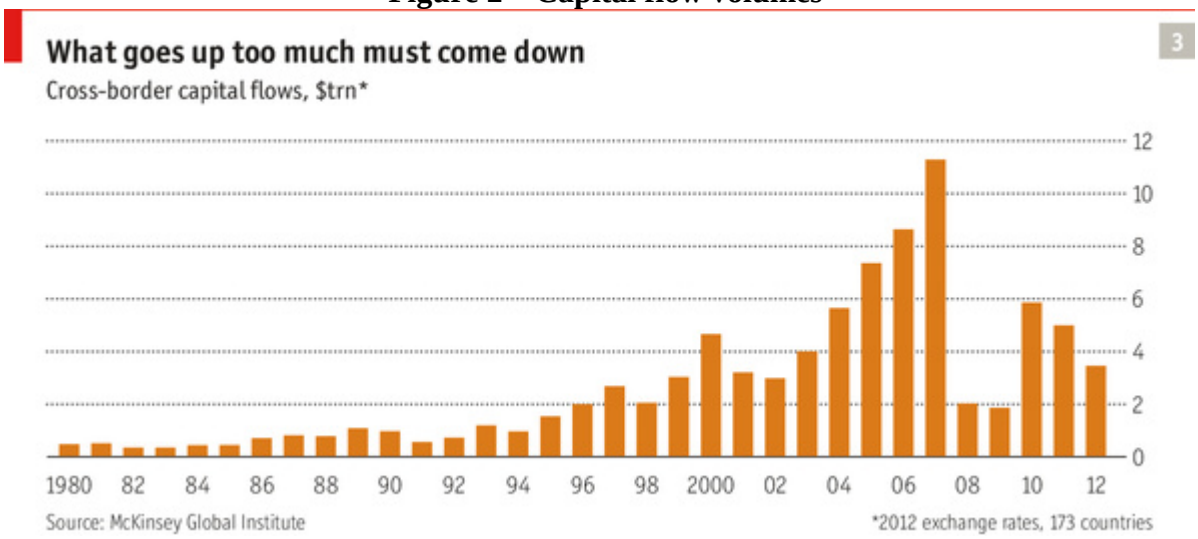
policy tools in the absence of other prudential regulations (Bhagwati, 1998; Cooper, 1998; Davis & Presno, 2014; Eichengreen & Wyplosz, 1993; Krugman, 1999; Neely, 1999). Krugman (1998) argued that countries experiencing crisis could benefit from temporary controls on outflows, as these would provide countries an opportunity to restructure their financial sector, and once this is achieved, the controls can be removed. This is the approach followed by Malaysia in 1998-99 on outflows (Edison & Reinhart, 2000). These valid reasons illustrate that markets can be left to operate on their own to a certain extent, but various mechanisms and institutions are still required (Chanda, 2005) to ensure that the required balances and checks are in place to rectify instances where the assumptions of free market economics are violated or do not exist.

A typical example of capital controls in practice and where they impose externalities is how the Financial Transaction Tax (FTT or Tobin tax used in Italy) imposed on certain types of financial transactions (such as foreign exchange trades so as to limit the amount of speculative trading) might have unintended consequences. Tobin (1978) argued that this global tax would reduce the destabilising effects of speculative activities in financial markets. Eichengreen and Wyplosz (1993) further contended that the Tobin tax would deter speculators who might be myopic in their approach and seek to benefit from gambling against currencies. Its merits included transparency, it would provide ample time to ensure that alignments occurred and it was not a quantitative restriction (which would have administrative effects). However, Edwards (1999) suggests that Tobin taxes were impractical as they would be effective only if implemented simultaneously by all countries. In this instance, the tax might penalise legitimate transactions which might have been inadvertently identified as speculative.

Capital controls are common in developing nations whereas developed nations see the value of financial liberalisation. Various scholars such as Chanda (2005) advocate for some form of government, central bank or regulatory institution intervention or capital control (as highlighted by the consequences of the Asian crisis in 1997 and the global financial crisis of 2007 – 2008) while others such as Montiel and Reinhart (1999) and De Gregorio et al. (2000) argue that capital controls have little effect and limited or no intervention will result in well-functioning financial markets.

Recently, the International Monetary Fund (IMF) has had to reverse its stance on capital controls to a certain extent[10] as more funds move to emerging economies (refer to Figure 2 below). Iceland in 2008, followed by countries such as Brazil, South Korean, Thailand and Indonesia to name a few implemented capital controls to limit the inflow (and anticipated outflow) of hot money which would have unintended consequences brought about by the appreciation of their currencies, which would make their products less competitive in the international markets. However, as this is hot money, the ensuing capital flight could do more damage to those countries that enacted controls without sound policy frameworks in place. By reviewing this it appears that there are merits for the capital controls, but these can only be effectively if the right institutions are in place, i.e., if robust institutions are in place everything else in the economy should operate effectively (including capital controls if required). In terms economic development then, as concluded by Chinn and Ito (2007) the level of development of legal systems is more important than finance-specific legal or institutional development.

Figure 2 – Capital flow volumes



Prates and Fritz (2013) investigated the Brazilian and Korean approach to foreign currency derivatives regulation subsequent to the global financial crises. Their study and the resulting toolkit (figure 1 in sub-section 2.1), advocated for the importance of both prudential financial regulation and capital controls in addition to the third type of financial regulation, foreign currency derivatives regulation (particularly in Brazil), required to restrain the currency

[10] http://www.economist.com/news/special-report/21587383-capital-controls-are-back-part-many-countries-financial-armoury-just-case

appreciation trend. A combination of adequate regulation and capital controls would ultimately benefit the economy more in the long run, highlighting the importance of capital controls.

The study by Singh (1997) reviews the relationship between liberalisation and one of the largest asset trading market, the stock market, which accounts for a sizeable amount of capital investment by businesses and individuals. The stock market is the closest example of a perfectly competitive market and restriction in the financial markets would hinder its efficiency because it owes its existence to well-developed financial systems. Stock market development and financial liberalisation are complementary and hence are vital for each other's advancement. This further highlights the limited need for capital controls as these would hinder the proper functioning of the stock market and its price discovery ability. Although modest government intervention is needed in some cases (Huang & Han, 2008), market competition and market mechanism (with limited controls) are crucial in the price discovery process.

However, Singh (1997) goes on to note that although stock markets play a vital role in financial liberalisation, this liberalisation does not augment long-term growth. As such, liberalisation and expansion of stock markets in developing countries is likely to hinder and not assist stock market development, a finding which supports continued use of capital controls. In his paper, the author does point out that other factors in developing nations contribute to this observation. These include volatility of pricing, instability caused by interaction between stock and currency markets when adverse economic conditions or shocks occur and the crowding out effect that stock markets have on existing group banking systems.

Capital controls may also be required to limit the negative effect or externalities caused by market failure and are used in rare or exceptional cases (Eichengreen & Rose, 2014) to limit undesirable behaviour by market participants. They are also required to protect those who are vulnerable or depend on institutions to ensure that market participants adhere to the rules of the game. In their paper on capital controls in the 21st century, Eichengreen and Rose (2014) presented the case that governments are reluctant to use capital controls where appropriate control frameworks or institutions are not in place, as it might be difficult to roll back or reverse the initial capital control measures. By viewing this in another way, one would argue that if capital controls are preceded by appropriate frameworks, then further strengthening these frameworks could do away with the need for capital controls in future.

Finally, Montiel and Reinhart (1999) provided evidence to support the notion that capital controls do little to influence the volume of capital flows, but instead have an impact on what constitutes the flows, similar to findings of De Gregorio et al. (2000). The authors found that it was sterilised intervention that increased the volume of total capital flows. Policymakers are interested in the volume of investment and how it contributes to economic growth and not overly concerned with a mere shift in the composition of capital flows as these might not result in tangible long-term growth.

2.2.2. Studies on selected emerging markets, the South African context and transition of capital controls

As the paper aims to focus on controls applicable to South African, further scrutiny on empirical literature on developing countries that have implemented similar restrictions to South Africa is considered useful as this allows specific focus (moving from a general view of studies, to emerging market studies and finally a focus on South Africa). In addition, since South Africa is considered an emerging economy, a review of such applicable literature provides a sound building block for the analysis.

The main purpose of capital controls in South Africa is to limit the purchase and sale of the national currency, reduce the impact on South Africa's exchange rate and ultimately foreign exchange reserves. From a South African perspective, exchange controls are governed by the regulations promulgated under the Currency and Exchanges Act No 9 of 1933. Regulation 10 (1) (c) covers aspects surrounding restrictions placed on South African residents with respect to the export of capital. Post-apartheid, South Africa followed a process of liberalisation that was gradual and sequenced, and continues till today. For instance, the foreign exchange limit imposed on individuals (i.e., controls on personal transactions at R5 million annually till 31 March 2015) was revised to R10 million from 1 April 2015 onwards and financial institutions such as investment companies are limited to investing a maximum of 35% of their retail assets under management in foreign assets) under the Exchange Control Regulations of the Currency and Exchanges Act. Rules governing transfers by parent companies to a holding company were relaxed during the 2013-2014 period, allowing transfers up to R2 billion per year, with an option for additional amounts provided approval is requested[11].

[11] IMF AREAER, October 2014

A look at other notable examples on emerging economies presents literature that is applicable to South Africa. Financial crises present evidence that some regulation is required, more so to rectify the effects on the economy or at least prevent further turmoil. This is the approach followed by Malaysia in 1998-1999 on outflows and Thailand in 1997 (Edison & Reinhart, 2000). The authors evaluated the impact of capital controls in achieving the intended objectives. In Malaysia, a country which imposed controls on outflows, the objectives of stable exchange and interest rates and enhanced policy autonomy were achieved. South Africa has restrictions on outflows and barring any political or institutional differences, the same effects should occur if South Africa continues to employ these methods. However, the economic conditions continued to worsen in Thailand, including more variable stock returns and exchange rates. Volatility spill overs were not eliminated in both countries. One of the limitations of their study involved introducing capital controls during period of crises. They note that in such unsettled periods, it is challenging to differentiate between the effects of the controls on the one hand, and effects that are due to actions brought about by the financial crises, such as reduced risk taking which have similar outcomes and implications as capital controls. This paper attempts to address this flaw by using event studies and solutions employed by other authors (Glick et al., 2006; Glick & Hutchison, 2011).

Glick et al. (2006), control for self-selection bias using propensity score matching given that countries that have liberalised their controls are more likely to have more robust institutions and policies that reduce the likelihood of crises, and equally, countries facing exchange rate instability have a higher probability of employing capital controls (which creates the assumed positive link between exchange rate stability and capital controls). They find that countries without controls have a lower probability of a currency crisis. Forbes et al. (2015) and Pandey et al. (2015) also use this approach to control for selection bias and endogeneity and demonstrate that most capital control measures do not have the intended effect on the variables under study.

In their work on capital controls and exchange rate instability, Glick and Hutchison, (2005) employed a panel data of 69 developing countries during the period 1975 – 1997 and controlled for macroeconomic, political, and institutional characteristics that have an impact on the probability of a currency crisis. In addition, they used alternate measures of limitations on international payments. Finally, they accounted for potential "joint causality between the likelihood of a currency attack and the imposition of capital controls" (Glick & Hutchison,

2005, p. 387). This entails identifying aspects that both result in the levying of capital controls by countries and at the same time contribute to currency attacks. This is similar to one of the limitations potentially not addressed in the work by Edison and Reinhart (2000). Glick and Hutchison (2005) show that countries that are more liberalised and have less restrictions surrounding capital controls are less susceptible to speculative attacks on their currency. The authors did note the weaknesses inherent in the IMF capital control measures, in that they were crude and provided a narrow view regarding the application and enforcement of these controls. However, they did not differentiate between controls on outflows, and those on inflows. For the purposes of this research, this is quite important as the controls under study are predominant those on outflows, albeit with some emphasis on inflows.

In a later paper focussing on capital controls and their contribution to currency stability, Glick & Hutchison (2011) extended the period (1975 – 2004) and used the panel data of 69 developing and emerging market economies for "standard and duration adjusted measures of capital control intensity" (Glick & Hutchison, 2011, p. 59). They found that controls did not adequately perform their intended role of shielding the emerging market and developing economies from currency crises in their sample period. They concluded that it was not capital controls but rather real gross domestic product (GDP) growth coupled with measures to prevent real overvaluation that were crucial in an attempt to avoid currency crises.

A study on the effects on capital controls on inflows in Chile from 1991 - 1998 (De Gregorio et al., 2000) on real exchange rate, volume and composition of capital inflows and interest rates, did not show a significant long-run effect on the variables in the study except for the composition of capital inflows, tending to result in capital inflows of a longer maturity. It was sound financial and macroeconomic policies that ultimately resulted in benefits. South Africa has been gradually relaxing capital controls but has yet to abolish them entirely. Were South Africa to concentrate on enhancing the existing institutions, implementing the appropriate economic policies in addition to observing their effects on economic development, the burden of capital controls or the apparent reluctance surrounding their removal would fall away.

Gidlow (2005) reviewed exchange control in South Africa during the period 2001-2002 (a period where the Rand was weak and exchange controls had been partially reduced) and assessed its effectiveness when the regulatory authorities imposed restrictions on new offshore investments by South African institutions to discourage foreign investment. He listed 8 factors that undermine the effectiveness of exchange controls. He concludes that the contentious

decision to tighten the exchange controls (especially when authorities had been gradually removing exchange controls) interrupted the efforts to abolish exchange controls when the weak Rand presented a golden opportunity to do so.

Angermann (2005) indicates that the government of South Africa abolished foreign exchange controls for business investment which included no restrictions on direct investment abroad by South African firms in 2004. Angermann further states that relaxation of foreign exchange restrictions in South Africa promotes capital flight as companies diversify.

After apartheid, South Africa required liberalisation in order to attract investments (Mohamed, 2006) and capital flows are correlated with significant capital flight from South Africa. These flows were however not linked to those that would result in long-term sustained economic growth. The factors that lead to an increase in capital flows could potentially weaken the economy over time as they were only short-term.

Frankel (2007) argues that the Rand behaves in a manner similar to currencies of developed countries with well-established financial markets. If this is the case then, South Africa should move from a state where overall limits apply on foreign assets with restrictions on specific types of these foreign assets to one where no foreign asset limits apply as documented in Leape and Thomas (2011). This is the same argument raised by Gidlow (2005) following the collapse of the Rand in 2001.

Much like Pandey et al. (2015), this research paper excludes an evaluation of the net benefit to society (overall savings and investment as well as increased investment opportunities and allowing for the benefits of diversification) using techniques such as cost-benefit analysis as this is not within the research scope. Therefore, the scope exclusions prevented an investigation of whether exchange control restrictions curtail the undesirable effects that the regulators are attempting to prevent. As such, the paper will not look at:

- Financial service provider, institutional and individual losses due to forced lack of diversification; and
- Administrative burden and costs when investment companies and financial service providers are required to close access to their products after reaching their prudential limits leading to the inability of individuals and institutions to use the offshore capacity afforded to them by financial service providers.

The panel data studies by Glick and Hutchison (2005, 2011) and the resulting classification and methodology applied are quite insightful for the research methodology and warrant some close inspection. These studies focus on:

a. capital controls and exchange rate instability (Glick & Hutchison, 2005); and

b. capital controls and their contribution to currency stability (Glick & Hutchison, 2011).

The first step in their methodology entailed identifying currency crises or periods of extreme volatility. The principal indicator for currency crises (***xrp_nw***) [12] was created using the extreme changes in the index of currency pressure. The next step focused on measuring the restrictions. This section dealt with *de jure* changes in capital control policies from the exchange rate arrangements and exchange restrictions[13] (legal and administrative controls) used in practice to insulate economies and included in the methodology. The final key step involved establishing and identifying the main currency crises determinants to use in their probit model[14]. The aim in this case was to determine whether financial globalisation (in the case of this paper, including liberalisation) had diminished the effectiveness of capital controls.

The results of Glick and Hutchison (2011) are consistent with evidence from most emerging markets in their study around the relative ineffectiveness of the capital controls. In addition, their identification of currency crises episodes using their model accurately identifies currency crises for a number of the countries such as Thailand, Philippines, Malaysia, Indonesia and to a lesser extent Singapore during the Asian crisis period (crises episodes in 1997 – 1999 were identified for these countries). However, the main pitfall of their research is that the model assumes that each country in the sample has an equal weight when arriving at the conclusion. It does appear though that a few select countries contribute a substantial portion to the final results (such as Venezuela and Zimbabwe) and some of the countries identified as having crises or assumed to contribute to the findings do not agree with financial data. This is the case for Swaziland which had numerous currency crises and is inconsistent with history and its exchange rate regime. In addition, the study uses the relatively rudimentary measures of capital controls from the IMF AREAER and focused on the intensity of capital controls instead of the actions to clearly articulate a causal relationship attributable to these controls.

[12] Values for currency crisis can either take binary measures with 0 (no crisis) and 1 or unity (crisis)
[13] AREAER, IMF 2014
[14] A probit model meant the authors could "focus on the contribution of payment restrictions to currency crises while controlling for other macroeconomic factors that vary across time and country" (Glick & Hutchison, 2011, p. 64).

Figure 3 below illustrates the event or capital restriction categories based on the IMF's AREAER of 2014 used in this research paper with some further enhancements. Details from the AREAER were used extensively in the papers by Glick and Hutchison (2005, 2011) and other authors (Forbes, Fratzscher, & Straub, 2013; Forbes et al., 2015; Pasricha, 2012).

Figure 3 - Event or capital restrictions

	Event / capital restrictions
	A. Capital Transactions
1	Controls on Capital market securities
2	Controls on Money market securities
3	Controls on Collective investment securities
4	Controls on Derivatives and other instruments
5	Controls on Commercial credits
6	Controls on Financial credits
7	Controls on Guarantees, sureties, and financial backup facilities
8	Controls on Direct investment
9	Controls on Liquidation of direct investment
10	Controls on Real estate transactions
11	Controls on Personal capital transactions
12	Provisions specific to Commercial banks and other credit institutions
13	Provisions specific to Institutional investors
	B. Arrangements for Payments and Receipts
14	Bilateral payments arrangements
15	Payments arrears
	C. Controls on payments for invisible
16	***transactions and current transfers***
	D. Proceeds from exports and/or invisible transactions
17	Repatriation requirements
18	Surrender requirements

A. Capital Transactions and controls -Describes regulations influencing both inward and outward capital flows
B. Arrangements for Payments and Receipts - When a country has payments agreements with other countries, the terms of these agreements often lead to a prescription of currency for specified categories of payments to, and receipts from, the countries concerned.
C. Controls on payments for invisible transactions and current transfers - Includes income from investment (for example, profits, dividends, interest); payments for travel, education expenses, medical expenses, subscription or membership fees; and unrequited transfers (for example, remittance of nonresidents' salaries and wages)
D. Proceeds from exports and/or invisible transactions - Describes restrictions on the use of export proceeds, as well as regulations on exports. Proceeds from invisible transactions and current transfers describes regulations governing exchange receipts derived from transactions in invisibles—including descriptions of any limitations on their conversion into domestic currency—and the use of those receipts

Source: AREAER 2014

The empirical study by Pandey et al. (2015), which assesses the effectiveness of capital controls on time series data, is instrumental for the general approach followed in this research report. This is in contrast to a majority of studies that have thus far focused on cross-sectional data and comparisons across countries. The authors also employed a combination of event study methodology and propensity score matching and focussed on better measurements of capital controls, i.e. looking at actions instead of the extent or "levels". Pandey et al. (2015) make reference to various authors who refined capital control data to ensure a robust approach. For instance, Forbes et al. (2015) attempt to build a database of these capital control actions [CCAs, (Pandey et al., 2015)] using the IMF AREAER data as a baseline upon which expand to allow for better measurements of capital controls while Pasricha (2012) also utilises the IMF AREAER information but incorporates additional sources, types of actions and asset classes to create a more expansive number of CCAs. Pandey et al. (2015) note that this improved the classification of actions to illustrate their impact. In their own words, "Studying individual CCAs allows us to observe their precise dates and to precisely classify the nature of the interventions" (Pandey et al., 2015, p. 4).

Pandey et al. (2015) examined the factors influencing changing capital controls and their effectiveness in India, particularly foreign borrowing which draws its justification from macroprudential issues. As such, they first created a set of CCAs applicable to foreign borrowing and used event study methodology to evaluate the factors that encourage the capital control actions. Similar to this research paper, their main aspect was the exchange rate (capital controls are relaxed after depreciation and tightened after an appreciation of the currency).

Pandey et al. (2015) state that a governance baseline for capital controls that is accepted as a universal guideline ought to have four key aspects which include: (1) specific explanations of the type of actions planned; (2) suggested procedures stipulating the circumstances when the actions can occur; (3) evidence to illustrate the attainment of the intended results; and (4) evidence that the benefits are far greater than the costs. In addition, the authors contend that to construct such a governance baseline, literature that addresses the following questions would have to be used for emerging market economies (EME):

(1) What are these so called capital controls?

(2) The type of situations that trigger the use of these controls?

(3) What effect do the various types of controls have; and

(4) Do the benefits compensate for the effort or costs?

The authors note that macroprudential policy objectives were not a key aspect driving the use of capital controls. In addition, their results from the event study (the event study was used to determine the effect of CCAs) are consistent with literature which finds no effect of capital controls on most of the variables examined. Although the limited evidence in their findings indicates that capital controls alleviate short-term currency pressures, this falls away in the long run and when selection bias is factored it. The propensity score matching allowed for the "causal identification of the impact of the CCA" (Pandey et al., 2015, p. iv) by enabling the analysis of the treatment effect because it can be used as an another method of constructing the counterfactual. Their examination of the sub-categories of capital controls to assess whether particular kinds of limits would more impactful did not yield any significant results.

2.3. MODELS FOR EXCHANGE RATE CHANGES AND VOLATILITY

The research assignment aims to determine the impact capital controls have on exchange rate stability. As such, a model is required to obtain forecasts of where the Rand was moving towards and where it eventually ended to isolate the effect capital controls had on this movement. As indicated in Farrell (2001), autoregressive conditional heteroscedasticity (ARCH)-type models first introduced by Engle (1982) and further expanded to give the generalised ARCH (Bollerslev, 1986) including empirical work by various authors (Bollerslev, Chou, & Kroner, 1992) and exponential GARCH or EGARCH specification (Nelson, 1991) have been considered. Their main attractiveness being their ability to describe certain characteristics of high frequency data such as the exchange rate (Diebold and Lopez, 1995). The section is broken into two sub-sections:

- Sub-section 2.3.1 presents an overview of the key model to be applied to measure volatility, the GARCH (1,1) as presented by Farrell (2001), Dukich, Kim, & Lin (2010) and Abdalla (2012). The discussion also focusses on the general form of the model and provides a high level view of alternative forms of the conditional variance; and
- Sub-section 2.3.2 introduces the base model that will be applied for the analysis of exchange rate changes from empirical work by Verdelhan (2015).

2.3.1. The GARCH (1,1) model and alternative forms of the conditional variance

The generalised autoregressive conditional heteroscedasticity (GARCH) model spearheaded by Bollerslev (1986) and Engle (1982) is the most commonly used ARCH model and is a crucial benchmark as it can be applied across a variety of asset categories and sampling frequencies (Farrell, 2001). It is also robust to several types of misspecification with the ability to estimate the volatility that has been overlooked (Nelson, 1992; Nelson & Foster, 1994). In his research, Farrell (2001) sought to establish if capital controls in South Africa affected the random probability distribution or manner in which exchange rates behave and whether this benefitted the common exchange rate. The conditional variance was used as a representation or proxy for exchange rate volatility. The author tested the movement of the volatility process of the exchange rate. The principle at play is that volatility effects in the commercial Rand market might affect the financial Rand but volatility attributable to the financial Rand should not have an unexpected consequence on the commercial Rand. As the author states, "in general the dual exchange rates should not exhibit a common volatility process" (Farrell, 2001, p. 1). The results showed that in general, the controls attributable to the financial Rand were successful in shielding the commercial Rand from volatility caused by portfolio flows.

Dukich, Kim, & Lin (2010) assessed the operating effectiveness of GARCH models in estimating daily changes in logarithmic exchange rates (LPR). Although the exchange rates fulfilled the GARCH model assumptions, they found that GARCH models do not appropriately represent the exchange rate patterns or were not consistent with the evidence from these patterns. To assess the adequacy of the GARCH model, the authors matched the LPR patterns to the simulated GARCH model results. Although the data was consistent with the assumptions of the model, the shortcomings they identified included inadequacies surrounding (a) showing the empirical description of each pattern and (b) replicating the sudden stop event linked to the 2007/08 financial crisis. The authors used a fairly extended period (2,700 trading days between January 4, 1999 and January 4, 2010) and because they did not use a short interval, it can be argued that this could result in a sound evaluation and perhaps be used to draw conclusive inferences about the long run effects. However, care should be taken as the sudden stop event was a unique and isolated event that could not have been easily predicted. In addition, the study did not consider other types of GARCH models such as the EGARCH and was conducted on

developed country exchange rates and applying it to an emerging market context could yield differing results.

Abdalla (2012) argues that exchange rate volatility can be appropriately expressed using GARCH models. A panel study of 19 Arab countries using daily data was performed for the period 1 January 2000 to 19 November 2011 and the analysis (which consisted of both symmetric and asymmetric models such as the EGARCH) incorporated common aspects of exchange rate returns, for instance leverage effects and volatility clustering. The author indicates that although academics have presented results showing the link between macroeconomic fundamentals (such as the GDP, inflation rate, interest rate etc.) and the volatility of the exchange rate (Hsing, 2016), empirical literature has also focused on the aspects mentioned above surrounding the time series evaluation of returns which include leverage effects and volatility clustering[15] (Bangia et al., 2002). Similar to this research paper, Abdalla (2012) takes the starting point of volatility as the standard deviation of the changes in the exchange rate, i.e. the standard deviation of the returns. However, this measure cannot be observed and is often widely a matter of dispute. The author also discusses implied volatility (an estimation of volatility that looks into the future) and historic volatility (which is based on values from previous periods). Abdalla (2012) finds that the coefficients for the GARCH model estimation are statistically significant for the constant, ARCH and GARCH terms. Based on the results of the empirical research, the author concluded that the volatility or conditional variance "is an explosive process for the ten of nineteen currencies, while it is quite persistent for seven currencies which is required to have a mean reverting variance process" (Abdalla, 2012, p. 10).

General form of GARCH models

The standard deviation is generally used to gauge or illustrate volatility of asset returns. The general form of the variance, which in some instances is also utilised to indicate volatility, is as follows:

$$\widehat{\sigma^2} = \frac{1}{T-1} \sum_{t=1}^{T} (r_t - \mu)^2 \qquad (1)$$

and a standard deviation, being the square root of the variance

[15] The aspects indicated by the author include (a) consistent or regular events (b) changes or co-movements in volatility (c) extreme or excess kurtosis also known as fat tails (d) leverage effects and (e) volatility clustering and persistence and (f) long memory (Abdalla, 2012).

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

where r_t represents the return of the exchange rate at time t
and μ signifies the average return during the T-day interval.

The realised variance can be used as the representation for volatility. In this research, the conditional variance is used as a proxy for volatility.
Consequently, for the GARCH[16] description, the mean equation is given by

$$r_t = \mu + \varepsilon_t \quad (3)$$

with ε_t being the residual returns which are used to construct the variance equation for the conditional variance σ^2 (a forward looking forecast based on historic information) which is

$$\boldsymbol{\alpha_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2} \quad \textbf{(4)}$$

where the constant term $\omega > 0$ (and could represent the long run variance), $\alpha \geq 0$, $\beta \geq 0$ (the closer the sum of these weights are to 1, there more persistent the volatility) and

- ε_{t-1}^2 relates to the lagged or previous interval squared residual returns from the mean equation representing historic information about volatility, i.e. the ARCH term
- σ_{t-1}^2 represents the lagged or historic interval variance i.e. the GARCH term

Concerning alternative forms, Erdemlioglu et al. (2012) employed econometric modelling for exchange rate volatility and captured the major characteristics of exchange rate volatility and periodic volatility patters (jump estimates). This approach was not necessary and not applied for this research report as the focus was not on intraday movements. The EGARCH model (Nelson, 1991) has a log specification for a positive sign for the conditional variance. This model is appropriate when dealing with the leverage effect, a situation where apparent asymmetry exists because negative scenarios generally result in greater volatility (negative scenarios generally increase uncertainty in the market) than their positive counterparts. Finally, refined GARCH-type models Ross (2013) could be considered as they enhance the existing models and use non-parametric statistics. The GARCH model treats volatility as a drift process, but empirical research suggests that volatility is best described as a "structural break" model where volatility is subject to both drifts and jumps. Although refined models have been known to better fit the estimation of volatility, for the purpose of this research paper the GARCH (1,1) model will be utilised as it adequately deals with the clustering and extreme kurtosis.

[16] Similar equations are described by Farrell with h_t^2 used for σ^2

2.3.2. Base model for event study: Model for exchange rate changes

The empirical research conducted by Verdelhan (2015) provides a view of factors[17] that should be included in models to explain deviations in bilateral exchange rates. While the author appreciates the importance of the primary components in explaining bilateral exchange rates, he identified two factors in the time series analysis, the carry and dollar factors, that are responsible for a significant percentage (ranging from 18% to 80%) of the exchange rate changes (Verdelhan, 2015, p. 1). The author notes that while the carry factor receives much more of the attention in studies, it is the dollar factor (measuring the dollar effect) which is crucial in determining the exchange rates. The main findings indicate that "…global shocks are key to describe exchange rates" (Verdelhan, 2015, p. 4) and cannot be removed through diversification (Verdelhan, 2015, p. 13). Similar to this research report, the exchange rates were specified in relation to the United States dollar. In addition, these two factors not only offer sound explanations of exchange rates when compared to the principal components, they are also priced into the markets (i.e., they are essentially risk elements). These risk factors are built from a collection of currencies. As defined by the author, "The carry factor corresponds to the change in exchange rates between baskets of high and low interest rate currencies, while the dollar factor corresponds to the average change in the exchange rate between the U.S. dollar and all other currencies" (Verdelhan, 2015, p. 2). The author does caution that the significant coefficient of determination values in the factor regressions are not meant to infer that forecasting exchange rates is a simple task as they are not predictive in nature but occur at the same time.

To demonstrate the concept of risk inherent in these two factors, the author uses the results of the work and literature (for the carry factor) to illustrate the link between these factors and the resulting average excess returns. In essence, the greater the interest rate values, the greater the weighting on the carry factor. For the dollar factor, the author looks at how the effect on the collection of countries fluctuates against the dollar factor using dollar beta values and finds that the collection of currencies with higher dollar betas are associated with higher excess returns than their lower dollar beta counterparts. The variance between these high and low counterparts is what he called the "global component of the dollar factor" (Verdelhan, 2015, p. 4). The risk

[17] The author stresses the importance of stochastic discount factors

factors which explain bilateral exchange rates in terms of United States dollars are thus a. carry factor immune to United States specific shocks and b. global component of the dollar factor. Verdelhan (2015, p. 4) used "dollar-neutral" explanatory variables to isolate country-specific effects. This is the similar approach this research paper aims to follow by making the effects specific to South Africa thus allowing the model to unpack changes linked to capital control events. The author also draws from previous empirical evidence to indicate that: "…the carry factor depends only on world shocks priced globally, while the dollar factor depends on U.S.-specific shocks and on world shocks priced locally" (Verdelhan, 2015, p. 5).

A significant finding by Verdelhan (2015) which is relevant to this research on capital controls is that a significant portion of systematic variation in exchange rates is linked to a large portion of systematic variation in total capital outflows, inflows and their corresponding averages[18]. The author notes that differences in the features of aggregate capital flows constitutes about 53% of the variation in systematic risk for the currencies.

Moving on to the model and the base regression, the latter being the equation selected for the market model in the event study, the author (Verdelhan, 2015) illustrates that during a complete market[19], the log change in nominal exchange rates, Δs_i, between the home country and its foreign counterpart *i* is given by:

$$\Delta s_{i,t+1} = m_{t+1} - m_{i,t+1} \qquad \text{[Note: this relates to logs]} \qquad (5)$$

with m and m_i representing the log stochastic discount factors (SDF) relating to the domestic and foreign country investors with the applicable exchange rate given as foreign currency per United States dollar.[20] The expanded form of equation 5, with the corresponding country *i* specific, United States specific and global shocks components is given by:

$$\Delta s_{i,t+1} = \alpha_i - \alpha + \chi_i \sigma_{i,t}^2 - \chi \sigma_i^2 + (\tau_i - \tau)\, \sigma_{w,t}^2 + \gamma_i \sigma_{i,t} u_{t+1}^i - \gamma \sigma_t u_{t+1} + (\delta_i - \delta)\, \sigma_{w,t} u_{w,t+1} + (\kappa_i \sigma_{i,t} - \kappa \sigma_t)\, u_{g,t+1} \qquad (6)$$

In the model, the components mentioned above are:

- $\gamma_i \sigma_{i,t} u_{t+1}^i \rightarrow$ country specific component;
- $\gamma \sigma_t u_{t+1} \rightarrow$ United States specific;
- $(\delta_i - \delta)\, \sigma_{w,t} u_{w,t+1} + (\kappa_i \sigma_{i,t} - \kappa \sigma_t)\, u_{g,t+1} \rightarrow$ global shocks.

[18] For the various capital control components, portfolio and other investments provide more useful information when compared to foreign direct investments (Verdelhan, 2015, p. 6).

[19] Results from the Euler equation and as presented in Verdelhan (2015) and Lustig & Verdelhan (2006), exchange rates are given by $S_{i,t+1} / S_{i,t} = M_{i,t+1} / M_i$ or as logs $\Delta s_{i,t+1} = m_{t+1} - m_{i,t+1}$.

[20] When the value of s_i rises, the home currency has appreciated.

Putting all this together and including the carry and dollar factors, the country-level regressions (Verdelhan, 2015, p. 20), and accordingly the starting point for the base model for the event study in this research paper will be:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i(r_{i,t} - r_t) + \gamma_i(r_{i,t} - r_t)Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Dollar_{t+1} + \varepsilon_{i,t+1} \quad (7)$$

As noted by (Verdelhan, 2015), the regression included the (unconditional) carry factor, the carry factor multiplied by the interest rate differential applicable to the country [conditional carry, $(r_{i,t} - r_t)Carry_{t+1}$], the interest rate differential and the dollar factor.

2.4. EVENT STUDY METHODOLOGY

The outline, description and explanations of the event study methodology used in this research paper are taken largely from the literature on event studies in economics and finance by MacKinlay (1997) as well as Kothari & Warner (2006). As stated by the author, "Event studies provide an ideal tool for examining the information content of disclosures" (MacKinlay, 1997, p. 16). The author's focus was on how the worth of a firm is affected by an economic event and utilised market data. Much like the efficient markets hypothesis (EMH), the rationale behind this is that the impact of events is immediately revealed in financial asset prices (be it weak form, semi-strong form or strong form efficiency). "Thus a measure of the event's economic impact can be constructed using security prices observed over a relatively short time period. In contrast, direct productivity related measures may require many months or even years of observation" (MacKinlay, 1997, p. 13). Capital controls are regulatory in nature and event study methodology can and has been applied to the governing arena as well[21] (Kothari & Warner, 2006; MacKinlay, 1997; Pandey et al., 2015; Schwert, 1981) Binder, 1985).

2.4.1. Background information on event study methodology

The main emphasis of event studies is the impact on the price of a certain asset, and it is usually securities in the form of common equity that are studied (MacKinlay, 1997, p. 13). In this research, the focus will be on the price of a currency, i.e. the Rand-Dollar exchange rate. Various enhancements have been made over the years regarding event study methodology such as eliminating "general stock market price movements and separating out confounding events"

[21] Kothari & Warner (2006) in their paper indicate that event studies have been used to assess the impact of regulation.

(MacKinlay, 1997, p. 14). This controlling for certain effects, variables or the information content to isolate the key items under study greatly enriches the predictive power of models used in event studies (Ball & Brown, 1968; Fama, Fisher, Jensen, & Roll, 1969). It is often difficult to separate out the effects that are due to capital controls and those that are as a result of other normal factors affecting the exchange rate such as inflation, economic growth, the dollar and carry effect (Verdelhan, 2015). More importantly, a direct relationship between capital controls and the exchange rate is not always evident (Forbes et al., 2015), which though making the testing problematic, should help illustrate to policy makers that the intended objectives of capital control are somewhat obscure. In addition, as this, and various other papers are statistical in nature and rely on assumptions which should not be breached or precise hypothesis that are being tested, certain changes have to be made with notable research being work by Brown & Warner (1980, 1985).

2.4.2. Overview of event study methodology – The approach in action

Key to an event study is the way we measure abnormal performance [abnormal stock return in MacKinlay (1997, p. 14)] as well as the initial step of normal performance measurement.
The event[22] to be studied ["event of interest" (MacKinlay, 1997, p. 14)] should be outlined for each event study. The assessment period also known as the event window should also be specified. For instance, in the case of an event such as unemployment data announcements and the impact on the stock market (Boyd, Hu, & Jagannathan, 2005), the event window will contain at least the day of the announcement. In most cases of event studies, the event window is usually specified as being greater than the "period of interest" or event significant interval. "This permits examination of periods surrounding the event" (MacKinlay, 1997, pp. 14–15). The event significant interval is usually lengthened to a number of days which include the announcement date and the day (or days) after the announcement date. In the case of the stock market, this will ensure that the impact of event after the conclusion of a particular trading day filter into the analysis. Empirical literature on the appropriate timeframe to include is varied, with some authors arguing for shorter time periods as opposed to long term periods (usually event windows longer than one year) as there are drawbacks associated with the latter[23]

[22] As noted by Kothari & Warner, "The event might take place at different points in calendar time or it might be clustered at a particular date (e.g., a regulatory event affecting an industry or a subset of the population of firms)" (Kothari & Warner, 2006, p. 9).
[23] These include the misspecification of tests, indicating both positive and negative abnormal performance all too frequently and pervasiveness of abnormal performance "throughout the horizon following a simulated event" thus results "require extreme caution" (Kothari & Warner, 1997, p. 302)

(Kothari & Warner, 2006). The interval before and after the event is at times considered because of pertinent information dissemination that occurs, such as adjustments to share values in response to new information (Fama et al., 1969). Scrutinising whether information in the pre-event and post-event periods (the estimation window and post-event window respectively) influences the event is vital to most studies. The next step once the event has been identified involves ascertaining the criteria used to select observations to include in the event study and well as limitations and aspects of these. This sample selection in itself presents sample selection bias. Putting this all together thus far, t would represent the time and $t = \tau$ would represent the event date for the capital control event (CCE) denoted by i.

The assessment of the effect of the event lies in, as stated earlier, the way we measure abnormal performance in order to get a gauge of the effect after the event. Accordingly, "abnormal return is the actual ex post return of the security over the event window minus the normal return of the firm over the event window" (MacKinlay, 1997, p. 15) presented as

$$AR_{i\tau} = R_{i\tau} - E(R_{i\tau}|X_\tau) \quad (8)$$

where $AR_{i\tau}$ represents the abnormal return, $R_{i\tau}$ is the actual return and $E(R_{i\tau}|X_\tau)$ is the normal return for the time interval τ. The normal return is on condition that X_τ has occurred (and represents the information content of the event for the normal return model.

The counterfactual in the event study is the normal return. This can be obtained using a forecast of the variable under study or using two types of statistical models[24], namely the constant mean return model and the market model[25]. Some authors have used economic models, the most notable (but with various constraints) are the Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing Theory (APT).

The market model describes the return on a given observation (usually a share) to the return on the market portfolio. As indicated in MacKinlay (1997, p. 18) its linear representation is associated with the normality of returns. The model for a given observation *i* is as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (9)$$

$$E(\varepsilon_{it} = 0); \quad var(\varepsilon_{it} = \sigma_{\varepsilon_t}^2)$$

[24] Assumptions for the statistical models include asset returns being (1) jointly multivariate and (2) independently and identically spread out over the period. The distribution assumption results in correct specification of models. The generalised method-of-moments could be used to ensure that abnormal returns are heteroskedasticity and autocorrelation consistent (MacKinlay, 1997, p. 17).

[25] According to MacKinlay (1997), the assumption in the constant mean return model is that the mean return of a share remains constant during the period. The market model however takes a different view in that the market return and the security return have a steady linear relationship.

with R_{it} and R_{mt} being security and market return respectively at time *t* and ε_{it} is the 0 mean error term. The constant α_i, the slope coefficient β_i and ${\sigma^2}_{\varepsilon_i}$ are parameters of the market model.

MacKinlay (1997) utilises the market model on a sample to estimate normal returns and shows that[26] the abnormal return is the error term applicable to the market model "on an out of sample basis"(MacKinlay, 1997, p. 20). This gives:

$$\widehat{AR}_{i\tau} = R_{i\tau} - \hat{\alpha}_i - \hat{\beta}_i R_{mt} \quad (10)$$

Or rearranged from formula (9)

$$\varepsilon_{it} = R_{it} - \alpha_i - \beta_i R_{mt} \quad (11)$$

Kothari & Warner (2006) present a simplified model of the return on a security given as:

$$R_{it} = K_{it} + \varepsilon_{it} \quad (12)$$

with K_{it} as the normal return, expected or predicted return, ε_{it} is the unexpected or abnormal portion of the returns (which could be underperformance or outperformance). Rearranging equation (12) we get the notation for the abnormal return as:

$$\varepsilon_{it} = R_{it} - K_{it} \quad (13)$$

This illustrates that the abnormal return is the difference between the actual ("observed") return and the expected return. The actual return relates to the return on condition that the event occurred, while the expected return is not guided by the event (denoted by the control observations and further expanded on in the propensity score methodology section). In this form, the abnormal return is the explicit gauge of the unanticipated change brought about by the event (Kothari & Warner, 2006, p. 9). For the purposes of this research, the market model is used. There are a variety of reasons for this, besides its simplicity, which are outlined in Appendix C.

Putting equations (12) and (9) and (7) in the form which presents error terms shows the following pattern (or similarities):

$$\varepsilon_{it} = R_{it} - K_{it} \quad (13)$$

$$\varepsilon_{it} = R_{it} - \alpha_i - \beta_i R_{mt} \quad (11)$$

$$\varepsilon_{i,t+1} = \Delta s_{i,t+1} - \alpha_i - \beta_i(r_{i,t} - r_t) - \gamma_i(r_{i,t} - r_t)Carry_{t+1} - \delta_i Carry_{t+1} - \tau_i Dollar_{t+1}$$

[from (7)] (14)

[26] The author notes that "ordinary least squares (OLS) is a consistent estimation procedure for the market model parameters" (MacKinlay, 1997, p. 20)

2.4.3. Specifying the null hypothesis for event studies

In event studies, the null hypothesis, H_0, usually states that the event has no effect or influence on the manner in which the returns (mean or variance) of the observation play out (MacKinlay, 1997, p. 21), or using the cumulative abnormal return (CAR, "…mean abnormal performance is equal to zero" (Kothari & Warner, 2006, p. 11).

2.4.4. Time series aggregation of abnormal returns

This step or process is used to make inferences for the event under study for both cross-sectional and time series analyses. One method of aggregating abnormal returns over time or the interval under study is the cumulative abnormal return or residuals (CAR)[27]. The CAR[28] approach starts off by outlining the sample cumulative abnormal returns $\widehat{\mathrm{CAR}}_i(\tau_1, \tau_2)$ from τ_1 to τ_2 with horizon length L. The sum of the included abnormal returns from τ_1 to τ_2 is given by

$$\widehat{\mathrm{CAR}}_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} \widehat{AR}_{i\tau} \tag{15}$$

As L increases the variance of $\widehat{\mathrm{CAR}}_i$ becomes:

$$\sigma_i^2(\tau_1, \tau_2) = (\tau_1 - \tau_2 + 1)\, \sigma_{\varepsilon_i}^2 \tag{16}$$

And the distribution of CAR for H_0 will be

$$\widehat{\mathrm{CAR}}_i(\tau_1, \tau_2) \sim N(0, \sigma_i^2(\tau_1, \tau_2)) \tag{17}$$

The null hypothesis testing can then be conducted as the CAR and null distributions of abnormal returns are available.

2.5. MEASURING LIQUIDITY EFFECTS

The preceding sections focussed on volatility (section 2.3) and analysis using the event study methodology (section 2.4). This section deals with the assessment of liquidity effects stemming from capital controls. Mancini, Ranaldo, & Wrampelmeyer (2013) utilised order data and intraday trading to assess[29] foreign exchange market liquidity. Their results illustrated that liquidity diminished during financial crisis and had a significant correlation across currencies.

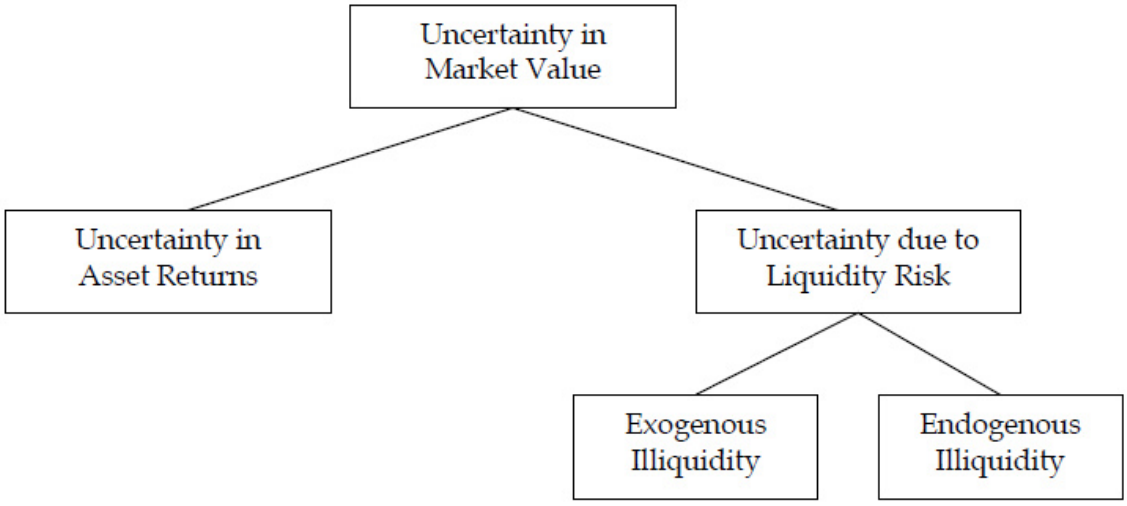
[27] See Kothari & Warner (2006) who discuss an alternative method called the buy-and-hold method.
[28] Refer to MacKinlay (1997, p. 21) for further information.
[29] The authors evaluated six liquidity measures, i.e. bid-ask spread, principal component, price impact, return reversal, effective cost and price dispersion for each exchange rate and each day.

Key to their work was the risk factor on tradable foreign exchange liquidity which explained a vast majority of the movement in returns attributable to daily carry trades. They also touch on the negative effects of illiquidity, something that policy makers attempt to rectify to ensure that liquidity is reinstated. However, the authors focused on a relatively short time period of about 3 years from January 2007 to December 2009, which might not be robust enough to draw conclusive inferences in the long run. This view is also shared by Karnaukh, Ranaldo, & Söderlind (2015).

Bangia et al. (2002) introduce the concept of an extra liquidity constituent inherent in markets which is a result of market participants overlooking not the mid-price when disposing of their positions, but instead the more important mid-price less bid-ask spread. They focus on the importance of the bid-ask spread as well as both liquidity elements that market makers can influence (endogenous) and those they cannot (exogenous). They also argue for overt modelling of liquidity risk, for instance in the Value at Risk (VaR) models. The authors liquidity risk model illustrates that overlooking the impact of liquidity can give rise to depressed approximations of market risk by about 25% to 30%. Trading when liquidity is scarce could drive up transaction costs as transactions occur at prices that might differ significantly from the mid-price.

Building on from their work, this research paper aims to not only focus on returns uncertaintly but also that of liquidity which are key in the overall operating environment as shown in their paper and in figure 4 below on the taxonomy of market risk. Thus this concept applies equally to foreign exchange.

Figure 4 - Taxonomy of Market Risk



Source: Modeling liquidity risk, with implications for traditional market risk measurement and management, Bangia et al. (2002)

Finally, and key to this research, Karnaukh, Ranaldo, & Söderlind (2015) investigate the liquidity of foreign exchange (spot rates) and show that:

a. Daily data can be used to obtain precise estimates of foreign exchange liquidity; and
b. Consistent with theoretical models on market liquidity and funding liquidity, liquidity of foreign exchange deteriorations with global risk and funding restrictions.

The authors assert that the assessment of liquidity effects in foreign exchange markets is limited and the reasons for liquidity imbalances are still unclear. The authors provide three motivations for assessing foreign exchange liquidity. The first, and as discussed in chapter 1 of this research paper, pertains to the magnitude of the average daily trading turnover of this foreign exchange market which was about $5 trillion in 2013 (Bank of International Settlements, 2013). This makes it the biggest financial market and given that the South African Rand was consistently ranked in the top 20 of currencies traded globally as shown in table 1 below, highlights the importance of such an evaluation of liquidity.

Table 1 Share and rank of average daily turnover of global exchange market for selected developed and emerging market economies 2001 – 2013

OTC foreign exchange turnover by currency in April 1995 - 2013, "net-net" basis

Daily averages, in billions of US dollars and percentage share

Currency full name	Currency - Code	2001			2004			2007			2010			2013		
		Amount	%	Rank	Amount	%	Rank	Amount	%	Rank	Amount	%	Rank	Amount	%	Rank
United States dollar	USD	1,114	89.9	**1**	1,702	88.0	**1**	2,845	85.6	**1**	3,370	84.9	**1**	4,652	87.0	**1**
Euro	EUR	470	37.9	**2**	724	37.4	**2**	1,231	37.0	**2**	1,551	39.1	**2**	1,786	33.4	**2**
Japanese Yen	JPY	292	23.5	**3**	403	20.8	**3**	573	17.2	**3**	754	19.0	**3**	1,231	23.0	**3**
British Pound sterlin	GBP	162	13.0	**4**	319	16.5	**4**	494	14.9	**4**	511	12.9	**4**	631	11.8	**4**
Australian dollar	AUD	54	4.3	**7**	116	6.0	**6**	220	6.6	**6**	301	7.6	**5**	462	8.6	**5**
Swiss franc	CHF	74	6.0	**5**	117	6.0	**5**	227	6.8	**5**	250	6.3	**6**	275	5.2	**6**
Canadian dollar	CAD	56	4.5	**6**	81	4.2	**7**	143	4.3	**7**	210	5.3	**7**	244	4.6	**7**
Mexican peso	MXN	10	0.8	**14**	21	1.1	**12**	44	1.3	**12**	50	1.3	**14**	135	2.5	**8**
Chinese Yuan (Renm	CNY	0	0.0	**35**	2	0.1	**29**	15	0.5	**20**	34	0.9	**17**	120	2.2	**9**
New Zealand dollar	NZD	7	0.6	**16**	21	1.1	**13**	63	1.9	**11**	63	1.6	**10**	105	2.0	**10**
Swedish krona	SEK	31	2.5	**8**	42	2.2	**8**	90	2.7	**9**	87	2.2	**9**	94	1.8	**11**
Russian rouble	RUB	4	0.3	**19**	12	0.6	**17**	25	0.7	**18**	36	0.9	**16**	85	1.6	**12**
Hong Kong dollar	HKD	28	2.2	**9**	34	1.8	**9**	90	2.7	**8**	94	2.4	**8**	77	1.4	**13**
Norwegian krone	NOK	18	1.5	**10**	27	1.4	**10**	70	2.1	**10**	52	1.3	**13**	77	1.4	**14**
Singapore dollar	SGD	13	1.1	**12**	18	0.9	**14**	39	1.2	**13**	56	1.4	**12**	75	1.4	**15**
Turkish lira	TRY	0	0.0	**30**	2	0.1	**28**	6	0.2	**26**	29	0.7	**19**	70	1.3	**16**
South Korean Won	KRW	10	0.8	**15**	22	1.1	**11**	38	1.2	**14**	60	1.5	**11**	64	1.2	**17**
South African Rand	ZAR	12	0.9	**13**	14	0.7	**16**	30	0.9	**15**	29	0.7	**20**	60	1.1	**18**
Brazilian real	BRL	6	0.5	**17**	5	0.3	**21**	13	0.4	**21**	27	0.7	**21**	59	1.1	**19**
Indian rupee	INR	3	0.2	**21**	6	0.3	**20**	24	0.7	**19**	38	1.0	**15**	53	1.0	**20**
	Total	**1,239**	**200**		**1,934**	**200**		**3,324**	**200**		**3,971**	**200**		**5,345**	**200**	

Countries with a percentage above 1% were included in the table. The sum of the percentage shares (which includes the omitted observations) totals 200% and not 100% because two currencies are involved in each transaction. Net-net basis implies that data is adjusted for local and cross-border inter-dealer double-counting. Source: Bank for International Settlements, Triennial Central Bank Survey (2013); Author (2016) computations for rankings

The second motivation stems from the foreign exchange market's importance in relation to the share, bond and derivative markets by ensuring that "efficiency and arbitrage conditions" (Karnaukh et al., 2015, p. 3074) exist in these markets.

Finally, the distinctive aspects of the foreign exchange markets result in trends in liquidity that might not be comparable to other traditional markets[30]. The key ones for this research include the sudden and marked decline in currency liquidity during sudden stop or crisis events and foreign exchange rates being linked to actions of central banks, such as capital control actions.

Their paper augments to literature by first clarifying currency liquidity fluctuations across time and observations for a long time period of 20 years, in contrast to work on shorter intervals (Mancini et al., 2013). They also look at the essential aspects that inform foreign exchange liquidity (both demand and supply side determinants) and its connection to volatility. Finally, they come up with a framework to estimate foreign exchange liquidity using high frequency data to create baselines which results in a better method as opposed to retrofitting low frequency measures. Their methodology to measure foreign exchange liquidity, mainly by utilising low-frequency (daily) data will be employed in this research paper to understand the impact of CCEs on foreign exchange liquidity.

The results of their work which will be used in this research paper, are quite profound and are as follows:

- Low-frequency liquidity estimators using bid-ask spreads and the Corwin-Schultz (2012) model provide the best relationships with the high frequency benchmarks[31]; and
- Liquidity of foreign exchange deteriorates with global risk and funding restrictions and illustrate the effect of TED and VIX spread changes on execution charges. They also point to the link with volatility and liquidity.

[30] The other factors include them being less transparent, diversity of members, consisting of differing segments (fragmented) as well as permitting participants to engage in large unsecured trades based on borrowed assets (Galati, Heath, & Mcguire, 2007).
[31] They use these estimates similar to the approach by Korajczyk and Sadka (2008).

2.6. DEVELOPMENT OF HYPOTHESIS

In sub-section 2.4.3, we noted that H_0 states that the capital control event has no effect or influence on the manner in which the returns (mean or variance) of the observation play out or behave (Kothari & Warner, 2006, p. 11; MacKinlay, 1997, p. 21). Accordingly, our null (H_0) and alternative (H_1) or research hypothesis are as follows:

- H_0: *The is no statistically significant relationship between the capital control event (introduction or changes in the event) and exchange rate stability. i.e. the expected exchange rate change is equal to zero; volatility and liquidity are not significantly impacted; and*
- H_1: *There is a statistically significant negative or positive relationship between the capital control event (occurrence or changes in the event) and exchange rate stability*.

This firstly flows from the efficient market hypothesis which postulates that daily frequency data for exchange rates follows a random walk rationale and therefore returns are close to zero. In non-statistical terms and for our study, it follows from the rationale that capital controls are implemented to cushion the economy from adverse effects that may otherwise increase the volatility of economic fundamentals or variables such as the exchange rate. Chapter 3 presents the research methodology applied to test the hypothesis.

CHAPTER 3: RESEARCH METHODOLOGY AND TECHNIQUES

3.1. INTRODUCTION TO RESEARCH APPROACH AND STRATEGY

This chapter outlines the methodology employed in the study. It starts with the econometric methodology including model specification, data used in the analysis, source of the data and alterations performed on the data. The analysis uses daily time series over the period 1 January 1999 to 31 December 2014 which was altered to construct the daily return or percentage changes in the Rand US Dollar exchange rate calculated as the natural logarithm between the current and previous day's spot exchange rate to represent the daily return on the currency. These were constructed using the following equation[32]:

$\ln\left[\frac{S_{i,t+1}}{S_{i,t}}\right]$ or amending the notation $\ln\left[\frac{S_{i,t}}{S_{i,t-1}}\right]$ (with s or e for the exchange rate) (18)

$\Delta s_{i,t+1}$ (natural logarithm form)

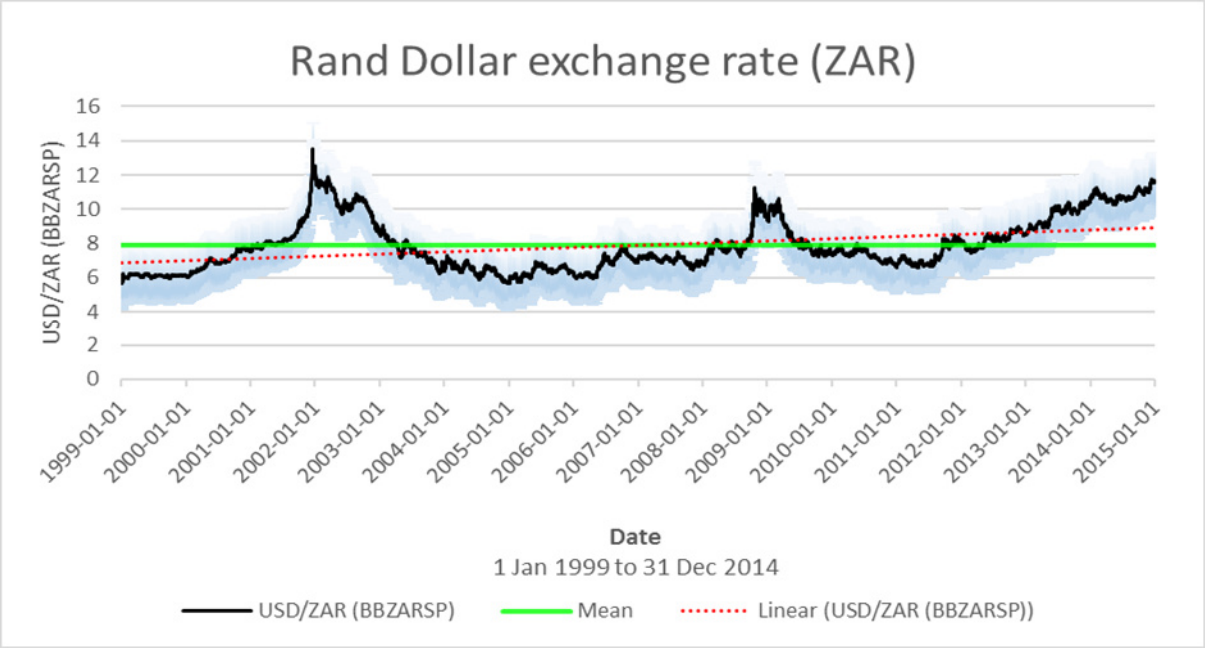
Diagnostic tests are also reviewed to ensure that the models are parsimonious or robust. A quantitative approach is utilised to answer the research question around relationships between explanatory variables and the dependent variable in order to explain, predict and control occurrences.

3.2. CAPITAL CONTROL EVENTS DURING THE PERIOD UNDER STUDY

Figure 5 illustrates the Rand US Dollar exchange rate over the period under study with an overlay of the trendline, the mean over the period and an area reflecting the errors bars representing the standard deviation over the period. Massive spikes represent the periods where the Rand collapsed in during the period 2000 to 2001 (and remained relatively weak through 2002) as well as during and post the 2007/08 financial crisis with the weakness persisting through 2009 (Čihák et al., 2012; International Monetary Fund, 2011)). As indicated in chapter 1, the period 2007 - 2009 corresponds to a sudden stop phase and is a useful reference point to test the effectiveness of capital controls on exchange rate changes in response to a major external shock. Two of the eight key capital control events selected for review occurred in 2008 and 2009 and another two occurred in 2000 and 2001.

[32] As indicated in section 2.3.2 of this paper, results from the Euler equation and as presented in Verdelhan (2015) and Lustig & Verdelhan (2006), exchange rates are given by $S_{i,t+1}$ / $S_{i,t}$ = $M_{i,t+1}$ / M_i or as logs $\Delta s_{i,t+1} = m_{t+1} - m_{i,t+1}$.

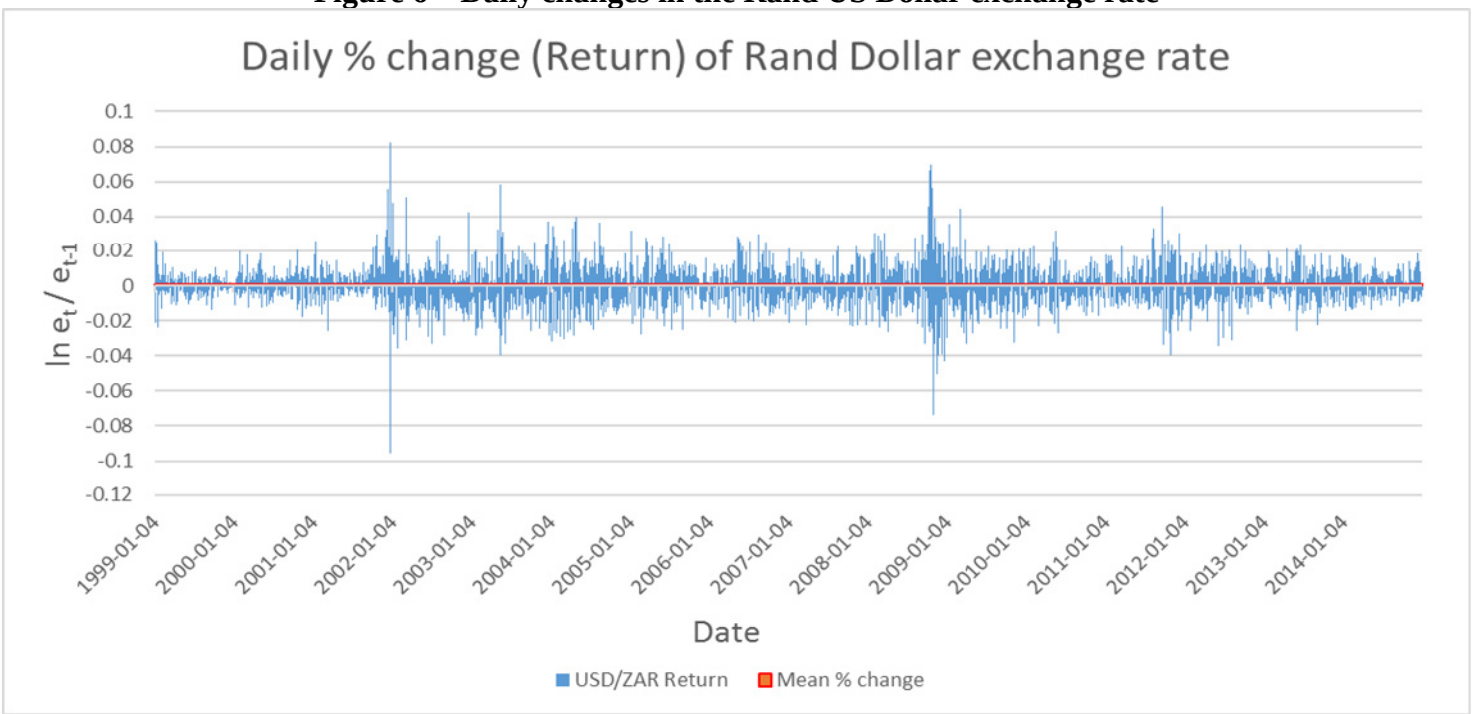
Figure 5 – Rand US Dollar exchange rate



Source: Datastream and Author, 2016

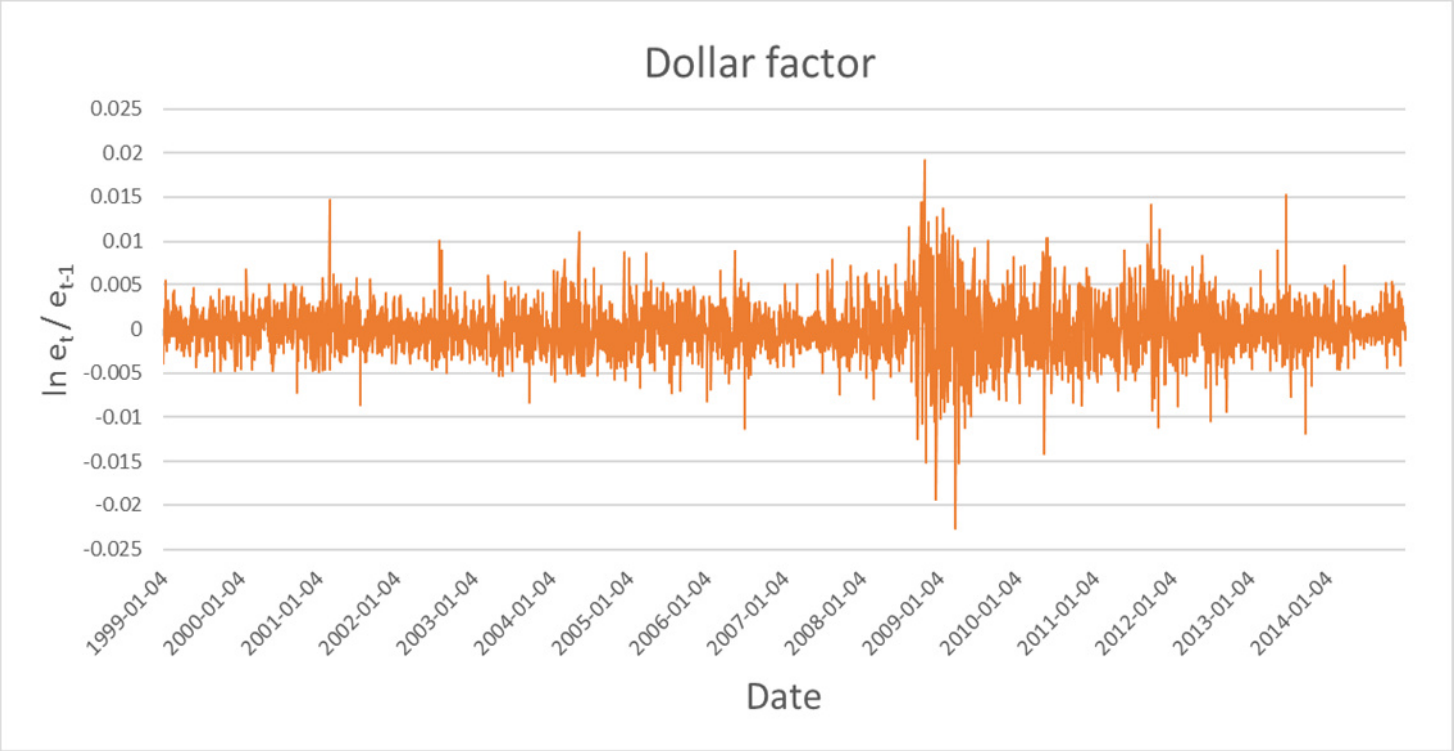
The daily percentage changes in the Rand US Dollar exchange rate are shown in figure 6. These were calculated as the log changes between the current and previous day's spot exchange rate to represent the daily return on the currency. The graph of the dollar factor only over the time period is presented in figure 7. In its simplified form, the dollar factor is the average change of the exchange rates used in the study in terms of the U.S. dollar.

Figure 6 – Daily changes in the Rand US Dollar exchange rate



Source: Datastream and Author, 2016

Figure 7 – Dollar factor over time period



Source: Datastream and Author, 2016

Table 2 below presents a view of capital control events or changes in South Africa, the date of announcement and/or effective date (where applicable and available) as well as the effect, i.e., easing or tightening of controls. The starting point is the South African Reserve Bank Exchange Control Manual (Section C) and additional categories, capital controls and restrictions contained in the 2014 AREAER are included. Additional sources also include news sources, websites for relevant regulators and numerous research papers. This is similar to the approach followed by Pasricha (2012) [as cited in Pandey et al. (2015)], who sought to enhance the measurement of capital control actions and were able to augment the amount of capital control actions, improved the cataloguing of actions thereby allowing for the ease in exposing their effects.

Table 2 –Key timelines of events and their effect

Announcement Date	Effective Date	Event / Detailed Change	Effect of change (Neutral, Tightening, Easing)	Key Exchange Control Event For Study
23 February 2000	23 February 2000	Increase in foreign asset limit for collective investment schemes (CIS / unit trust) companies to 20 percent of assets under management,(AUM); no change for other institutional investors as limits of 15% of total assets of long term insurers and pension funds and 15% of total assets for fund managers were retained (change supports competition with foreign CIS) . **Definition of assets applicable changed from total assets employed in South Africa to total assets or total assets under management.** Increase in the cash flow allowance for long-term insurance companies, pension funds and fund managers through their CIS to 10% of net inflow of funds in 1999 subject to foreign asset limits of 15% (15 % of total assets for long-term insurers, pension funds and fund managers) and 20% (for unit trust management companies).	Easing	Yes
21 February 2001	21 February 2001	Asset swap mechanism removed for new transactions (total foreign assets acquired under the asset swap mechanism amounted to R100 billion). Cash flow allowances renewed to an increased amount of 10% of the net inflow of funds in calendar 2000 (subject to foreign asset limits of 15% and 20%). New foreign investments by long-term insurers, pension funds and unit trust management companies were limited to 10 per cent of the net calendar 2000 inflow, subject to the overall asset limits. The cash flow dispensation expired at the end of 2001 and was not renewed.	Easing	Yes
October 2001	October 2001	Reserve Bank outlawed the financing of short rand positions in the domestic market by foreigners, i.e., borrowing rands locally in order to sell them for dollars (this practice of non-resident borrowing of rands to speculate in the currency market had been officially banned for many years but not been fully adhered nor adequately enforced and this statement reinforced an old rule). Authorised dealers were required to obtain certificates from non-resident banks and they could not trade with these parties without the certificates to indicate compliance with South African exchange control rules.	Tightening	No
13 November 2001	13 November 2001	The cash flow dispensation of February 2001 was extended to registered fund managers, who were authorized to make new foreign investments up to 10 per cent of their net calendar 2000 inflow, subject to the 15 per cent asset limit.	Easing	No
31 July 2003	31 July 2003	As an interim step towards prudential regulation, exchange control limit on foreign portfolio investment by institutional investors applied to an institution's total retail assets. Foreign exposure of retail assets could not exceed 15% for retirement funds, long-term insurers and investment managers registered as institutional investors for exchange control purposes, and 20% in the case of CIS / unit trust management companies. **New foreign asset limits introduced (though with reporting mechanisms and pre-application process to ensure prudential regulation of foreign exposure).**	Tightening	Yes
March 2004	March 2004	Additional foreign asset limit as 5% of total retail assets could be invested in African securities listed on the JSE and BESA (extended to include the entire universe of portfolio investments in 2006).	Easing	No
25 October 2005	25 October 2005	Foreign exposure limit on CIS was increased from 20% to 25% of total retail assets. For investment managers, the limit was increased from 15% to 25% percent of total retail assets. South African residents could therefore diversity their investment portfolios through domestic channels and enhanced the role of South African fund managers in facilitating the flow of funds to the continent.	Easing	Yes
10 February 2006	10 February 2006	Institutional investors were (on application) allowed to invest an additional 5% of total retail assets by acquiring foreign currency denominated portfolio assets in Africa through foreign currency. Transfers from South Africa or by acquiring inward listed securities.	Easing	No
20 February 2008	20 February 2008	Foreign asset limits for retirement funds and non-investment linked products of long-term insurers increased from 15% to 20% (clear distinction between underwritten policies and investment-linked business of long-term insurers was introduced). Foreign asset limits for CIS / unit trusts, investment managers registered as institutional investors as well as investment-linked products of long-term insurers increased to 30% of total retail AUM (**reporting mechanisms maintained but pre-application process removed**). Dispensation from 10 February 2006 available to institutional investors to invest an additional allowance equal to 5% of total retail assets into portfolio investments in Africa remained in place.	Easing	Yes
27 February 2009	27 February 2009	Limit on foreign capital allowance raised, restrictions on local FDI removed.	Easing	No
27 October 2009	27 October 2009	The R50m limit of 20 February 2008 (where an application had to be made where the total cost of new outward foreign direct investments exceeded R50m) was increased to R500m. Applications below R500m could be processed by Authorised Dealers, on condition that all existing criteria and reporting obligations remained). 180-day rule requiring companies to convert their foreign exchange, held in Customer Foreign Currency account (C.F.C account is opened in the name of the company and is conducted in the name of the Authorised Dealer), into Rand was removed.	Easing	Yes
01 March 2010	01 March 2010	Authorised dealers were allowed to acquire direct and indirect foreign exposure up to a macro-prudential limit of 25% of their total liabilities, excluding total shareholder's equity.	Easing	No
01 July 2010	01 July 2010	1961 Exchange Control Regulations amended, new Voluntary Disclosure Program (VDP) proposed.	Neutral	No
24 August 2010	24 August 2010	Future easing of controls announced, including removing tax hurdles for multinationals.	Neutral	No
27 October 2010	01 January 2011	Blocked rand transfers relaxed, various other exchange controls relaxed.	Easing	No
14 December 2010	14 December 2010	Prudential foreign investment limits raised, various other controls relaxed further. Foreign asset limits of retail assets were increased to 25% for retirement funds and non-investment linked products of long-term insurers. Investment managers registered as institutional investors for exchange control purposes, CIS management companies and investment-linked business of long-term insurers was increased to 35% of total retail AUM.	Easing	Yes
25 October 2011	27 October 2011	Future easing of rules announced in budget statement. South African companies are permitted to diversify and make bona fide new outward FDIs in areas outside their existing lines of business. Authorised Dealers may authorise requests for these outward FDIs (for investments not exceeding R500m per applicant company per calendar year). The Financial Surveillance Department will also consider requests by South African companies to make investments, excluding passive investments, in excess of R500m per applicant company per calendar year outside of their line of business. The prohibition of the transfer of additional working capital funding in for investments below R500 million per applicant company per calendar year was withdrawn.	Easing	Yes
27 October 2011	27 October 2011	Cross-border money transfer rules simplified and relaxed.	Easing	No
08 June 2012	08 June 2012	New regulation that extends controls to any intellectual property rights.	Tightening	No

Announcement Date	Effective Date	Event / Detailed Change	Effect of change (Neutral, Tightening, Easing)	Key Exchange Control Event For Study
2012	2012	Limit on offshore investments by individuals raised (gradual liberalization of outward capital transactions)	Easing	No
2012	2012	South Africa allowed the raising and deployment of capital abroad without exchange control approval for qualifying internationally headquartered companies	Easing	No
2012	2012	South Africa permitted companies to make investments unrelated to current businesses and lifted restrictions on additional working capital for existing businesses	Easing	No
2012	2012	On purchases by residents abroad, as part of its overall outflow liberalization strategy, South Africa raised the threshold below which such purchases would not require tax certification	Easing	No
2012	2012	South Africa, continuing the gradual liberalization of its financial account, allowed resident institutional investors to purchase securities that are registered in the local stock exchange	Easing	No
2012	2012	South Africa and Swaziland raised the permitted percentage of prepayment for capital goods	Easing	No
2012	2012	1. South Africa eased controls on (payments on) travel allowances. 2. South Africa raised the limit on miscellaneous payments to nonresidents	Easing	No
2013	2013	Nonresidents and qualifying South African and Common Monetary Area entities may now engage in Zambian-referenced grain derivative contracts, which may be listed on the South African stock exchange	Easing	No
2013	2013	• South Africa eased some of its rules governing the International Headquarter Company regime, including the approval requirement for direct investment; reduced the shareholding requirement to 10 percent; and permitted companies established under this regime to list shares and debt on the local stock exchange. • South Africa also permitted companies listed on the local stock exchange to establish one subsidiary in South Africa for African and offshore operations that is not subject to foreign exchange restrictions • South Africa permitted limited outward investment in companies, branches, and offices outside the Common Monetary Area operating outside the investor's current line of business and allowed the transfer of additional capital overseas on approval	Easing	No
2013	2013	South Africa imposed an approval requirement for treasury outsourcing companies before they may do business in the domestic foreign exchange market	Tightening	No
February 2013	February 2013	Following a significant easing of controls on outward foreign direct investment in 2011, banks in South Africa were allowed to invest an additional 5 percent of their total liabilities, excluding total shareholder equity, for expansion in Africa	Easing	No
2013	2013	South Africa and Swaziland raised the amount of advance payments that may be made for imports up to R 10 million from 50 percent to 100 percent of ex-factory cost	Easing	No
2014	2014	South Africa permitted certain unlisted companies to list overseas or to raise foreign loans and capital	Easing	No
2014	2014	South Africa permitted certain unlisted companies to borrow from overseas with approval	Easing	No
2014	2014	• South Africa eased some of the rules governing holding companies by permitting parent companies to transfer up to R 2 billion a year to a holding company; additional amounts require approval • South Africa permitted companies listed on the local stock exchange to establish one subsidiary in South Africa for African and offshore operations that are not subject to foreign exchange restrictions. To facilitate further foreign direct investment, South Africa also permitted certain unlisted companies to list overseas or to raise foreign loans and capital and companies listed on the local exchange to have a secondary listing or list depository receipt programs on foreign exchanges	Easing	No
2014	2014	South Africa eliminated a document review requirement for advance payments for transactions below a threshold	Easing	No

*Sources: South African Reserve Bank Exchange Control Manual, Section C; AREAER 2014; Gidlow (2005); Farrell & Todani (2006); Leape & Thomas (2011); Baumann & Gallagher, (2013) [Baumann & Gallagher cited Bloomberg, South Africa Reserve Bank and Wall Street Journal]

Key

✓ Represents the existence of the restriction / that it is an element of the exchange system	
× The restriction is not a feature of the exchange system	
	Actual date known
	Actual date not known, only month and year available
A. Capital Transactions and controls - Describes regulations influencing both inward and outward capital flows	
B. Arrangements for Payments and Receipts - When a country has payments agreements with other countries, the terms of these agreements often lead to a prescription of currency for specified categories of payments to, and receipts from, the countries concerned.	
C. Controls on payments for invisible transactions and current transfers - Includes income from investment (for example, profits, dividends, interest); payments for travel, education expenses, medical expenses, subscription or membership fees; and unrequited transfers (for example, remittance of nonresidents' salaries and wages)	
D. Proceeds from exports and/or invisible transactions - Describes restrictions on the use of export proceeds, as well as regulations on exports. Proceeds from invisible transactions and current transfers describes regulations governing exchange receipts derived from transactions in invisibles—including descriptions of any limitations on their conversion into domestic currency—and the use of those receipts	

3.3. DATA SOURCES AND COLLECTION

Data sourcing and collection of dependent and independent variables were obtained from various sources. These include the International Monetary Fund (IMF) and the Work Bank's World Development Indicators (WDI) database. The daily exchange rate and reserve data including the macroeconomic data were obtained from the International Monetary Fund's International Financial Statistics and the refined exchange rate data was obtained from the South African Reserve Bank (SARB). Additional daily exchange rate data and the Mid-Low-High quotes were obtained from Thomson Reuters Datastream [Barclays and Reuters]. The relative Bid-Ask spread data was obtained from Bloomberg. Data on capital account restrictions and events was obtained from the IMF's AREAER, Section C of the Exchange Control Manual as published by the South African Reserve Bank (SARB) and the Exchange Control Circulars from the Financial Surveillance Department of the SARB. Additional data on capital control actions was augmented by information from research by Gidlow (2005),

Farrell & Todani (2006), Leape & Thomas (2011) and Baumann & Gallagher (2013) [Baumann & Gallagher cited Bloomberg, the South African Reserve Bank and the Wall Street Journal]. The TED spread, VIX and VXO data were obtained from the Federal Reserve Bank of St. Louis, Economic Research Division.

3.4. DATA DEFINITIONS AND KEY VARIABLES USED IN THE RESEARCH METHODOLOGY

This sub-section provides a summary of the definitions of the data and key variables used in the study. As indicated previously in Chapter 2, this research paper uses existing literature on such as determinants of capital controls (Neely, 1999) as a foundation but explored a base regression for the event study stipulated by Verdelhan (2015). Appendix D contains the detailed definitions, sources and research support for the variables and data.

Table 3 – Summary of data definitions and key variables including research justification

Variable	Definition and research support / sources
$\Delta s_{i,t+1}$	The exchange rate return (Verdelhan, 2015). Source: Thomson Reuters Datastream [Barclays and Reuters]
α_t^2	Conditional variance (Abdalla, 2012; Bollerslev, 1986; Dukich et al., 2010; Farrell, 2001)
Dollar factor	The average change of the exchange rates in terms of the U.S. Dollar (Verdelhan, 2015)
Bid-Ask spread	Difference between bid and ask prices. Bloomberg, Karnaukh et al. (2015)
Corwin-Schultz (CS) measure	A low frequency measure of illiquidity. (Corwin & Schultz, 2012; Karnaukh et al., 2015)
TED*[33] *spread	Difference between the 3-month LIBOR and 3-month T-Bill yield (Forbes et al., 2015) Source: Federal Reserve Bank of St. Louis, Economic Research Division
VIX (S&P 500)	Index of market volatility as computed by the Chicago Board Options Exchange (CBOE); (Forbes et al., 2015) Source: Federal Reserve Bank of St. Louis, Economic Research Division
VXO (S&P 100)	Index of market volatility as computed by the CBOE; Uses options on the S&P 100 index. Source: Federal Reserve Bank of St. Louis, Economic Research Division

[33] **TED** is derived from **T**-Bills which are short term United States government debt and **ED** being the symbol for Eurodollar futures contracts (on the open outcry as opposed to the electronic where it is GE). T-Bill yield is the interest at which the U.S. Government can borrow for the 3-month period and Libor is the rate at which banks in the financial system can lend to each other on the over a 3-month period. The TED spread is an indicator of credit risk and the stability of the banking environment ("Definition of Ted spread," n.d.).

3.5. APPLYING THE EVENT STUDY METHODOLOGY TO THE RESEARCH TOPIC

The event study methodology will be applied to the eight key events shown in table 4 below to obtain the preliminary results of the effect of the capital control events on the exchange rate returns, volatility and liquidity. The abnormal returns for the event window will be calculated for each of the events, including the aggregation during the event window and the around the event. This approach is similar to that indicated by MacKinlay (1997, p. 21). The intention of this exercise is to assess whether statistically significant trends exist around the periods leading up to and during the event window and carried forward after the event.

Table 4 – The 8 key capital control events

Announcement Date	Effective Date	Effect of change (Neutral, Tightening, Easing)	Key Exchange Control Event For Study
23 February 2000	23 February 2000	Easing	Yes
21 February 2001	21 February 2001	Easing	Yes
31 July 2003	31 July 2003	Tightening	Yes
25 October 2005	25 October 2005	Easing	Yes
20 February 2008	20 February 2008	Easing	Yes
27 October 2009	27 October 2009	Easing	Yes
14 December 2010	14 December 2010	Easing	Yes
25 October 2011	25 October 2011	*Easing	Yes

* One of the events announced on 25 October 2011 only became effective on 27 October 2011

3.5.1. Methodology for assessing the impact returns

As stipulated in the literature review, the base market model for the event study arrived at by incorporating the carry and dollar factors (Verdelhan, 2015, p. 20) is:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i(r_{i,t} - r_t) + \gamma_i(r_{i,t} - r_t)Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Dollar_{t+1} + \varepsilon_{i,t+1} \quad (7)$$

The regression equation included the (unconditional) carry factor, the carry factor multiplied by the interest rate differential applicable to the country [conditional carry, $(r_{i,t} - r_t)Carry_{t+1}$], the interest rate differential and the dollar factor. However, the result of the author's work indicated that the carry factor did not contribute significantly to improving the explanatory power of the model (the R^2). As such, the carry factor was dropped from the base regression model to give a simplified model of the form:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i Dollar_{t+1} + \varepsilon_{i,t+1} \quad (19)$$

According to Pandey et al. (2015) who assessed the motivations and effectives of CCAs, controls are tightened following appreciation, and easing occurs in response to depreciation of

the exchange rate. This is consistent with the view that controls are utilised as an instrument to prevent instability or imbalance in an economy as well as extreme pressure on the exchange rate to appreciate as a result of increase in net capital inflows (Pradhan et al., 2011). Part of the event study is aimed at assessing whether the capital control event results in the anticipated change in the exchange rate. Table 5 illustrates the expected trends prior to and impact of the capital control events. Fratzscher (2005) presents four criteria based on existing literature to define the success of an event. These are the event criterion, direction criterion, reversal criterion and smoothing criterion[34]. The event criterion determines whether the exchange rate trend ***during the event*** is in line with the real intervention such that a capital control event to strengthen the currency results in the anticipated change ***during the event***. The direction criteria would evaluate "if the exchange rate movement over the ***post-event window*** is in the desired direction" (Fratzscher, 2005, p. 22). For instance, if the trend prior to tightening is appreciation of the currency, authorities would employ a tightening capital control event to ensure that the currency depreciates. ***However, and as mentioned by Fratzscher (2005), it is worth noting that it is difficult to determine the actual goal the policymakers had in mind as these can be diverse and ambiguous at times***. This research paper frames the goal according to the approach by Pandey et al. (2015) and Fratzscher (2005) which assumes that the intention is directly observable and known. Furthermore, the focus will be on the event and direction criterion only.

Table 5 – Expected trends of motivations and effectiveness

	Motivations	
	Trend prior to	
Exchange rate objective	*Easing*	*Tightening*
ZAR/USD returns	Depreciation	Appreciation
	Effectiveness	
	Expected impact of	
Exchange rate objective	*Easing*	*Tightening*
ZAR/USD returns	Appreciation	Depreciation

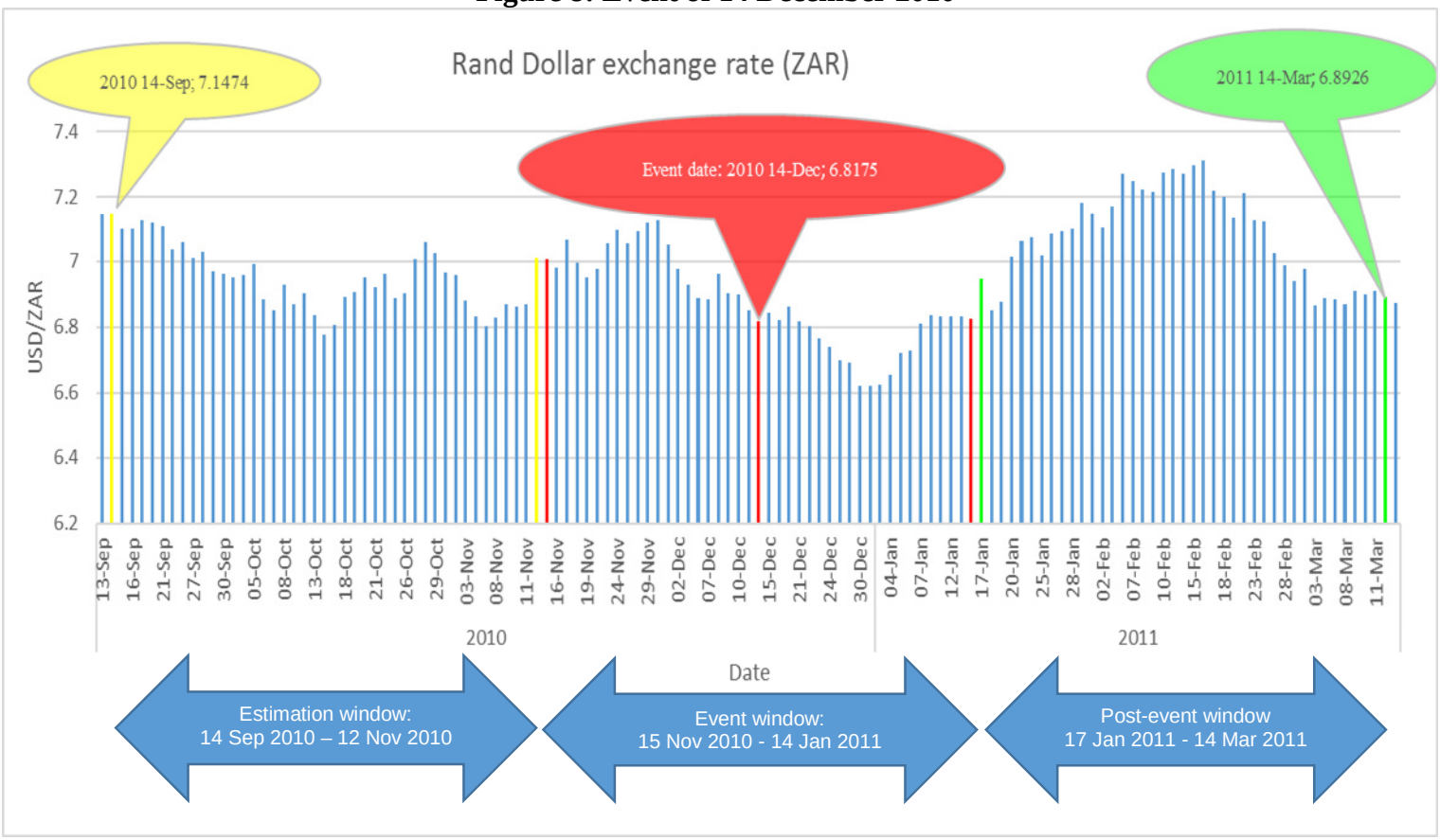
Source: Pandey et al. (2015)

This study used a total event window of 2 months, being 1 month before and 1 month after the introduction of the capital control event with emphasis on the exclusion window as indicated in Forbes et al. (2015) where the effects of the control might still be prevalent. Shorter time periods as is the case for event studies were not applied. The first day of the estimation window

[34] For further details on all four criteria see Fratzscher (2005, p. 22)

was set as 3 months before the event date and the final day of the post event window was 3 months after the event as shown in figure 8 for the capital control event that occurred on 14 December 2010. Additional evidence from Forbes, Fratzscher, Kostka, & Straub (2016) indicate that capital control events impact capital flows for an interval which is greater than a month but less than 3 months. Pandey et al. (2015) suggest that a suitable period to evaluate the effect on the exchange rate is less than 3 months and possibly a smaller timeframe.

Figure 8: Event of 14 December 2010



Source: SARB and Author, 2016

The choice of the market model to apply to this event study was driven by the availability of data, the variables used to explain the changes in the exchange rate and the explanatory power. A simple yet insightful model that is applied as an expanded form of the basic event study market model is the one used by Verdelhan (2015) as noted above. As indicated earlier in the literature review, the dollar factor was identified by the author as being the most crucial in

determining exchange rates. A dollar factor based on daily exchange rates was constructed using the following formula[35]:

$$Dollar_{t+1} = \frac{1}{N} \sum_i \Delta s_{i,t+1} \quad (20)$$

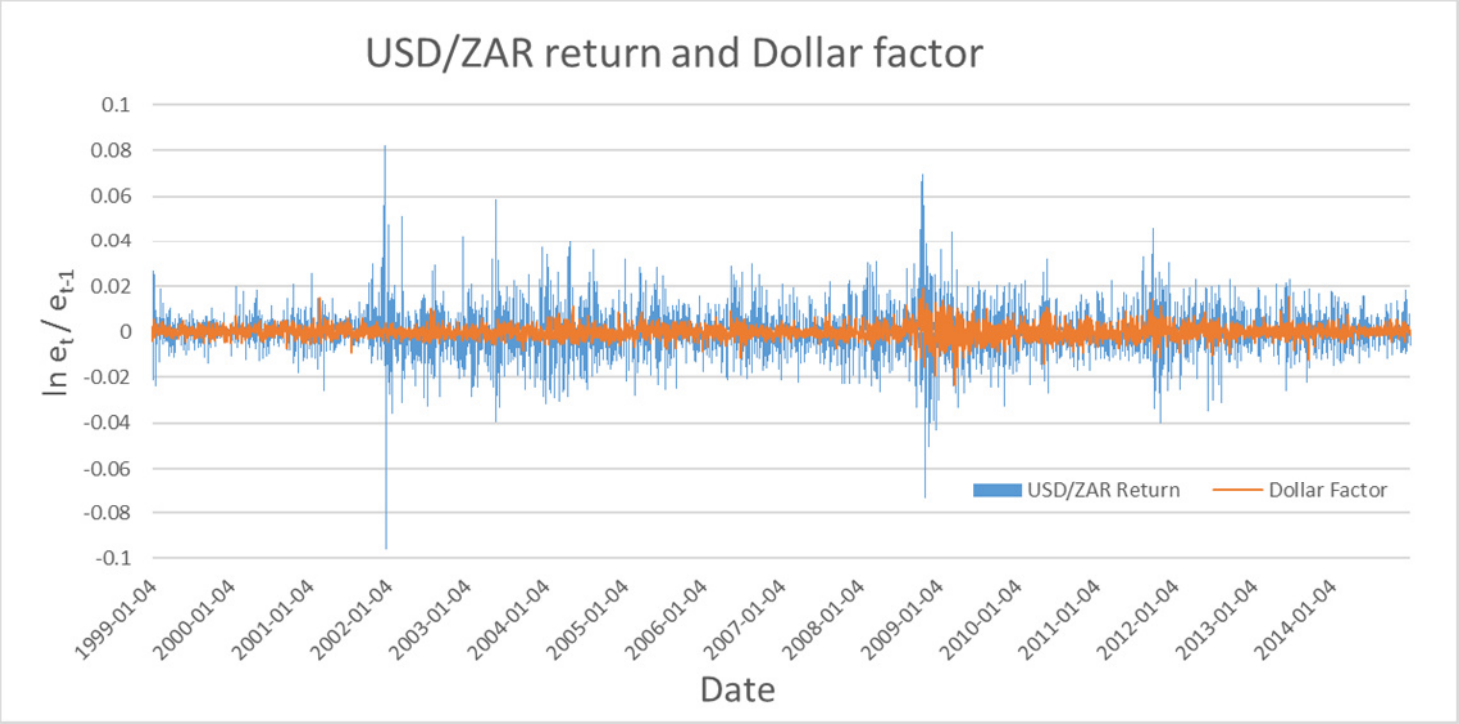
In constructing the dollar factor, the currency spot rates for the 28 countries that were used to compute the dollar factor (South African is included in this number) were obtained from Datastream[36]. The returns (or percentage change) for each exchange rate were computed by taking the natural logarithm. Thereafter, the daily returns for the 27 countries excluding South Africa (which would be the dependent variable for the regression) were summed up and divided by 27 to obtain the dollar factor. As such, a dollar factor was calculated for each business day (where applicable) from 1 January 1999 to 31 December 2014.

Figure 9 illustrates the ZAR/USD exchange rate return including the dollar factor and shows the layered view of the two variables. Although the graphs appear to show a common trend, it is inconclusive (at least at this stage) whether the effect of the dollar factor is significant enough to explain a large proportion of the variability of the ZAR/USD returns. A more conclusive answer to this will be obtained from the results of the regression analysis and the event study in Chapter 4. However, figure 9 does illustrate that the time series shows evidence of non-constant variance. The two notable instances are the abrupt increases in variation prevalent in 2002 and 2009, which are episodes immediately after the Rand collapsed in 2001 and the 2007/08 financial crisis respectively.

[35] The currency being investigated is excluded when calculating the Dollar factor.

[36] All data are daily, obtained from Thomson Reuters Datastream [Barclays and Reuters with the Mnemonics - BBZARSP,USDAUSP,BBCADSP,BBDKKSP,EUDOLLR,BBJPYSP,BBNZDSP,NWUSDSP,BBSEKSP,BBCHFSP,UKDOLLR,BBHKDSP,PRUSDSP,HNUSDNB,U$IRFR2,USINDON,USKUWTD,U$M$FR2,USMEXPF,PHUSDSP,POUSDSP,USSAUDR,USFR2,KOUSDSP,U$TWFR2,U$TBFR2,TKUSDSP,USUTDAD]

Figure 9 – ZAR/USD return and Dollar factor



Source: Datastream and Author, 2016

A number of the procedures used for measuring the returns will be applied when analysing the impact on liquidity and volatility.

3.5.2. Measuring impact on volatility

The GARCH (1,1) model will be the main focus of the impact on volatility. A number of other procedures will be performed on the data. As noted in sub-section 2.3.1 and as taken from Farrell (2001), the conditional variance can also be used as a representation or proxy for exchange rate volatility. Before that analysis, in keeping with first principles and as noted by Abdalla (2012), the starting point of volatility will be the standard deviation[37] of the changes in the exchange rate (i.e. standard deviation of the returns). Like Abdalla (2012), the research paper will, through the application of the GARCH (1,1) model, look at implied volatility (an estimation of volatility that looks into the future) and historic volatility (which is based on values from previous periods).

First, the average of the volatility (standard deviation) during the entire period (1 January 1999 to 31 December 2014) will be calculated in Microsoft Excel. The mean and maximum for the period will also be taken.

[37] Abdalla (2012) indicates that this measure cannot be observed and is often widely a matter of dispute.

Secondly, to assess the 8 key events, the average volatility across the 8 key events will be constructed and compared to the average of the over the entire period. The volatility for each key event will be calculated and recorded. The minimum and maximum for the 8 key events will be recorded (i.e. one of the key event periods will have the maximum volatility while another key event period will have the minimum).

Thirdly, the comparison will be based on the (a) average volatility over the entire period and compare that to the average volatility for the 8 key event periods; (b) a look at the maximum volatility for the 8 key events and (c) the minimum volatility for the 8 key events. The expected results this exercise aims to achieves are as follows:

- If the volatilities are sporadic or irregular and differ significantly to the average (over the period and for the 8 events), especially during the key events and keeping in mind the minimum and maximum, then the capital controls might not have the intended impact; and
- If the volatilities are consistent and tightly packed (not significantly different to the averages) then there could be merit or a case for capital controls as they managed to contain volatility within the required bounds.

The scenario indicated in the second bullet point would indicate that the authorities had looked at the impact to volatility before they implemented the controls and therefore timed the interventions appropriately to coincide with periods where they anticipated that such intervention would have limited impact on the market. It would also vindicate their decisions where volatility was high but reduced after the interventions. To achieve this objective, the analysis will review the following:

- The trend in volatility including what happened to the Rand during the entire 15-year period (using graphs of returns and volatility);
- Checking whether volatility also increased subsequent to each event window. Where there is no discernible trend and the foreign exchange market was relatively stable, the controls would not have distorted or had a negative impact on the market; and
- A view of each event by assessing the pre-event and post-event volatility to determine whether the impact of the CCE was significant.

The final part of the analysis will assess whether the data follows a GARCH process.

3.5.3. Measuring impact on liquidity

The liquidity section is based on the premise of assessing liquidity of any currency at any point in time. In this research paper, to assess the liquidity or illiquidity of the Rand exchange rate, a combination of the average of the a) Rand against the United States Dollar (ZAR/USD) and the b) Rand against the British Pound Sterling (ZAR/GBP) will be used.

This research paper will replicate the approach to assess liquidity and a monthly measure will be calculated much in the same way as illustrated in Karnaukh et al. (2015) and incorporates the methodology by Corwin & Schultz (2012). The intention is to use the average liquidity over a predetermined period and compare it to the entire period and the period when a CCE was implemented. More specifically, we will obtain monthly approximations of liquidity, mainly by utilising low-frequency (daily) data for each exchange rate and for the overall foreign exchange market for the period under study. The steps are outlined in appendix E.

In keeping with our event study intervals for the returns and volatility exercises, the benchmark for the currency will be set as over the last 3 months prior to the event window (therefore including the 2 months of the estimation window / interval) and this benchmark will be compared against the liquidity during the event window (and to an extent, during the post-event window).

The review will aim to illustrate, as per Karnaukh et al. (2015), the link between volatility and liquidity, the premise being that increased volatility would lead to illiquid market conditions[38].

3.6. DATA ANALYSIS TECHNIQUES

3.6.1. Unit Root tests

Several time series data exhibit trends or non-stationarity in the mean. This applies to exchange rates (which are price of currencies as well as asset prices). In some econometric techniques, the most appropriate structure of the trend must be established and the data changed to stationary before analysis. Non-stationary data might produce misleading results where the trends may cause spurious correlations which imply false relationships. To test for stationarity, the augmented Dickey-Fuller (ADF) type unit root test and the Phillips-Perron test are used. EViews by design produces the critical values for these tests.

[38] See page 12 of Karnaukh et al. (2015) for a description of their first hypothesis.

3.6.2. Autocorrelation

The test inspects whether the errors are uncorrelated or independent of each other. Where the errors are dependent, they are said to be serially correlated or autocorrelated. The purpose of this test is to avoid making a type I error, that is, rejecting a null hypothesis when it is in fact true. The regression results provide the Durbin-Watson statistic which is used to test autocorrelation.

3.6.3. Normality

A key assumption in econometric analysis such as the Analysis of Variance (ANOVA) method or those using the parametric t-test is the normality assumption[39] where the error terms must be normality distributed (they must resemble the normal probability distribution, also known as Gaussian distribution). The normality assumption is therefore a very important element underlying parametric t-tests, even in event studies. Where the data is non-normal, one should be cautious when using linear equations as regressions will lead to inaccurate conclusions. The Jarque-Bera test statistic is used to determine whether a series is normally distributed. EViews automatically presents the statistic and the probability for the summary statistics. The probability relates to the Jarque-Bera test statistic exceeding the observed null hypothesis value, where the null represents a normally distributed series. As such, a small probability implies a rejection of the null hypothesis of a normal distribution.

3.6.4. Correlation Matrix

A correlation matrix between the variables is a crucial as it provides a good measure of the co-movement and relationships between the variables. A view of the statistically positive (or negative) associations between variables including their strength can be established from the matrix.

3.6.5. Testing for Heteroscedasticity

As a general rule, and as noted by Abdalla (2012), a key aspect to consider prior to using the GARCH methodology is to inspect the residuals of the exchange rate returns for heteroscedasticity. The Lagrange Multiplier or ARCH LM can be utilised. Where volatility

[39] The other assumptions are that 1) The expected values of the error terms must be zero, 2) Variances of all errors terms are equal and 3) Errors are independent.

clustering is present, the residual or error term will be conditionally heteroscedastic and the ARCH and GARCH (1,1) model can be introduced when the residual behaves in this manner. As indicated in section 2.3, the mean and variance equation for the GARCH description are illustrated using equation 3[40] and 4 respectively as follows:

$$r_t = \mu + \varepsilon_t \quad (3)$$

$$\alpha_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4)$$

with ε_t being the residual returns (error term) which are used to construct the variance equation for the conditional variance $\boldsymbol{\alpha_t^2}$ (a forward looking forecast based on historic information);

- α_t^2 represents the current day's variance or volatility of the exchange rate returns;
- where the constant term is ω;
- ε_{t-1}^2 relates to the lagged or previous interval squared residual returns from the mean equation representing historic information about volatility or the previous interval exchange rate information about volatility, i.e. the ARCH term; and
- σ_{t-1}^2 represents the lagged or historic interval variance or volatility of the exchange rate i.e. the GARCH term.

The exogenous or predetermined variables such as the VIX, VXO and TED spread make up the final part of the equation with their corresponding constant terms[41]. These regressors might also contribute to the volatility of the exchange rate.

Where the intention is to estimate the mean and variance equations simultaneously, the GARCH (1,1) model would provide better results. The objective of this analysis is to model the volatility of the of the ZAR/USD returns and factors affecting the volatility of the exchange rate returns. More specifically, we aim to identify the factors that affect or contribute to the volatility i.e., is it the ARCH term, GARCH term, the exogenous variables or all. Three types of distributions can be used in the study which are:

i. Normal Gaussian distribution where the ARCH and GARCH term are significant and can influence the return volatility;
ii. Student's t-distribution with fixed degrees of freedom (df) with the same result as when the distribution is normal as stated above; and

[40] The mean equation $r_t = \mu + \varepsilon_t$ is converted into its expanded version, $\Delta s_{i,t+1} = \alpha_i + \beta_i Dollar_{t+1} + \varepsilon_{i,t+1}$ from the base regression model in equation 19 for the regression and GARCH estimation in EViews .

[41] The expanded version of variance equation including the 3 exogenous variables would be $\boldsymbol{\sigma^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \phi VIX + \psi VXO + \vartheta TED.}$ The VIX, VXO and TED variables were dropped from the equation as they were not significant for the GARCH expression.

iii. Generalized Error Distribution Assumption (GED) with fixed parameters where the results around the significant terms would be similar to i and ii above.

In terms of model selection and determining which of the 3 distributions is best suited, the following three assumptions must be fulfilled for the best model:

a. Serial correlation tested using the Correlogram of squared residuals (Q-statistic test)

   H_0: *There is no serial correlation in the residual or error term*

   H_1: *There is serial correlation*

b. Serial correlation Lagrange Multiplier (LM) test for ARCH effect

   H_0: *There is no ARCH effect*

   H_1: *There is an ARCH effect*

c. Residuals are normally distributed: Histogram and normality test (Jarque-Bera test statistic)

   H_0: *Residuals are normally distributed*

   H_1: *Residuals are non-normal*

In all three cases, all three null hypotheses are desirable to achieve the "best model" status.

3.7. TESTS OF STATISTICAL SIGNIFICANCE

3.7.1. Goodness of fit - R^2

Post the parameter estimates and regression results, one needs to determine how good a fit the least squares regression line is to the sample observations of the dependent variable and the independent variables. A common measure is the coefficient of determination or R-squared, which is the square of the correlation coefficient. It indicates the proportion of the total variation of the dependent variable that is explained by the independent variable.

3.7.2. Testing the significance of coefficients

The parameters are also tested for their adequacy using the t-statistics and the probabilities of the coefficients for the significance of the coefficients. Generally, where the t –statistics are greater than 2 and the probabilities (p-values) are less than 5% or closer to zero then the coefficients are significant. The coefficients provide an approximation of the trend. The p-value tests the null hypothesis that the coefficient is equal to zero or that the independent variable has no effect on the dependent variable. As such a low p-value (less than 0.05 or the selected significance level) indicates rejection of the null hypothesis and the response variable is affected by the predictor variable. The opposite applies for high p-values and we cannot reject the null hypothesis in favour of the alternative hypothesis.

CHAPTER 4: RESEARCH FINDINGS, ANALYSIS AND DISCUSSION

4.1. INTRODUCTION

This chapter presents the main results of the study. It includes a review of the descriptive statistics, and an analysis of the correlation matrix. It also discusses the diagnostic tests performed, the regression results and the findings from the hypothesis testing which form the basis upon which conclusions and recommendations of the study are drawn from.

4.2. REVIEW OF DESCRIPTIVE STATISTICS

Table 6 present the descriptive statistics for the Rand exchange rate and the daily changes in the exchange rate (returns) respectively, i.e. the dependent variable.

Table 6: Microsoft Excel summary statistics

5.1: Rand exchange rate		**5.2: Exchange rate returns (dependent)**	
Mean	7.895323	Mean	0.000162
Standard Error	0.023572	Standard Error	0.000161
Median	7.519650	Median	0.000000
Mode	6.150000	Mode	0.000000
Standard Deviation	1.522914	Standard Deviation	0.010391
Sample Variance	2.319267	Sample Variance	0.000108
Kurtosis	-0.278482	Kurtosis	6.097328
Skewness	0.839792	Skewness	0.238508
Range	7.895400	Range	0.178202
Minimum	5.645100	Minimum	-0.095883
Maximum	13.540500	Maximum	0.082319
Sum	32955.077100	Sum	0.674487
Count	4174	Count	4174
Largest(1)	13.540500	Largest(1)	0.082319
Smallest(1)	5.645100	Smallest(1)	-0.095883

Source: Author, 2016

A summary of the descriptive statistics for the collection of the dependent and independent variables used in the regression equations for the period 1999 to 2014 is shown in table 7 (summary statistics on individual samples basis) and 8 (on a common sample basis). Table 7 and 8 report the statistical characteristics of the daily returns. **The sample average return of 0.0162% (0.000162) is not significantly different to zero.** Regarding the dependent variable, on 16 October 2008, the ZAR/USD return increased to its second highest level of 6.95% from

its highest level of 8.23% recorded in 2001 (on 20 December 2001). The lowest levels recorded are a low of -9.59% on 21 December 2001 (a day after highest value in the period under study) and the second lowest being a return of -7.36% on 29 October 2008. As previously indicated, these dates are consistent with the collapse of the Rand during 2001 and the financial crisis of 2007/08 where the currency volatility was considerably high. Given that Verdelhan (2015) indicates that the dollar factor (and to lesser extent the carry factor) accounts for a significant proportion of the exchange rate movements, it is not surprising to see that the highest level of 1.9% for the dollar factor calculated was recorded on 22 October 2008 which corresponds to a similar period as the second highest level for the ZAR/USD return. The lowest level of the dollar factor of -2.26% occurred on 19 March 2009 when the effects of the financial crisis were still prevalent.

Table 7 – Individual samples descriptive statistics

	RAND_$_BBZARSP_RETURN	DOLLAR_FACTOR	TEDRATE	VIXCLS	VXOCLS
Mean	0.000162	0.000013	0.479878	21.157350	21.648620
Median	0.000000	-0.000013	0.330000	19.540000	20.170000
Maximum	0.082319	0.019176	4.580000	80.860000	87.240000
Minimum	-0.095883	-0.022647	0.090000	9.890000	8.510000
Std. Dev.	0.010391	0.002910	0.451894	8.793671	9.782740
Skewness	0.238422	0.114228	3.158833	1.971028	1.759863
Kurtosis	9.088590	7.269899	17.859880	9.522811	8.324293
Jarque-Bera	6486.797000	3179.933000	42618.340000	9741.652000	6828.466000
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.674487	0.054005	1882.560000	85158.320000	87092.400000
Sum Sq. Dev.	0.450546	0.035345	800.903900	311170.500000	384913.400000
Observations	4174	4174	3923	4025	4023

Source: Author, 2016

Table 8 – Common sample descriptive statistics

	RAND_$_BBZARSP_RETURN	DOLLAR_FACTOR	TEDRATE	VIXCLS	VXOCLS
Mean	0.000138	0.000013	0.479967	21.160690	21.660550
Median	0.000000	-0.000015	0.320000	19.550000	20.180000
Maximum	0.082319	0.019176	4.580000	80.860000	87.240000
Minimum	-0.095883	-0.022647	0.090000	9.890000	8.510000
Std. Dev.	0.010641	0.002965	0.452190	8.803831	9.792349
Skewness	0.232379	0.108875	3.156961	1.972505	1.759688
Kurtosis	8.762510	7.086106	17.837840	9.541144	8.340982
Jarque-Bera	5454.834000	2732.707000	42438.580000	9523.152000	6677.197000
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.541439	0.051598	1880.030000	82886.430000	84844.390000
Sum Sq. Dev.	0.443444	0.034434	800.728100	303519.100000	375505.700000
Observations	3917	3917	3917	3917	3917

Source: Author, 2016

4.3. RESULTS OF DATA ANALYSIS TECHNIQUES

4.3.1. Unit Root tests

For the time series variables in the study, the ADF regression estimated was in the format:

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + \varepsilon_t \quad (21)$$

with ΔY_t being the first differences of the series, p is the suitable length of the lag, γ and β represent the parameter estimates and ε_t is the random error term. The test is executed on γ and compared to the critical values. For both the ADF and Phillips-Perron tests, the intercept and trend were excluded from the computation as they were both insignificant.

Table 9: Results of unit root tests

Variable	ADF*	Probability		Phillips-Perron	Probability
Rand $ BBZARSP Return	-63.97922	0.0001		-63.98557	0.0001
Dollar factor	-50.96228	0.0001		-51.42236	0.0001

*At 1%, 5% and 10% significance levels. Source: Author, 2016

The results in the table indicate that the null is rejected for the two variables and therefore there is no unit root. The variables are deemed to be stationary which is consistent for the expected results on logged returns of the exchange rate. The comprehensive results are shown in appendix G.

4.3.2. Autocorrelation

To measure the validity of the estimated model, one of the tests performed was for serial correlation using the Durbin-Watson (DW) test. The results are shown in table 10 below. The Durbin-Watson test statistic indicates the absence of serial correlation. A DW statistic around 2 indicates that there is no serial correlation, which is the case for our time series data. This is also shown in figure 11 which shows a plot of the residuals over time and no discernible trend and hence showing independence of error terms.

Table 10 - Serial correlation results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOLLAR_FACTOR	1.785592	0.047866	37.30367	0.0000
C	0.000138	0.000139	0.994253	0.3202

R-squared	0.250121	Mean dependent var	0.000162
Adjusted R-squared	0.249941	S.D. dependent var	0.010391
S.E. of regression	0.008999	Akaike info criterion	-6.582933
Sum squared resid	0.337855	Schwarz criterion	-6.579897
Log likelihood	13740.58	Hannan-Quinn criter.	-6.581859
F-statistic	1391.564	Durbin-Watson stat	2.104669
Prob(F-statistic)	0.000000		

Source: Author, 2016

4.3.3. Normality

One of the expected key results from the descriptive analysis relates to the Jarque-Bera test statistic and its accompanying probability (which is very small) which indicate that the series of exchange rate returns is not normally distributed. This is not surprising as it is a common problem of using daily data in studies. Brown and Warner (1985) report the same results for abnormal returns of NYSE_AMEX based on daily data. The authors indicate that the returns diverge significantly from the normality condition both in terms of kurtosis and skewness. The authors however do suggest that even though the findings are not in line with the normality assumption, the level of non-normality does not result in a severe issue for accurate test specification as the empirical power of the tests is similar to the theoretical power based on the normality assumption. This is also in line with empirical evidence where returns display so called volatility clustering (Abdalla, 2012; Bangia et al., 2002), with variances changing across the time series period. This is consistent with the data (see figure 6 in section 3.2) which shows small changes occurring after small fluctuations and larger fluctuations preceded by large fluctuations. In this research paper, we have opted to use the GARCH (1,1) model in the

assessment of volatility as it is among the group of volatility models established to manage volatility clustering (Abdalla, 2012; Bangia et al., 2002).

4.3.4. Correlation Matrix

The correlation matrix between the variables is a crucial as it provides a good measure of the co-movement and relationships between the variables. The correlation matrix in table 11 indicates positive signs for the coefficients. There is a strong and statistically positive associations between variables, specifically the ZAR/USD return and the dollar factor. The VIX and VXO variables are close to 1 because they are similar in nature with the VIX a measure for the S&P500 while the VXO relates to the S&P100. In addition, the VXO was termed the "original" VIX index prior to 22 September 2003. This relationship was expected. Finally, a positive correlation exists between the dependent variable and the remaining explanatory variables. It should be noted that in the regression these variables were not significant and inferences based on these should be taken with caution.

Table 11 Correlation matrix for the variables

	DOLLAR_FACTOR	RAND_$_BBZARSP_RETURN	TEDRATE	VIXCLS	VXOCLS
DOLLAR_FACTOR	1.000000	0.500121	0.054527	0.081525	0.080347
RAND_$_BBZARSP_RETURN	0.500121	1.000000	0.035069	0.035059	0.034865
TEDRATE	0.054527	0.035069	1.000000	0.502157	0.506424
VIXCLS	0.081525	0.035059	0.502157	1.000000	0.987977
VXOCLS	0.080347	0.034865	0.506424	0.987977	1.000000

Source: Author, 2016

4.4. TESTS OF STATISTICAL SIGNIFICANCE

4.4.1. Goodness of fit - R^2 and significance of coefficients

Table 12 below shows the parameter estimates and regression results for dollar factor, the TED spread and the VIX and VXO. The coefficient of determination or adjusted $\boldsymbol{R^2}$ value of 24.9 (24.8 for the adjusted $\boldsymbol{R^2}$ in the regression which excludes missing values) indicates that the variables alone do not explain a significant portion of the variability in the exchange rate returns. However, adding more variables did not significantly increase the predictive ability of the model as exchange rate data for South Africa contains an inherently greater variability that is difficult to explain or even unexplainable. Table 13 shows the results of the regression with only the dollar factor. The other variables were dropped given their higher p-values which

rendered them insignificant. The R^2 value for this regression increases slightly to 25.0 indicating that the additional independent variables did not contribute towards explaining the variability in the dependent variable (and the slight reduction of the adjusted R^2 indicates how the model penalises for the additional variables that do not support how well the model explains variability). Although the R^2 value is still relatively lower than preferred, the manner in which we interpret the significant variable, the dollar factor, will be the same regardless of whether this was a high or low R^2 model.

The p-value tests the null hypothesis that the coefficient is equal to zero or that the independent variable has no effect on the dependent variable. The low p-value obtained from the results indicates rejection of the null hypothesis and the response variable is affected by the predictor variable, i.e., the dollar factor has a positive impact or relationship on the exchange rate movements and is a meaningful addition to the model. Other things equal, a unit change (or increase) in the in the dollar factor will increase the exchange rate return by an average factor of 1.79. Plots of the residuals are shown in figures 10 and 11 while a histogram is shown in figure 12. Additional outputs are shown in appendix G.

Table 12 – Regression results including Dollar factor, TED spread, VIX and VXO

Dependent Variable: RAND_$_BBZARSP_RETURN
Method: Least Squares
Date: 06/28/16 Time: 02:58
Sample: 1/01/1999 12/31/2014
Included observations: 4174

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOLLAR_FACTOR	1.786580	0.048044	37.18657	0.0000
TEDRATE	0.000325	0.000357	0.910033	0.3629
VIXCLS	-2.23E-05	9.50E-05	-0.234339	0.8147
VXOCLS	7.56E-06	8.68E-05	0.087093	0.9306
C	0.000289	0.000349	0.826281	0.4087

R-squared	0.250307	Mean dependent var	0.000162
Adjusted R-squared	0.249588	S.D. dependent var	0.010391
S.E. of regression	0.009001	Akaike info criterion	-6.581744
Sum squared resid	0.337771	Schwarz criterion	-6.574154
Log likelihood	13741.10	Hannan-Quinn criter.	-6.579059
F-statistic	347.9860	Durbin-Watson stat	2.106124
Prob(F-statistic)	0.000000		

Source: Author, 2016

Dependent Variable: RAND_$_BBZARSP_RETURN
Method: Least Squares
Date: 05/07/16 Time: 13:46
Sample (adjusted): 1/04/1999 12/31/2014
Included observations: 3917 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOLLAR_FACTOR	1.791682	0.049952	35.86775	0.0000
TEDRATE	0.000427	0.000375	1.140338	0.2542
VIXCLS	-7.95E-05	0.000108	-0.738032	0.4605
VXOCLS	5.32E-05	9.71E-05	0.548167	0.5836
C	0.000439	0.000415	1.058045	0.2901

R-squared	0.249028	Mean dependent var	0.000138
Adjusted R-squared	0.248260	S.D. dependent var	0.010641
S.E. of regression	0.009226	Akaike info criterion	-6.532222
Sum squared resid	0.333014	Schwarz criterion	-6.524215
Log likelihood	12798.36	Hannan-Quinn criter.	-6.529381
F-statistic	324.3115	Durbin-Watson stat	2.092812
Prob(F-statistic)	0.000000		

Source: Author, 2016

Table 13 – Regression results with Dollar factor only

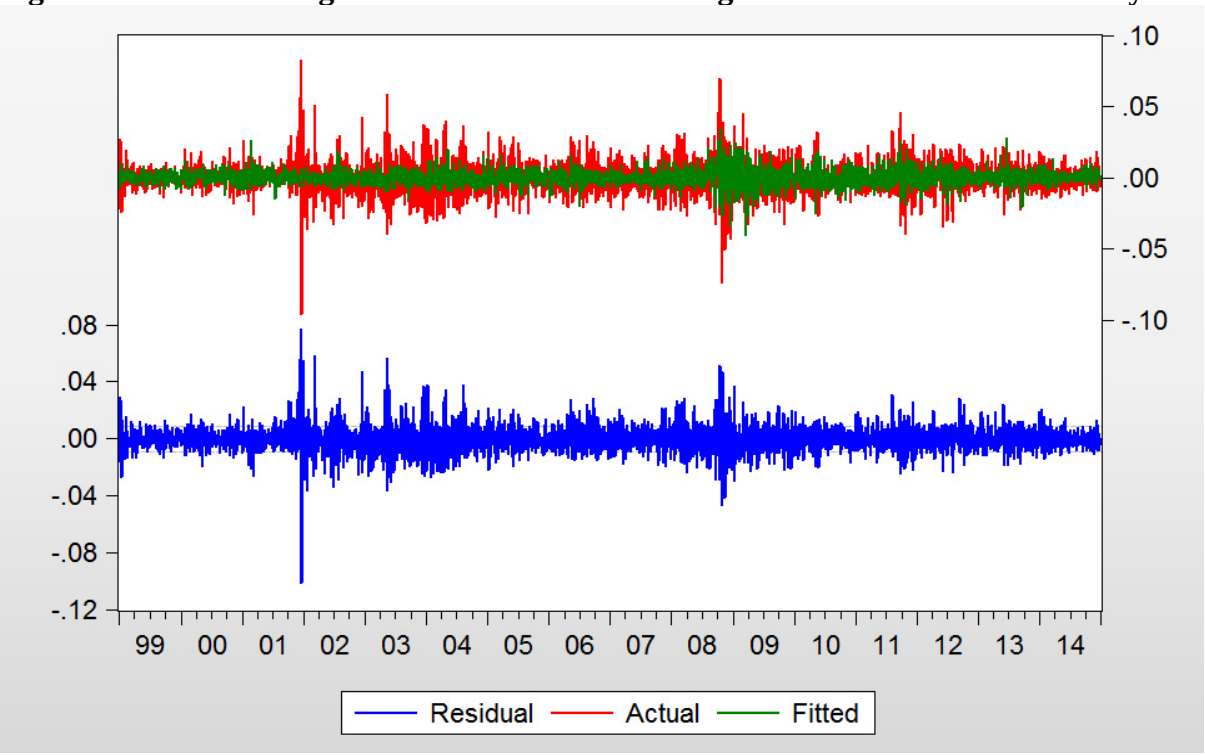
Dependent Variable: RAND_$_BBZARSP_RETURN
Method: Least Squares
Date: 05/06/16 Time: 03:02
Sample: 1/01/1999 12/31/2014
Included observations: 4174

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOLLAR_FACTOR	1.785592	0.047866	37.30367	0.0000
C	0.000138	0.000139	0.994253	0.3202

R-squared	0.250121	Mean dependent var	0.000162
Adjusted R-squared	0.249941	S.D. dependent var	0.010391
S.E. of regression	0.008999	Akaike info criterion	-6.582933
Sum squared resid	0.337855	Schwarz criterion	-6.579897
Log likelihood	13740.58	Hannan-Quinn criter.	-6.581859
F-statistic	1391.564	Durbin-Watson stat	2.104669
Prob(F-statistic)	0.000000		

Source: Author, 2016

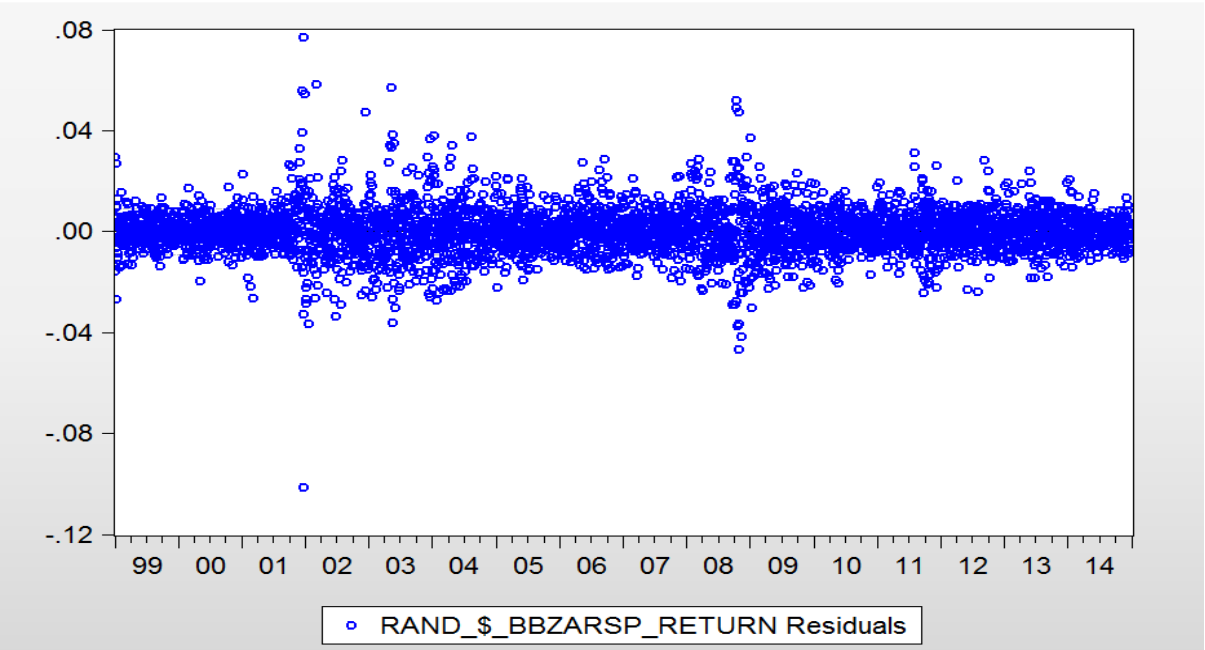
Figure 10 – Residuals against actual and fitted for regression with dollar factor only



Source: Author, 2016

The figure above indicates how well the data from the model is in line with the actual values.

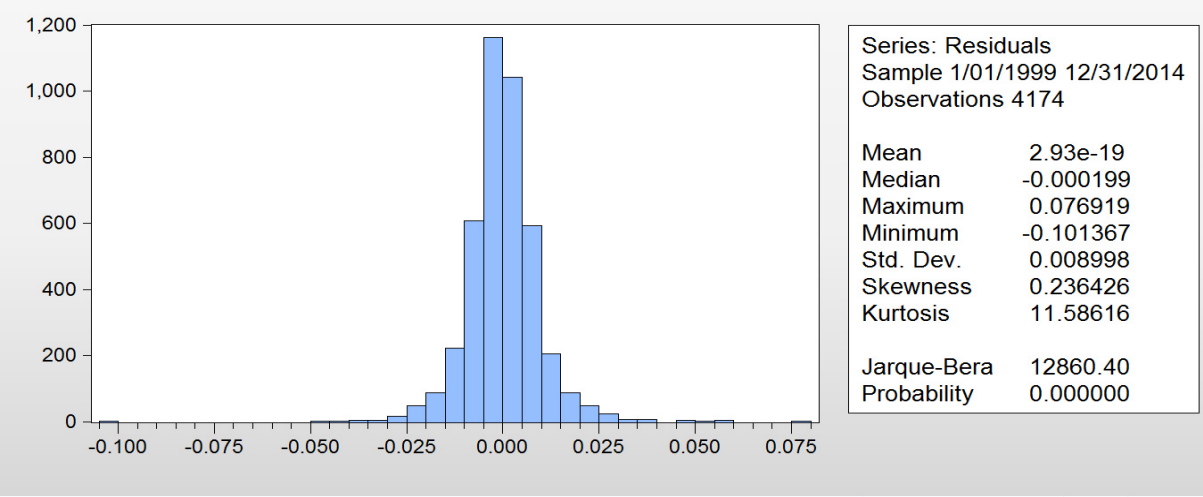
Figure 11 - Scatter plot of residuals over time for regression with dollar factor only



Source: Author, 2016

The plot of the residuals over time indicates that there is no discernible trend and hence showing independence of error terms.

Figure 12 – Histogram of residuals against time



Source: Author, 2016

The plot above was used to check for non-normality of the residuals to detect heteroscedasticity. The Jarque-Bera statistic shows that the residuals are non-normal.

4.5. EMPIRICAL RESULTS AND DISCUSSION

4.5.1. Applying the event study methodology - Results of the event study to 8 key events on returns

The event study methodology was applied to the eight key events discussed in section 3.5 (Table 4) to obtain the preliminary results of the effect of the capital control events on the exchange rate returns. The abnormal returns for the event window were calculated for each of the events using a regression based on the estimation window and applying the regression results to the event window. Thereafter, the abnormal return observations were aggregated for the event window and through the observations surrounding the event, similar to the approach indicated by MacKinlay (1997, p. 21). As stipulated in the literature review as well as section 3.5, the result of the author's work (Verdelhan, 2015) indicated that the carry factor did not contribute significantly to improving the explanatory power of the model (the R^2). As such, the carry factor was dropped from the base market model for the regression to give a simplified model of the form, i.e.

$$\Delta s_{i,t+1} = \alpha_i + \beta_i Dollar_{t+1} + \varepsilon_{i,t+1} \quad (19)$$

Table 14 below provides a view of the events, the estimation window, event window and post event window. A summary of the average percentage changes in the exchange rate before,

during and after the capital control event did not reveal any noticeable trend or signal of effectiveness.

Table 14 – 8 Key events and percentage change in exchange rate

Announcement Date	Effective Date	Effect of change (Neutral, Tightening, Easing)	Estimation window start date =EDATE(A2;-3)	Estimation window end date (day before event period start) =I2-1	Event Period start date =EDATE(A2;-1)	Event period end date =EDATE(A2;1)	Post-event window start date (day after event period end) =J2+1	Post-event window end date =EDATE(A2;3)	% exchange rate change		
									Before	During	After
23 February 2000	23 February 2000	Easing	23 November 1999	22 January 2000	23 January 2000	23 March 2000	24 March 2000	23 May 2000	-0.0062%	0.1291%	0.2063%
21 February 2001	21 February 2001	Easing	21 November 2000	20 January 2001	21 January 2001	21 March 2001	22 March 2001	21 May 2001	0.0340%	0.0322%	-0.0323%
31 July 2003	31 July 2003	Tightening	30 April 2003	29 June 2003	30 June 2003	31 August 2003	01 September 2003	31 October 2003	0.0963%	-0.0383%	-0.1428%
25 October 2005	25 October 2005	Easing	25 July 2005	24 September 2005	25 September 2005	25 November 2005	26 November 2005	25 January 2006	-0.0874%	0.0434%	-0.1768%
20 February 2008	20 February 2008	Easing	20 November 2007	19 January 2008	20 January 2008	20 March 2008	21 March 2008	20 May 2008	0.1022%	0.3411%	-0.1712%
27 October 2009	27 October 2009	Easing	27 July 2009	26 September 2009	27 September 2009	27 November 2009	28 November 2009	27 January 2010	-0.0923%	-0.0016%	0.0638%
14 December 2010	14 December 2010	Easing	14 September 2010	13 November 2010	14 November 2010	14 January 2011	15 January 2011	14 March 2011	-0.0637%	-0.0050%	-0.0329%
25 October 2011	25 October 2011	*Easing	25 July 2011	24 September 2011	25 September 2011	25 November 2011	26 November 2011	25 January 2012	0.4374%	0.0700%	-0.1432%

Source: Author, 2016. Where the date in question fell on a holiday or non-business day, the previous or following business day was used.

The abnormal return, $\widehat{AR}_{i\tau} = R_{i\tau} - \hat{\alpha}_i - \hat{\beta}_i R_{mt}$ as indicated by MacKinlay (1997) was calculated using the market model, $\Delta s_{i,t+1} = \alpha_i + \beta_i Dollar_{t+1} + \varepsilon_{i,t+1}$.

$\widehat{AR}_{i\tau}$ in this case was approximated as $\varepsilon_{i,t+1}$ thus rearranging equation 19, our equation for the abnormal return, which is a subset of equation 7 is given as

$$\varepsilon_{i,t+1} = \Delta s_{i,t+1} - \alpha_i - \beta_i Dollar_{t+1}. \quad (22)$$

In a similar manner to the Haldane and Hall (1991) exchange rate equation used in Frankel and Wei (1994), the error term, $\varepsilon_{i,t+1}$, would represent the South African specific fluctuations in the Rand Dollar exchange rate.

The test statistic for each day in the event were constructed using the formula which divided the abnormal return by the standard error calculated from the regression on the estimation period data. Thereafter the abnormal returns were aggregated over the period to obtain the cumulative abnormal returns (CAR) where $\widehat{\mathrm{CAR}}_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_{i\tau}$ (15)

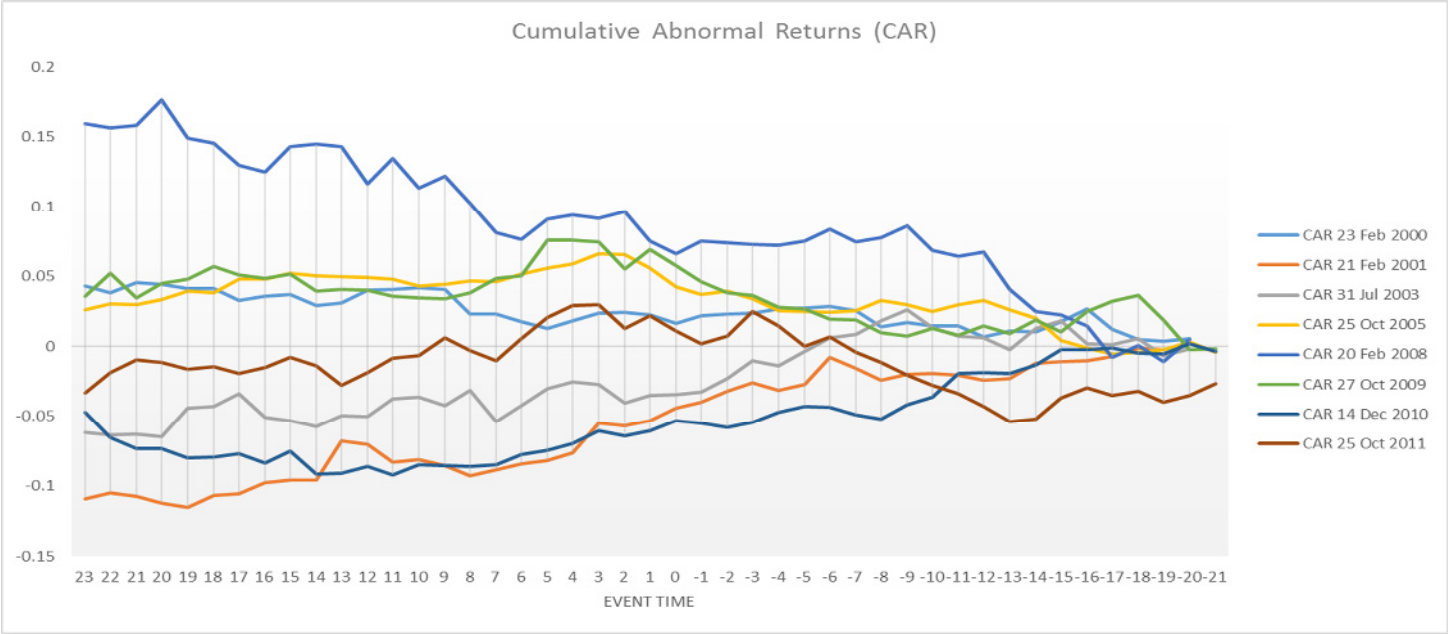
Figure 13 illustrates the CAR for all 8 key events during the event window on one graph. Although there are a limited number of periods where the t-statistics are significant, the t-statistics are insignificant in the majority of instances. In addition, a close inspection of the graph shows that the CAR converge to zero towards the end of the event window which appears consistent with the view that capital controls are not effective and the mean abnormal return or

performance is zero. In summary, the following steps in Microsoft Excel were followed to compute the results:

1. Firstly, construct the intervals for each event (i.e., pre, post and event intervals);
2. Arrange the pre, post and event periods, name them (e.g. the pre-event interval was named “EstRandReturn”) and save them using the macro enabled spreadsheet;
3. Use Excel formulas to compute the intercept, the slope (beta), the standard error and the R-squared;
4. Use equation 22 to obtain the abnormal return (AR) where the actual return is $\Delta s_{i,t+1}$, the calculated slope is used for α_i and the Dollar factor is multiplied by the computed slope (or beta);
5. The t-statistic is calculated as the abnormal return divided by the standard error;
6. The significance of the t-statistic is determined by whether the absolute value of the t-statistic is greater than the critical value of 1.96. Where the absolute value of calculated t-statistic is greater than the critical value, the result is significant, otherwise if it is less than the critical value it is not significant; and
7. The CAR is then calculated by adding up the previous day’s AR to the following day’s AR. The starting point being the event period start date.

As such, the evidence supports a random walk effect and an inclination to not reject the null hypothesis.

Figure 13 – Event study Cumulative Abnormal Returns (CAR) for 8 key events

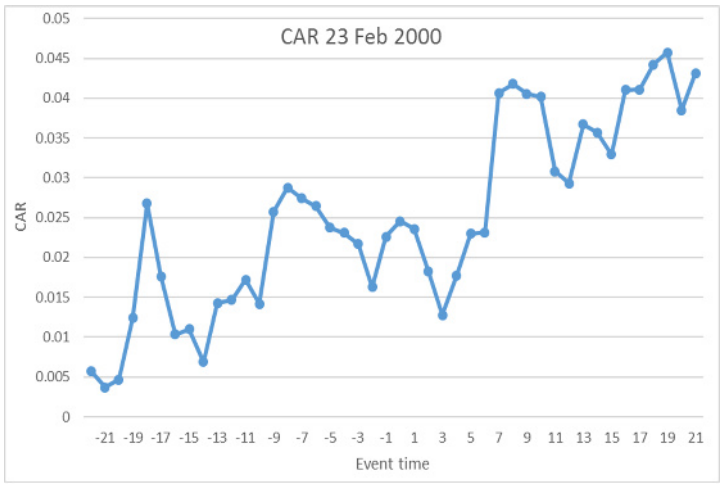


Source: Author, 2016

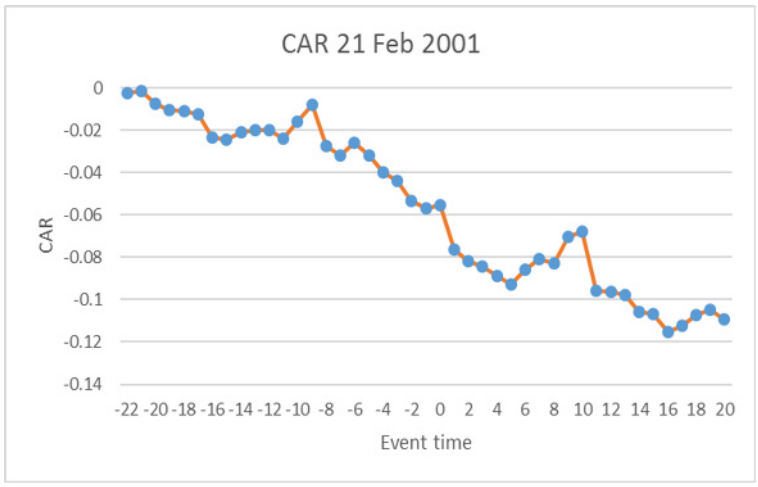
The individual graphs illustrating the CAR for the key events as shown in figure 14 were plotted and no discernible or statistically significant trends could be established. These results are consistent in some way to the shortcoming of prior measures of capital controls indicated by Pandey et al. (2015, p. 10) where a couple of factors are at play and do not show expected trends that are a signal of effectiveness. Firstly, indices used in previous literature do not account fully for the intricacies of capital controls, such as the regulatory environment and reporting requirements. However, in this study, the shortcomings are not as severe as the focus was on capital control events and not the extent of capital account openness. To add on, capital account openness, and the resulting effect on exchange rates usually occur when the complete sub-category of the capital account changes. In most instances, the capital control events generally represent a change in a portion of the sub-categories. Finally, like India, South Africa's capital account liberalisation involves onerous statutory processes without actually undoing the configuration of capital controls. As a result, measures to ease capital controls might not have the desired effect as the regulators are able to undo past capital control events which could offset the short-term effect of those changes. It should be noted that a number of the t-statistics were significant but this would not necessarily be an indication of capital control event impact[42].

Figure 14 – CAR for the 8 key events

14.1: 23 February 2000 event

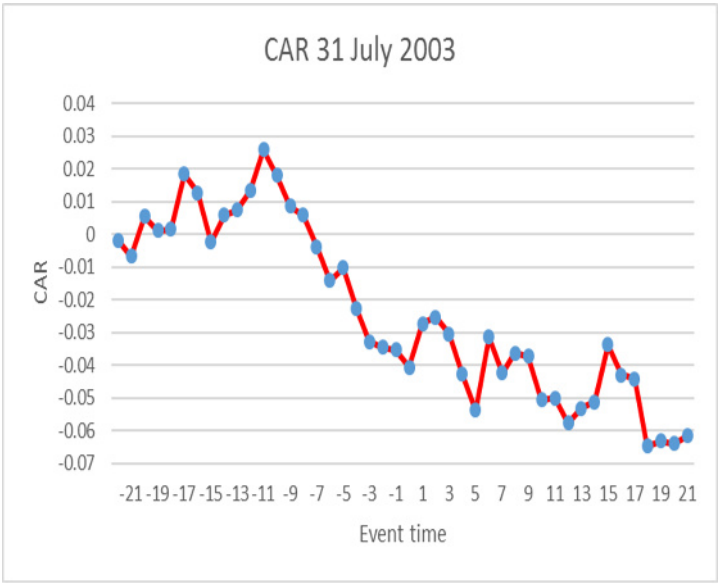


14.2: 21 February 2001 event

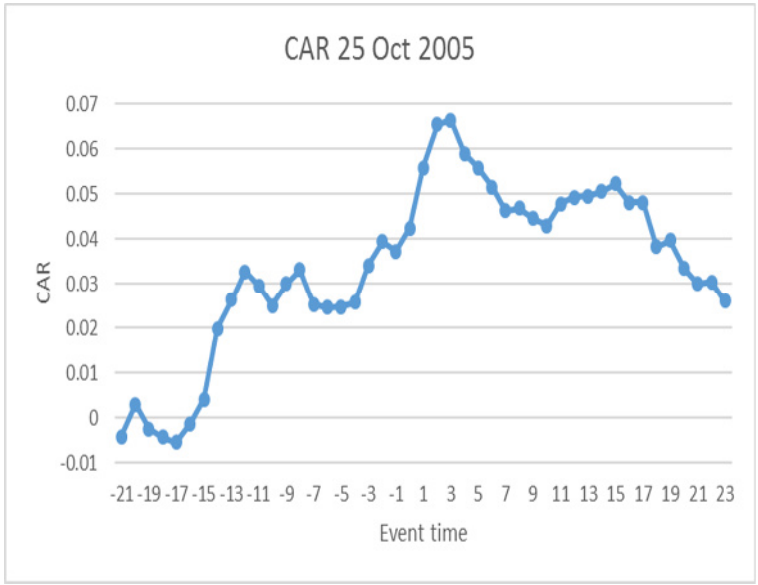


[42] To indicate with increased certainty whether the results indicate causal impact (Pandey et al., 2015) propensity score matching can be used to compare the treated groups against the untreated groups. This is a focus for future research.

14.3: 31 July 2003 event



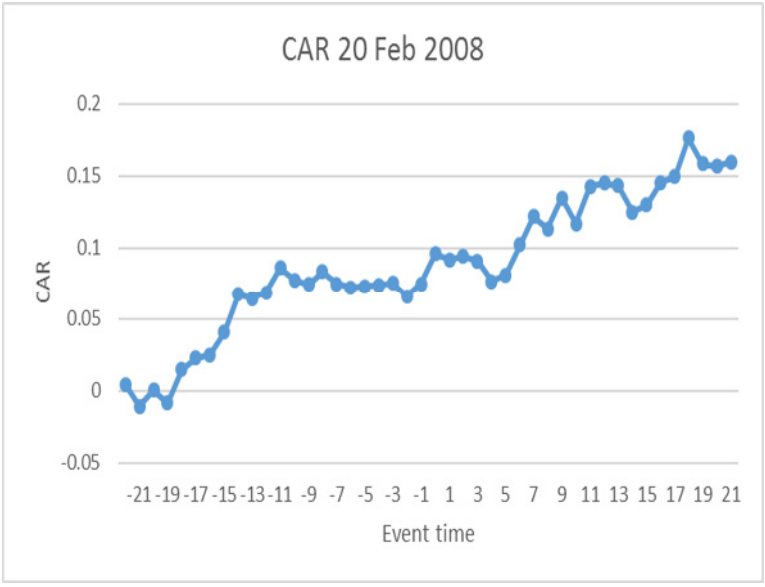
14.4: 25 October 2005 event



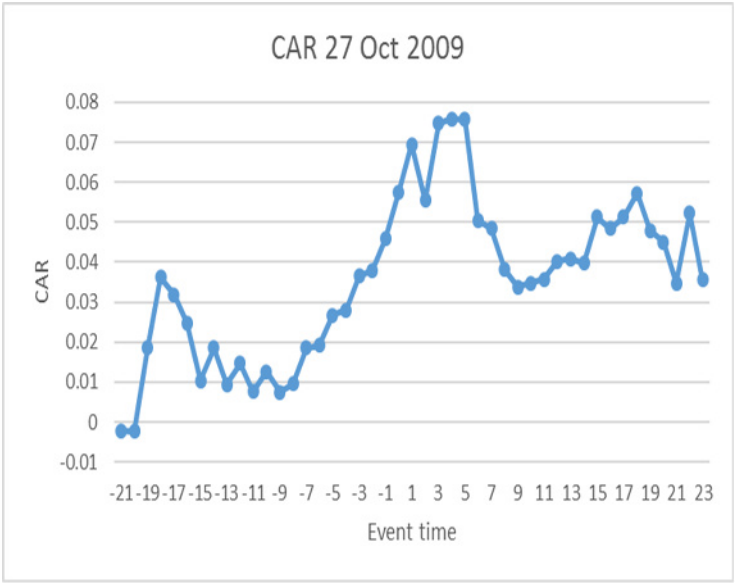
Source: Author, 2016

Figure 14 continued

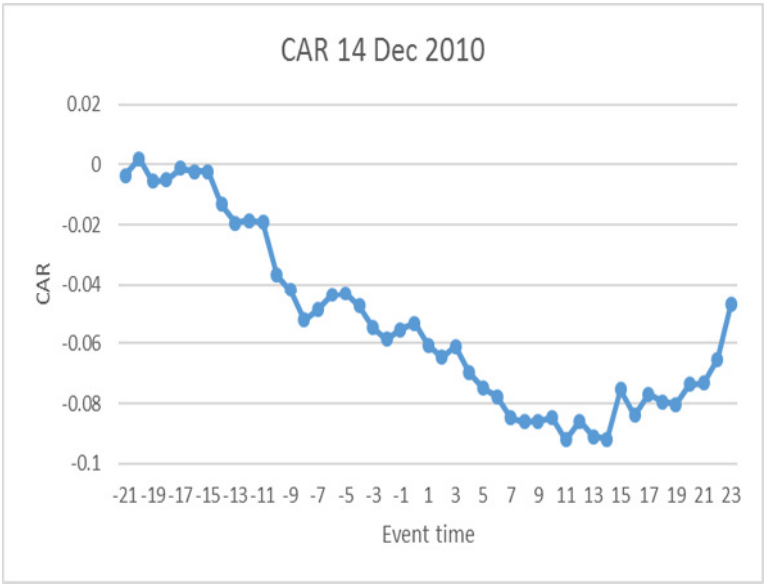
14.5: 20 February 2008 event



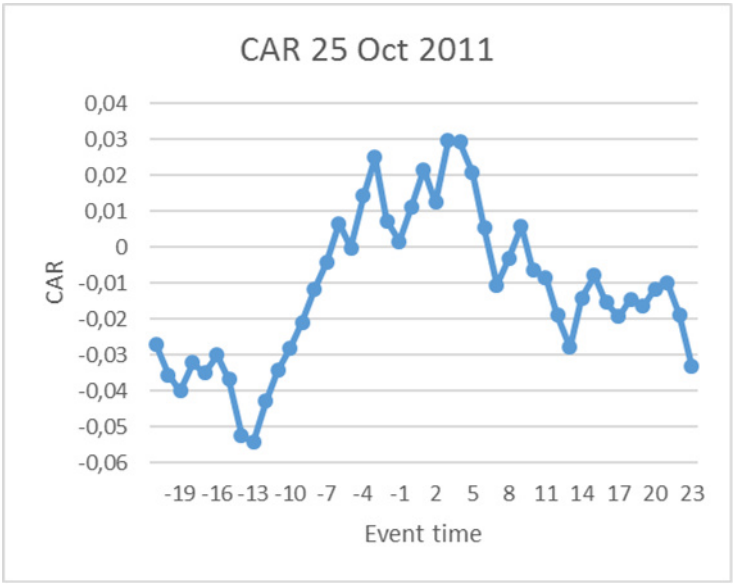
14.6: 27 October 2009 event



14.7: 14 December 2010 event



14.8: 25October 2011



Source: Author, 2016

Measuring success of an event based on returns analysis

To measure the success of an event, and in keeping with the criterion mentioned in sub-section 3.5.1 and table 5, we assess the event criterion and direction criterion in much the same manner as Pandey et al. (2015) and Fratzscher (2005), the latter's approach[43] uses the event study approach described by MacKinlay (1997). As previously mentioned, the event criterion assesses whether the exchange rate trend ***during the event interval*** is in line with the real intervention such that a capital control event to strengthen the currency results in the anticipated change ***during the event interval.***

The direction criterion assesses whether the exchange rate change is in the intended direction ***during the post-event interval***. For instance, if the trend prior to tightening is appreciation of the currency, authorities would employ a tightening capital control event to ensure that the currency depreciates. As indicated by the author 'many interventions are of the "leaning-against-the-wind" type, i.e. they try to reverse or at least to smooth the pre-event exchange rate movements' Fratzscher (2005, p. 22). The additional intention of the CCEs is for the post-event interval movement to counter the effects of the intervention during the event to ensure that there are no adverse market distortions.

[43] Fratzscher's work (2005) also uses empirical research by Humpage (1999) and by Fatum and Hutchison (2003).

The results of the measurement of success are shown in table 15 below. Of the 8 key events, 7 of them turned out to be unsuccessful based on the comparison of their expected impact and actual impact as well as the event and direction criterion. Only one of the 8 key events was successful.

In addition, as the counterfactual for this research paper and in the paper by Fratzscher (2005) is taken to be an exchange rate change or returns of zero owing to the efficient market hypothesis which postulates that daily frequency data for exchange rates follows a random walk (even though at times they might show patterns), **we cannot reject the null hypothesis** [*There is no statistically significant relationship between the capital control event (introduction or changes in the event) and exchange rate stability. i.e. the expected exchange rate change is equal to zero]* as the exchange rate returns are close to zero[44].

It should be noted however that the swings in the exchange rate were not drastic therefore in most instances there could be merit to the policy decisions.

Table 15 – Results of measurement of success

	Announcement Date	Effective Date	Effect of change	% exchange rate change			Motivation	Effectiveness		Measuring success	
				Before	During	After	Trend prior to easing / tightening	Expected impact	Actual impact	Event criterion (during event)	Direction criterion (post-event)
Event 1	23 February 2000	23 February 2000	Easing	-0.0062%	0.1291%	0.2063%	Depreciating	Appreciation	Depreciation	Unsuccessful	Unsuccessful
Event 2	21 February 2001	21 February 2001	Easing	0.0340%	0.0322%	-0.0323%	Depreciating	Appreciation	Depreciation	Unsuccessful	Unsuccessful
Event 3	31 July 2003	31 July 2003	Tightening	0.0963%	-0.0383%	-0.1428%	Appreciating	Depreciation	Appreciation	Unsuccessful	Unsuccessful
Event 4	25 October 2005	25 October 2005	Easing	-0.0874%	0.0434%	-0.1768%	Appreciating	Depreciation	Appreciation	Unsuccessful	Unsuccessful
Event 5	20 February 2008	20 February 2008	Easing	0.1022%	0.3411%	-0.1712%	Depreciating	Appreciation	Depreciation	Unsuccessful	Unsuccessful
Event 6	27 October 2009	27 October 2009	Easing	-0.0923%	-0.0016%	0.0638%	Appreciating	Depreciation	Appreciation	Unsuccessful	Unsuccessful
Event 7	14 December 2010	14 December 2010	Easing	-0.0637%	-0.0050%	-0.0329%	Appreciating	Depreciation	*Depreciation	Successful	*Successful
Event 8	25 October 2011	25 October 2011	* Easing	0.4374%	0.0700%	-0.1432%	Depreciating	Appreciation	Depreciation	Unsuccessful	Unsuccessful

* One of the events announced on 25 October 2011 only became effective on 27 October 2011

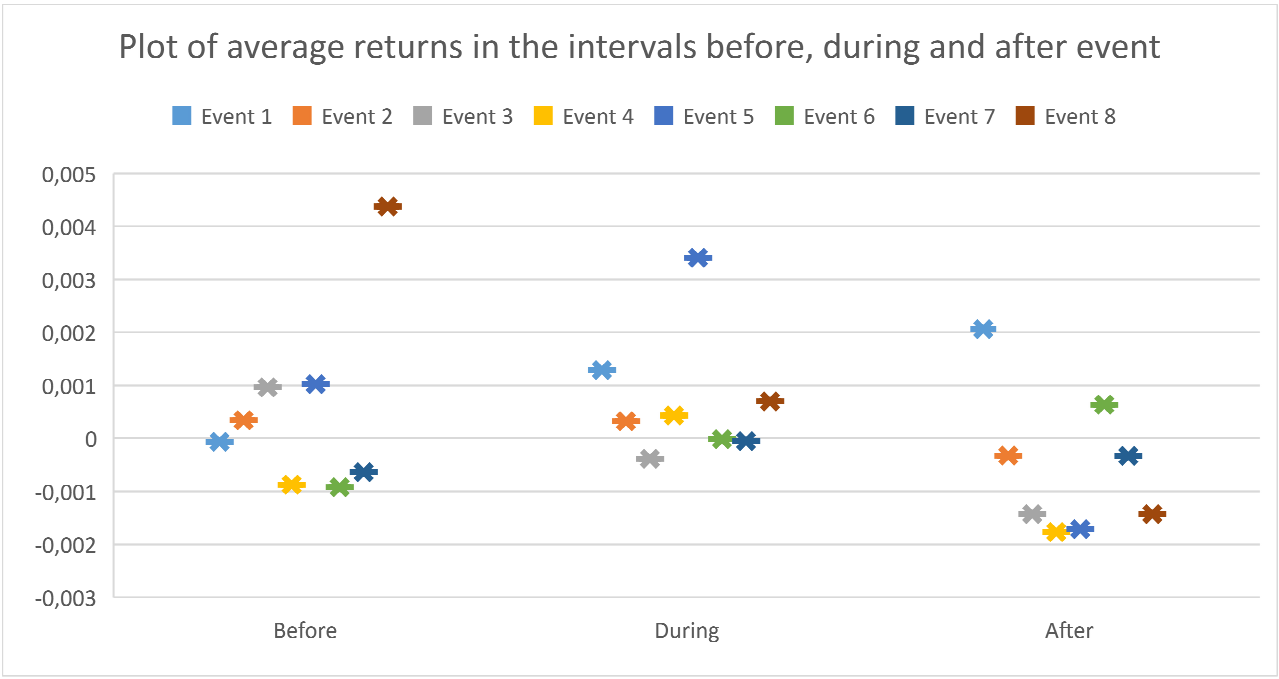
* The overall effect during the post-event interval for event 7 leans more towards a success but this should be read with caution as there was an initial depreciation and then an appreciation towards the end.

Source: Author, 2016

Figure 15 below provides a view of the average returns in the intervals before (pre-event), during and after (post) the event. In line with the results above, there is no trend in the data points. The same data is shown in a column chart in figure 16 to illustrate the movement per each event.

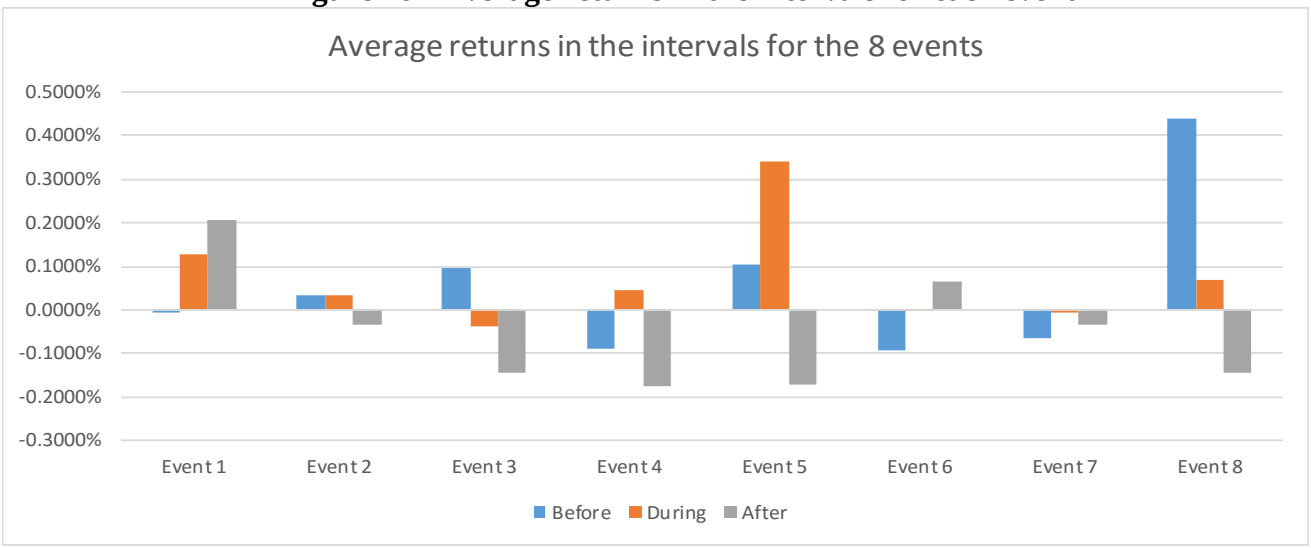
[44] Fratzscher (2005) further refined the assessment of success using a sign test and a binomial model to determine whether the instances of success of was greater than 50% or more than the number of failures.

Figure 15 - Plot of average returns in the intervals before, during and after event



Source: Author, 2016

Figure 16 - Average returns in the intervals for each event



Source: Author, 2016

4.5.2. Results pertaining to volatility and analysis using the GARCH (1,1) model

In sub-section 3.5.2 we alluded to the analysis of the standard deviation as a simple view of volatility. Table 16 and figure 17 provide the average of the standard deviation (or daily volatility) of **1.0391% (0.01039)** during the entire period (1 January 1999 to 31 December 2014) calculated in Microsoft Excel. In addition, the following were also computed[45]:

- The average daily volatility for each event (the calculation included values for the estimation window, event and post event window) was calculated ranging from a minimum of **0.5339%** (**0.00534**) to a maximum of **1.3867%** (**0.01387**) with a range of **0.8529%** (**0.00853**). As the volatilities are sporadic (though not in great magnitudes owing to the smaller changes in the exchange rate) and there is no pattern as shown in figure 17, we can infer that there was limited impact of the controls.
- The average daily volatility across the 8 key events was recorded as **0.9612%** (**0.00961**) and compared to the average over the entire period **1.0391%** (**0.01039**). The values are not significantly different which implies that the impact of the controls was minor to negligible.

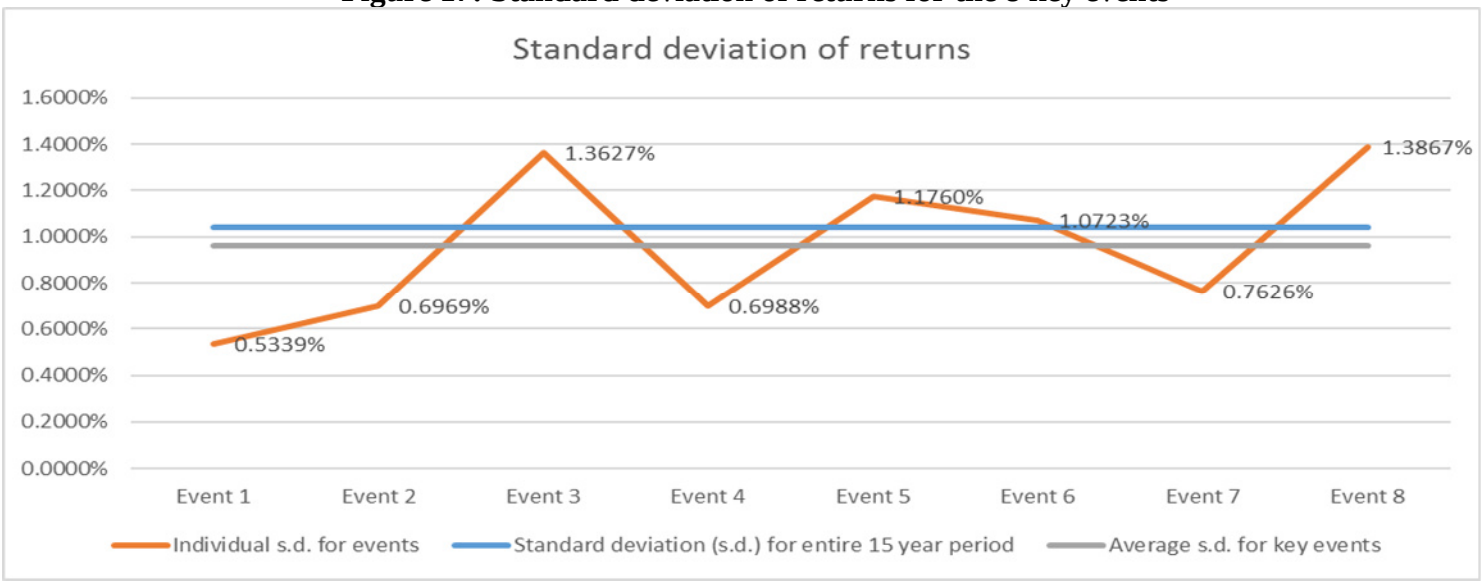
Table 16 – Standard deviation calculations

	15 year period Jan 1999 - Dec 2014	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
Mean	0.000162	0.001090	0.000115	-0.000291	-0.000720	0.000927	-0.000111	-0.000336	0.001254
Standard deviation	**1.0391%**	**0.5339%**	0.6969%	1.3627%	0.6988%	1.1760%	1.0723%	0.7626%	**1.3867%**
Event with max s.d.									**X**
Event with min s.d.		**X**							
Average s.d. for the 8 events	**0.9612%**								

Source: Author, 2016

[45] The Microsoft Excel function "=STDEV.S(XX:YY)" was used to calculate the sample standard deviation with XX being the start of the series and YY being the last observation in the series.

Figure 17: Standard deviation of returns for the 8 key events



Source: Author, 2016

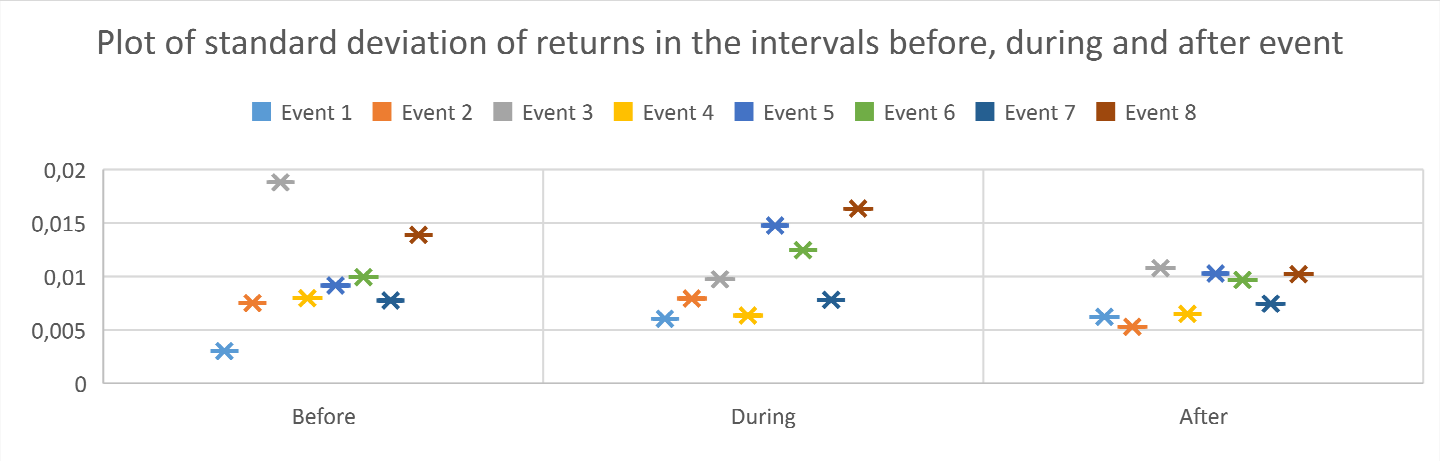
As previously noted in sub-section 3.5.2, it is worth noting however that no significant deviation in average volatility could also mean that the timing of controls was rather precise and the authorities achieved their goal of limited market distortions. Though our intention for this research paper was not on the motivations for the CCE but their impact, we obtained a view of this as well. In addition, we assessed the impact of the controls on the standard deviation or volatility during the estimation, event and post-event window as shown in table 17 and figure 18 below. In table 17, we checked whether volatility increased subsequent to each event window. There is no discernible trend and the controls would not have distorted or had a negative impact on the exchange rate. This is also shown in figure 18 where the volatility pre-, during and post the events do not show a pattern which implies that the impact of the events was not significant. However, the tightening event shows evidence of a decrease which will be discussed further when evaluating the annualised values as there is evidence of a decrease in volatility. The same data is shown in a column chart in figure 19 to illustrate the movement per each event.

Table 17 – Standard deviation in estimation, event and post-event intervals

	Announcement Date	Effective Date	Effect of change	Standard deviation of exchange rate returns - exchange rate volatility		
				Before	During	After
Event 1	23 February 2000	23 February 2000	Easing	0.304%	0.606%	0.622%
Event 2	21 February 2001	21 February 2001	Easing	0.752%	0.793%	0.530%
Event 3	31 July 2003	31 July 2003	Tightening	1.881%	0.973%	1.077%
Event 4	25 October 2005	25 October 2005	Easing	0.795%	0.635%	0.651%
Event 5	20 February 2008	20 February 2008	Easing	0.917%	1.476%	1.026%
Event 6	27 October 2009	27 October 2009	Easing	0.994%	1.247%	0.968%
Event 7	14 December 2010	14 December 2010	Easing	0.775%	0.781%	0.746%
Event 8	25 October 2011	25 October 2011	Easing	1.390%	1.633%	1.021%

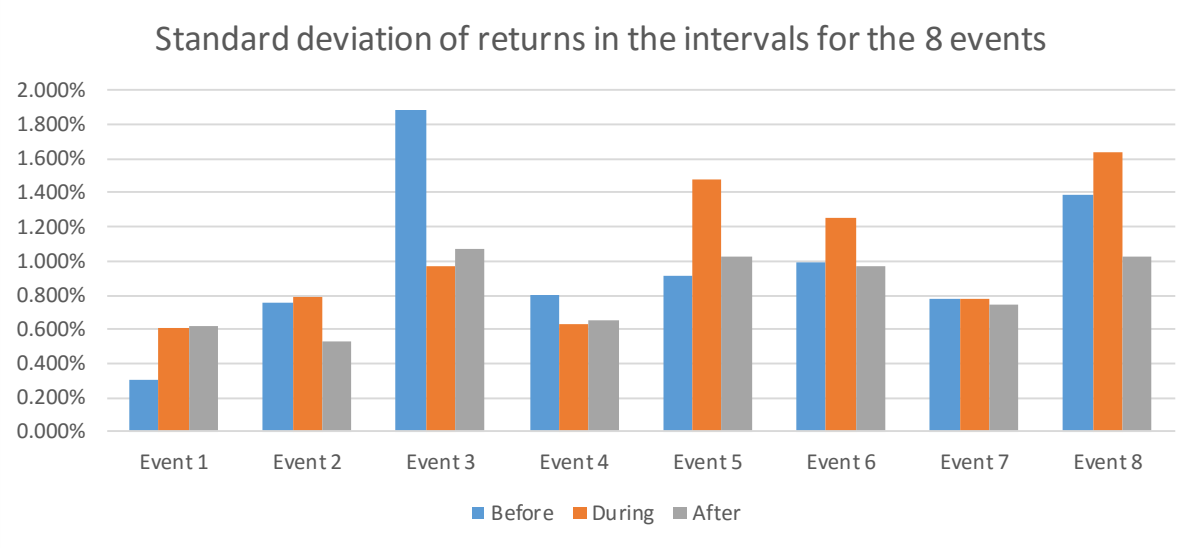
Source: Author, 2016

Figure 18 – Plot of standard deviation in the intervals before, during and after event



Source: Author, 2016

Figure 19 - Standard deviation of returns in the intervals for each event



Source: Author, 2016

The standard deviation data shown above is daily volatility data. In order to present the information accurately statistically, the annualised standard deviation must be calculated. The annualised standard deviation is calculation by multiplying the result of the standard deviation by the square root of 252, the commonly used average trading days in a calendar year.

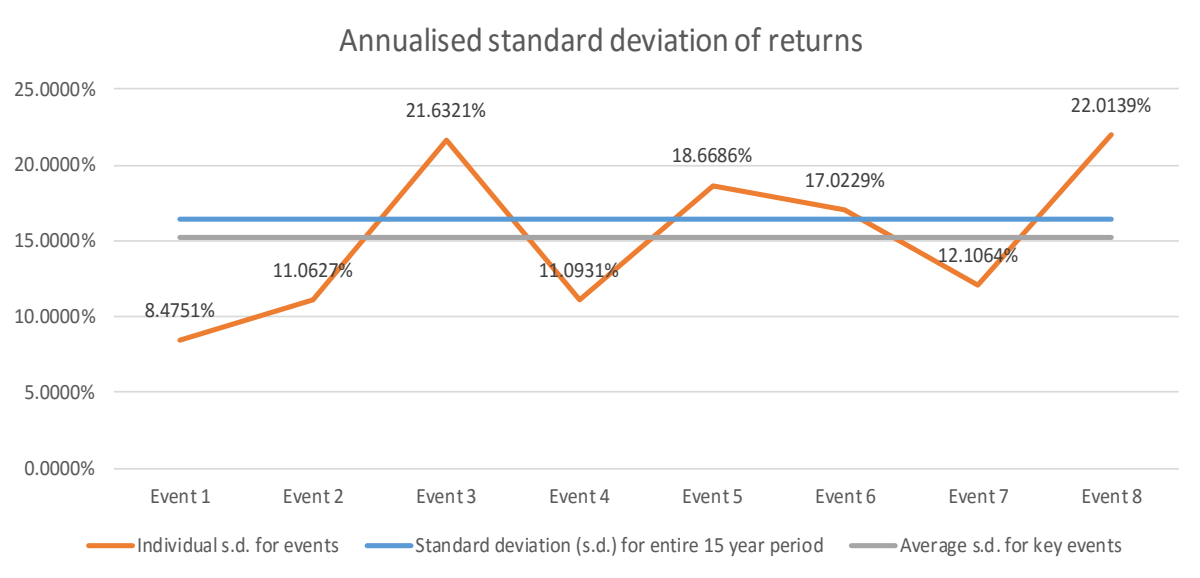
Table 18 presents this annualised volatility data for the period and key events. The average volatility for the entire period is **16.4947%** with annualised volatilities for the key events have a minimum of **8.4751%** and a maximum of **22.0139%** (a range of 13.5389%). Figure 20 also shows that no pattern is present.

Table 18 – Annualised standard deviation calculations

	15 year period Jan 1999 - Dec 2014	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
Mean	0.000162	0.001090	0.000115	-0.000291	-0.000720	0.000927	-0.000111	-0.000336	0.001254
Standard deviation	**16.4947%**	**8.4751%**	**11.0627%**	**21.6321%**	**11.0931%**	**18.6686%**	**17.0229%**	**12.1064%**	**22.0139%**
Event with max s.d.									X
Event with min s.d.		X							
Average s.d. for the 8 events		**15.2593%**							

Source: Author, 2016

Figure 20 – Annualised standard deviation of returns for the 8 key events



Source: Author, 2016

The average annualised volatility is also consistent with the previous figures that are not annualised values (albeit a bit higher) and the difference is not substantial with the daily volatility at **15.2593%** compared to **16.4947%**. The annualised volatility values for the key events across the pre-event, during the event and post-event intervals are shown in table 19

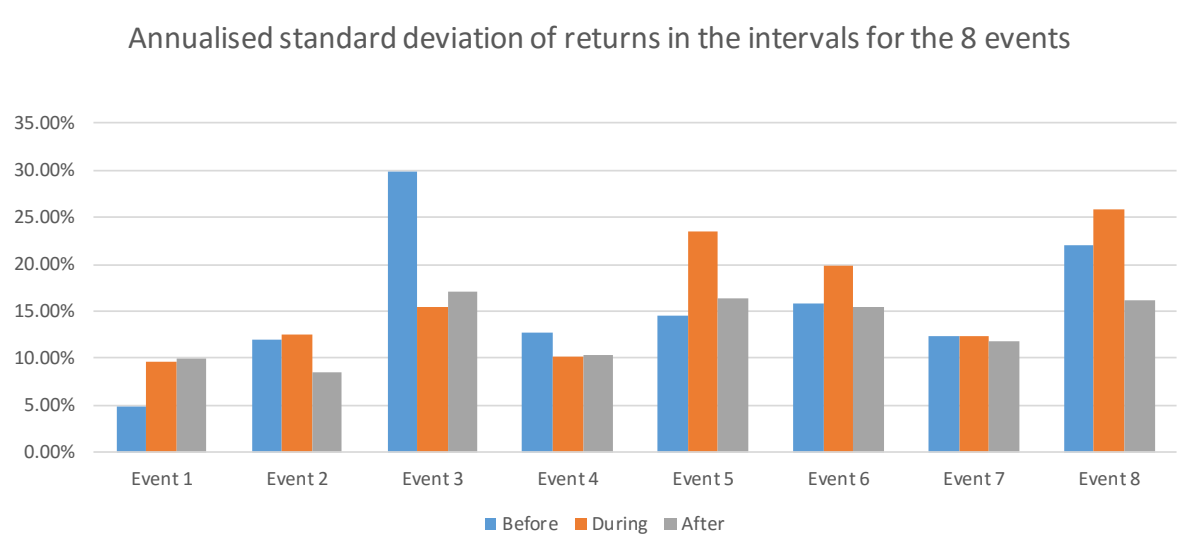
below. Figure 21 illustrates the values for the 8 key events before, during and after each event but do not indicate that an increase or decrease in volatility is attributable to the CCEs save for the tightening event on 31 July 2003. This event shows a decrease in the volatility from a high of 29.86% in the estimation interval, to 15.44% in the event interval and finally levelling at value of 17.09% in the post-event interval. In this instance, there seems to have been merit to the efforts to curtail adverse effects of volatility by tightening the exchange control restrictions.

Table 19 – Annualised standard deviation in estimation, event and post-event intervals

	Announcement Date	Effective Date	Effect of change	Standard deviation of exchange rate returns - exchange rate volatility		
				Before	During	After
Event 1	23 February 2000	23 February 2000	Easing	4.82%	9.63%	9.88%
Event 2	21 February 2001	21 February 2001	Easing	11.94%	12.59%	8.42%
Event 3	31 July 2003	31 July 2003	Tightening	29.86%	15.44%	17.09%
Event 4	25 October 2005	25 October 2005	Easing	12.63%	10.08%	10.33%
Event 5	20 February 2008	20 February 2008	Easing	14.56%	23.43%	16.29%
Event 6	27 October 2009	27 October 2009	Easing	15.79%	19.79%	15.37%
Event 7	14 December 2010	14 December 2010	Easing	12.30%	12.40%	11.84%
Event 8	25 October 2011	25 October 2011	Easing	22.07%	25.93%	16.21%

Source: Author, 2016

Figure 21 – Annualised standard deviation of returns in the intervals for each event

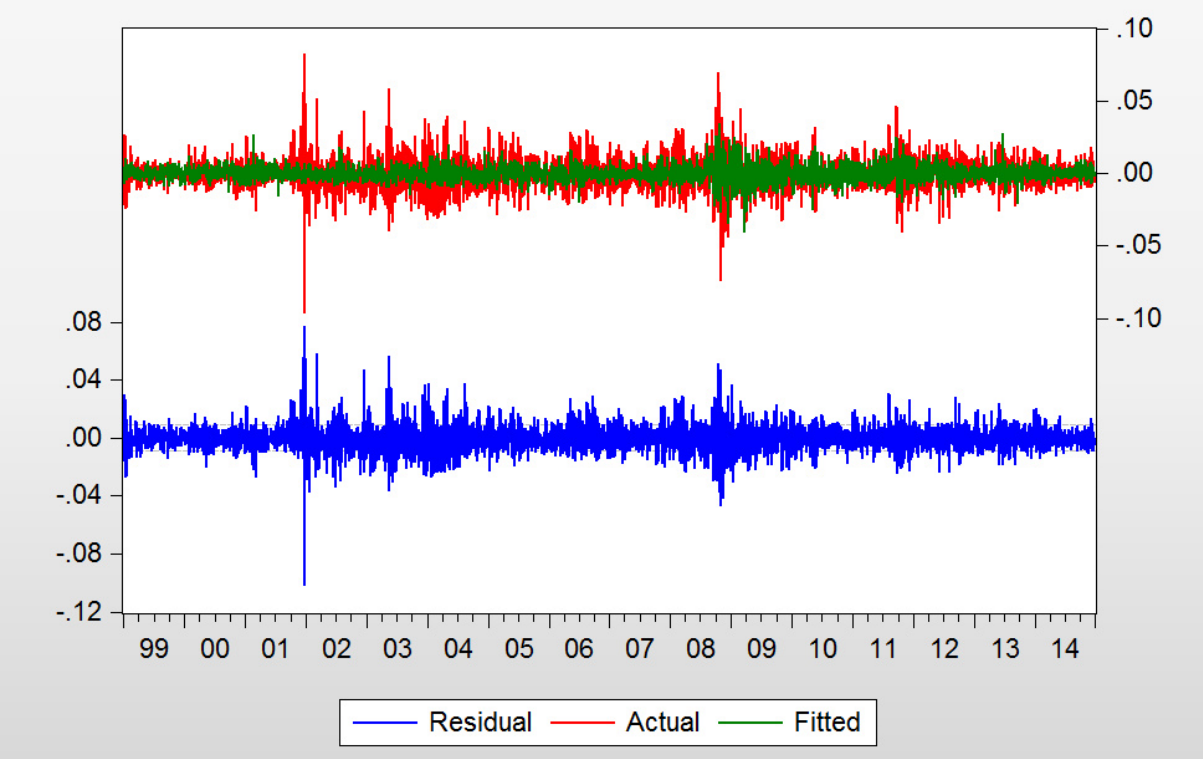


Source: Author, 2016

This next part of the volatility section looks at the GARCH model. In section 2.3, the concepts of leveraged effects and volatility clustering were explored. The return data (see figure 6 and 9) exhibit this clustering. Figure 10, the plot of residuals from the mean equation (equation 3

in sub-section 2.3.1) shows that prolonged periods of low volatility are followed by intervals of low volatility from 1999 to the beginning of 2001, indicating small fluctuations creating small fluctuations for a long period. The opposite behaviour is shown where periods of high volatility from 2001, which coincide with the period during the collapse of the Rand, are followed by persistent high volatility until 2003 – 2004. The same volatility clustering occurs from 2007 shortly after the 2007/08 financial crisis and continues through to the end of 2009 illustrating how large volatility values cause another large volatility interval for an extended period. The data suggests that volatility clustering is present, the residual or error term is therefore conditionally heteroscedastic (as the procedure detailed in sub-section 3.6.5 sought to assess) and can be presented using the ARCH and GARCH (1,1) model. The same fluctuation behaviour is exhibited in the residuals from the regression equation as shown in figure 22 below. In addition, sub-section 4.3.1 shows that the daily data on logged returns of ZAR/USD exchange rate (and variables included) appears to be stationary according to the Phillips-Perron and ADF type unit root test results, allowing us to apply this model.

Figure 22 – Residual plot of regression equation (ZAR/ USD against Dollar factor)



Source: Author, 2016

The results of the tests to determine the best model specification indicate that we cannot reject the null at the 1% under both the (a) Q-test [therefore there is no serial correlation in the residual or error term] and the (b) ARCH LM test [indicating that there is no ARCH effect in the residual]. We do however reject the null hypothesis of residuals being normally distributed in favour of the alternative, i.e., the residuals are non-normal. Although it is desirable for the residuals to be normally distributed and non-normality might be an issue, we indicated that various authors (Abdalla, 2012; Bangia et al., 2002; Brown & Warner, 1985) suggest that non-normality in residuals is expected given daily data and the volatility clustering and may therefore not be as serious an issue as these best estimators are still consistent. As such, although all three fail on the normality assumption, we can take either three as the best models for forecasting the ZAR/USD return volatility. Table 20 shows the results of the tests.

Table 20: Results of tests on the 3 distributions for GARCH modelling

	i. Normal Gaussian distribution	**ii. Student's t-distribution**	**iii. Generalized Error Distribution Assumption (GED)**
Assumptions / Tests and results			
a. Correlogram of squared residuals (Q test)	Do not reject H_0: There is no serial correlation	Do not reject H_0: There is no serial correlation	Do not reject H_0: There is no serial correlation
b. LM test for ARCH effect	Do not reject H_0: There is no ARCH effect	Do not reject H_0: There is no ARCH effect	Do not reject H_0: There is no ARCH effect
c. Histogram and normality test (Jarque-Bera test statistic)	Reject H_0 in favour of H_1: Residuals are non-normal	Reject H_0 in favour of H_1: Residuals are non-normal	Reject H_0 in favour of H_1: Residuals are non-normal

Source: Author, 2016

The Student's t-distribution with fixed degrees of freedom (df) was selected for this study. The key results illustrated in figure 23 are as follows:

- The ARCH term [RESID(-1)^2 in the EViews output shown in figure 23] or previous interval squared residual returns representing historic information about volatility is significant and influences the current or subsequent volatility; and
- The GARCH term [GARCH(-1)] or the historic interval variance or volatility of the exchange rate return is significant and can influence the current or subsequent volatility.

Finally, the sum of α (0.078421) and β (0.906402), the coefficients of the ARCH and GARCH respectively, is very close to 1 therefore volatility shocks are highly persistent, as suggested by Abdalla (2012). The Akaike information criterion for this model made it a better choice than

the others versions considered. In summary, the ZAR/USD return volatility is influenced by its own ARCH and GARCH factors, i.e. its own shocks and is dependent on these terms.

Figure 23 - GARCH (1,1) using Student's t with fixed df

Dependent Variable: RAND_$_BBZARSP_RETURN
Method: ML ARCH - Student's t distribution (BFGS / Marquardt steps)
Date: 07/07/16 Time: 02:26
Sample: 1/01/1999 12/31/2014
Included observations: 4174
Convergence achieved after 26 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
t-distribution degree of freedom parameter fixed at 10
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
DOLLAR_FACTOR	1.664973	0.037447	44.46165	0.0000
C	-3.79E-05	0.000106	-0.357791	0.7205
Variance Equation				
C	1.05E-06	2.32E-07	4.543909	0.0000
RESID(-1)^2	0.078421	0.007760	10.10586	0.0000
GARCH(-1)	0.906402	0.008659	104.6800	0.0000

R-squared	0.248686	Mean dependent var	0.000162
Adjusted R-squared	0.248506	S.D. dependent var	0.010391
S.E. of regression	0.009008	Akaike info criterion	-6.880253
Sum squared resid	0.338501	Schwarz criterion	-6.872663
Log likelihood	14364.09	Hannan-Quinn criter.	-6.877568
Durbin-Watson stat	2.104720		

Source: Author, 2016

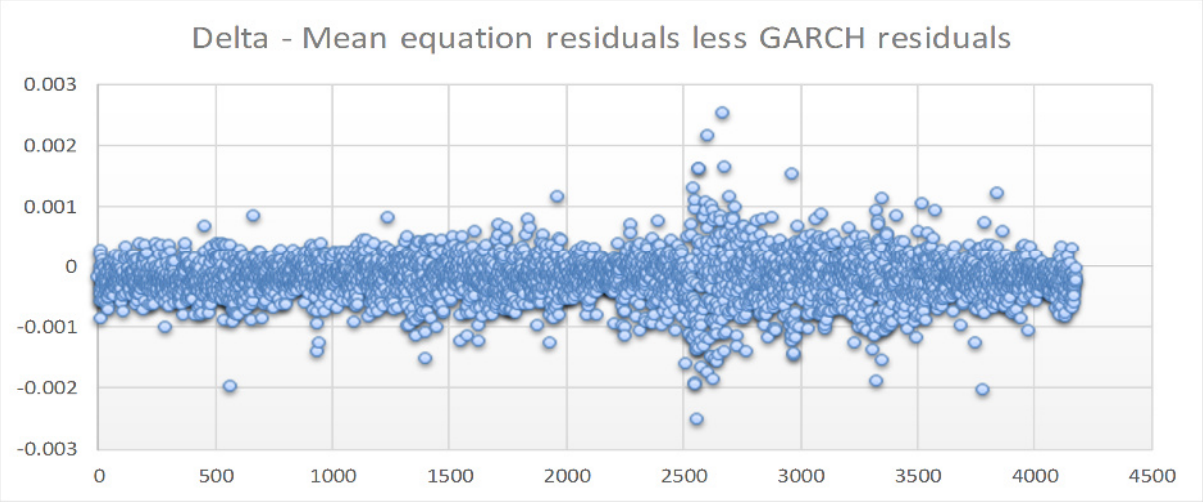
The final part of the volatility exercise involves analysing the variance series and using the GARCH estimate. It involves creating a "shock" to the variance by looking at the squared residuals from the mean regression and subtracting the GARCH predicted residuals (expected or normal volatility). We then assess the results of these in the following manner:

- Assessing whether the volatility has increased or not and how large the surprise was;
- Assessing whether the pattern or trend is positive or negative on average; and
- Focussing on the effects attributable to the 8 key events.

The residuals from the mean equation were saved in EViews ("RESID01LS") as well as the residuals from the GARCH estimate using the Student's t with fixed df (saved as "RESID01GARCH"). The compare option in EViews was used to obtain a view of the difference between the two residual series. The results show that volatility has not increased substantially as a result of the CCEs and there is no pattern in the data as the residual series are almost similar as shown by the figure 24.1 below which shows the delta or differences in the

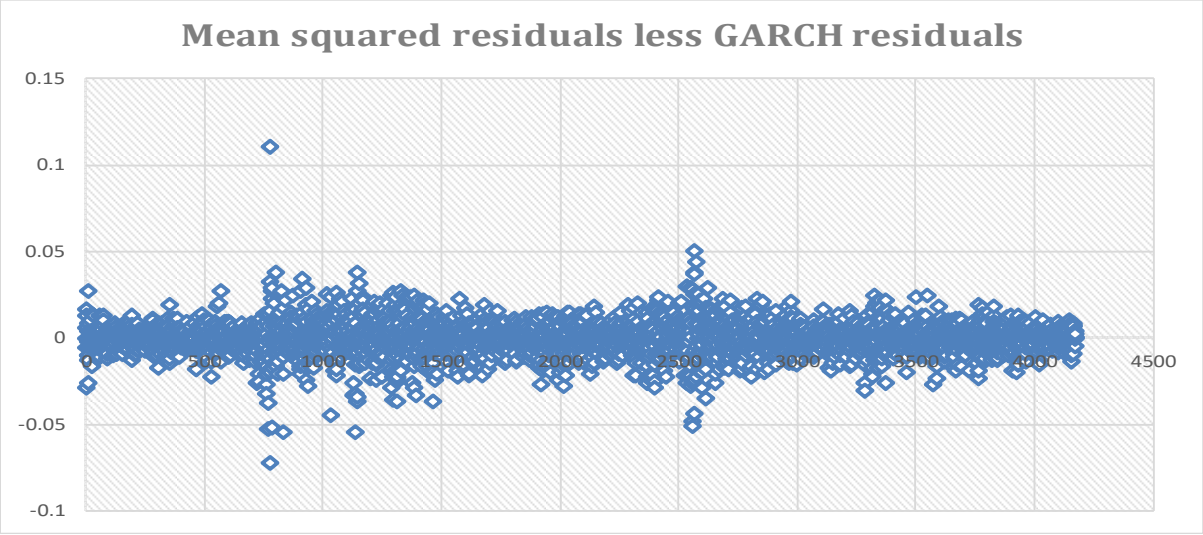
two series. The data does show that the number of positive differences (1,115) are less than their negative counterparts (3,059) for the total of 4,174 difference observations. Where we take the squared residuals from the mean equation and subtract the predicted residuals from the GARCH output, the number changes as the differences are more or less evenly spread with 2,093 positive differences versus 2,081 negative ones. The conclusion is that the volatility has neither increased nor decreased during the period following the CCEs therefore the controls had no significant impact. Figures 32 to 39 in appendix G illustrate a layered view of the mean equation residuals less those from the GARCH forecast[46].

Figure 24.1 – Mean equation residuals less GARCH (1,1) using Student's t with fixed df



Source: Author, 2016

Figure 24.2 – Mean regression squared residuals less GARCH residuals



Source: Author, 2016

[46] The conditional standard deviation and variance are shown in figures 30 and 31 of appendix G.

4.5.3. Results of the liquidity impact as a result of the CCEs

The monthly foreign exchange illiquidity measures were constructed using the steps outlined in the instructions document from the research by Karnaukh et al. (2015). The focus was primarily on the average standardised bid-ask spread and Corwin-Schultz (CS) measure using the low-frequency (daily) data which are included in the low frequency (LF) measure. In this paper, instead of using the systematic low frequency (LF) illiquidity measure which is an average of the 30 currencies used in the sample, we only include an average of the United States Dollar and the British Pound which we call the USD_GBP LF illiquidity measure (refer to appendix E on the steps to construct the measures). As the LF illiquidity measure values constructed were similar to those obtained by by Karnaukh et al. (2015), the research paper utilised the previously calculated values. Note that a larger CS measure indicates less liquidity[47].

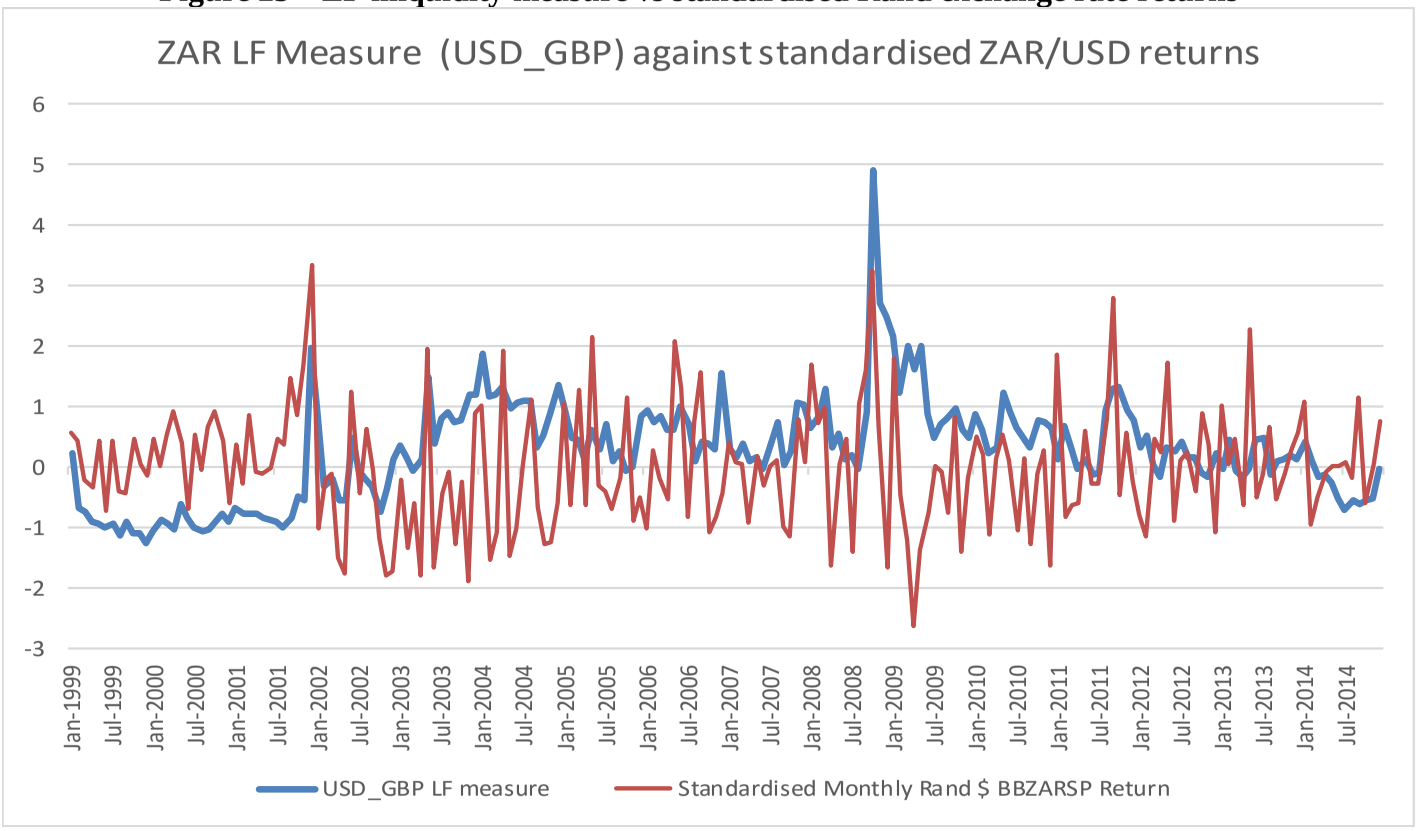
In order to compare the return and volatility to the LF illiquidity measure, monthly values were constructed from the daily return (which were standardised afterwards by taking the mean of the series, subtracting it from each observation and dividing the result by the standard deviation of the set of observations or the series) and volatility measures. For volatility, the exponential weighted moving average (EWMA) or exponential weighted volatility was used to proxy for volatility which was obtained from the EWMA function in Microsoft Excel (using the NUMXL add-in).

The results show a constant theme with the results on returns and volatility and is consistent with the literature. Figure 25 depicts the USD_GBP LF measure against the standardised ZAR/USD returns. For the entire period, the LF measure peaks during 2001 and during the period 2008 to 2009 which is consistent with the 2001 Rand collapse and the financial crisis of 2007/08 similar to the discussion in section 4.2. This indicates foreign exchange illiquidity during these crisis periods when the exchange rate was under pressure.

The volatility overview as shown in figure 26 is consistent with the results in Karnaukh et al. (2015). The LF measure, which is shown on the primary (left) axis and the EWMA follow a similar pattern in the majority of instances with less liquidity during periods of high volatility. This confirms the link between volatility and liquidity as postulated by Karnaukh et al. (2015).

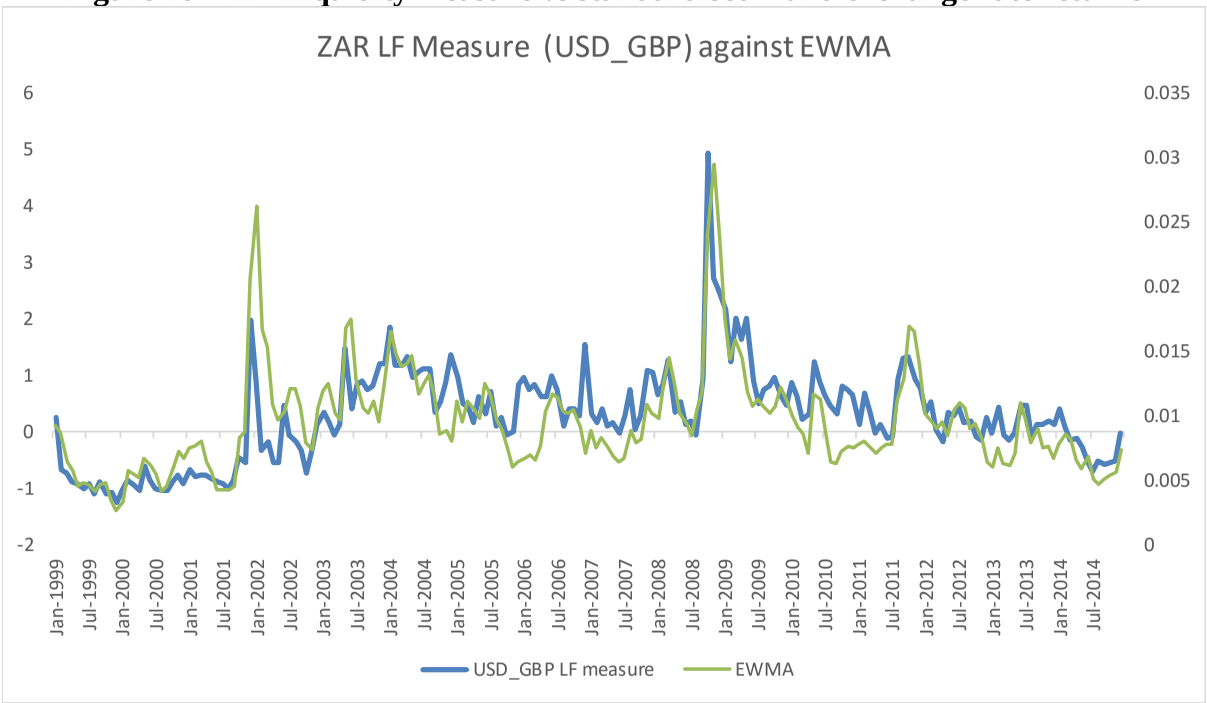
[47] Refer to page 8 of the Appendix to Understanding FX liquidity (Karnaukh et al., 2015)

Figure 25 – LF illiquidity measure vs standardised Rand exchange rate returns



Source: Author, 2016

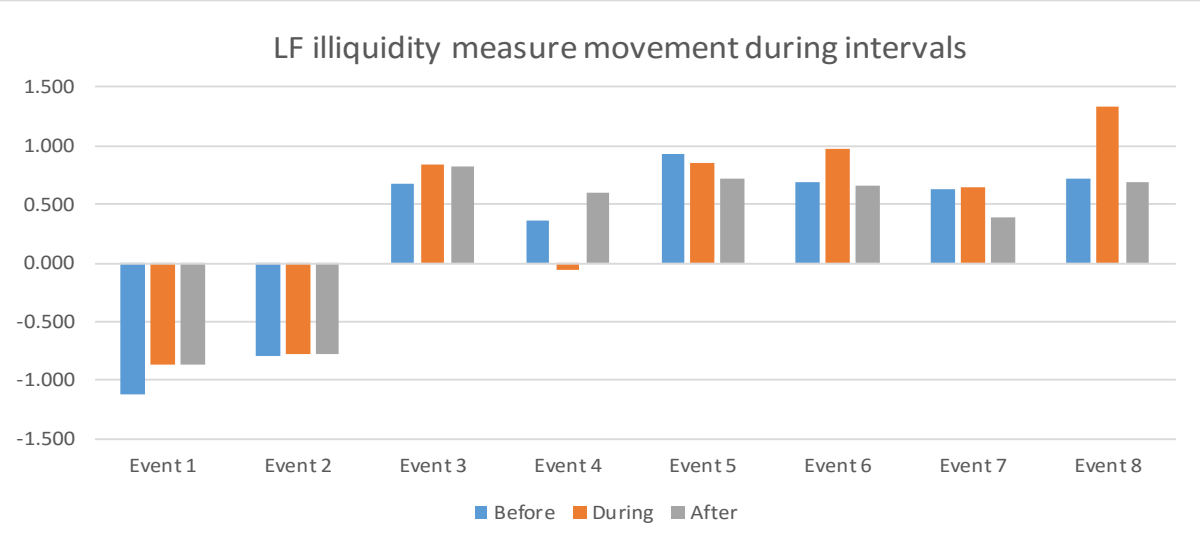
Figure 26 – LF illiquidity measure vs standardised Rand exchange rate returns



Source: Author, 2016

The final analysis focusses on liquidity around the 8 events[48]. The expected outcome of easing of controls would be to enhance liquidity in the market and tightening events should result in illiquidity. The estimation interval or benchmark was used to assess the resultant impact of the event on the liquidity as shown by the LF illiquidity measure. Figure 27 below shows the behaviour of the LF illiquidity measure for the events. None of the events (especially the easing events) show a drop in the LF illiquidity measure, i.e. a sustained improvement in liquidity following the event. The actual values are shown in table 21.

Figure 27 – LF illiquidity measure in the intervals for each event



Source: Author, 2016

Table 21 – LF illiquidity measure in estimation, event and post-event intervals

	Announcement Date	Effective Date	Effect of change	change in LF illiquidity measure during intervals		
				Before	During	After
Event 1	23 February 2000	23 February 2000	Easing	-1.12775	-0.86401	-0.86033
Event 2	21 February 2001	21 February 2001	Easing	-0.78411	-0.77818	-0.78291
Event 3	31 July 2003	31 July 2003	Tightening	0.67533	0.83429	0.81986
Event 4	25 October 2005	25 October 2005	Easing	0.36589	-0.05749	0.60119
Event 5	20 February 2008	20 February 2008	Easing	0.92697	0.85716	0.72406
Event 6	27 October 2009	27 October 2009	Easing	0.68498	0.96970	0.66433
Event 7	14 December 2010	14 December 2010	Easing	0.62641	0.64691	0.39013
Event 8	25 October 2011	25 October 2011	* Easing	0.72213	1.34043	0.69013

Source: Author, 2016

[48] The adjustment to focus on monthly measures resulted in a reduction in the event window from on average two months to one month. An average of the 3 months for the estimation interval and 3 months for the post-event window were used in the analysis.

Liquidity actually decreased during the event interval for 4 of the events and was fairly constant for 3 events. There was a drop in illiquidity during the event interval for the easing event 4 but the illiquid conditions increased in the post-event interval to a level higher than (and almost doubled) those in the estimation interval prior to the event, an indication of the nature in which the events were unable to significantly alter the illiquidity in the market.

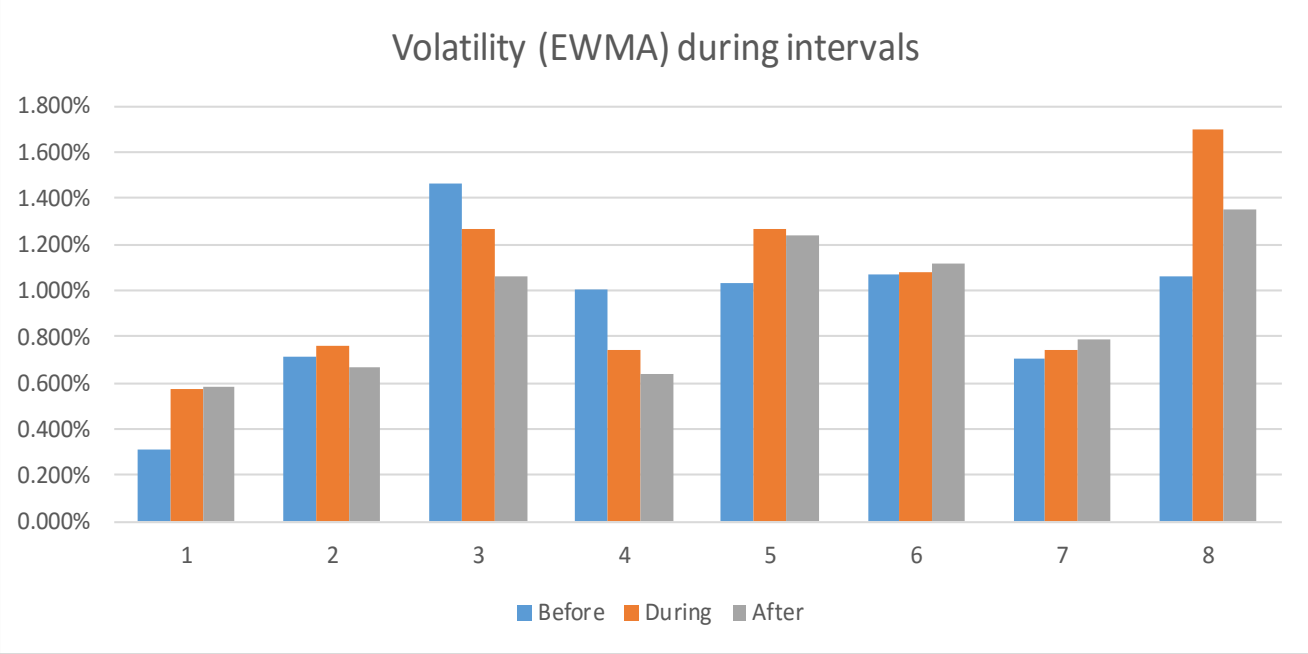
In creating the link between volatility and illiquidity, table 22 and figure 28 produce the volatility measures (using the EWMA as a proxy) for the 8 events.

Table 22 – Volatility (EWMA) measure in estimation, event and post-event intervals

	Announcement Date	Effective Date	Effect of change	change in exchange rate volatility proxy (EWMA)		
				Before	During	After
Event 1	23 February 2000	23 February 2000	Easing	0.314%	0.572%	0.581%
Event 2	21 February 2001	21 February 2001	Easing	0.718%	0.763%	0.673%
Event 3	31 July 2003	31 July 2003	Tightening	1.467%	1.272%	1.061%
Event 4	25 October 2005	25 October 2005	Easing	1.004%	0.747%	0.641%
Event 5	20 February 2008	20 February 2008	Easing	1.032%	1.263%	1.244%
Event 6	27 October 2009	27 October 2009	Easing	1.075%	1.080%	1.120%
Event 7	14 December 2010	14 December 2010	Easing	0.706%	0.746%	0.788%
Event 8	25 October 2011	25 October 2011	* Easing	1.064%	1.696%	1.355%

Source: Author, 2016

Figure 28 – Volatility (EWMA) measure in the intervals for each event



Source: Author, 2016

The purpose of this is to clearly show the link between volatility and liquidity in the paper. Table 23 illustrates this link in a clear summary for each of the 8 events using information from table 21 and 22. The results show that a link between volatility and illiquidity exist and the CCEs generally did not impact liquidity as intended.

Table 23 – Volatility and LF illiquidity measure comparison

	Volatility (EWMA) pattern	Liquidity trend
Event 1	Volatility increases	Illiquidity increases (i.e. lower liquidity)
Event 2	Relatively constant	Liquidity (or illiquidity) unchanged
Event 3	Volatility decreases	Illiquidity increases (due to tightening)
Event 4	Volatility decreases	Illiquidity initially decreases then increases significantly
Event 5	Volatility increases slightly	Illiquidity slightly decreased
Event 6	Volatility fairly constant (increases after event)	Illiquidity increases (then decreases after event)
Event 7	Volatility rising slightly (but fairly constant)	Illiquidity fairly constant (but decreases after event)
Event 8	Volatility increases then decreases slightly (still above initial benchmark)	Illiquidity follows same pattern of initial increase then decrease

Source: Author, 2016

4.6. CONCLUSION

The findings from the research on returns, volatility and liquidity are consistent with literature (such as (Pandey et al., 2015) that CCEs (or CCAs) have little to no impact on the variables evaluated. This was augment by an event study approach (Kothari & Warner, 2006; MacKinlay, 1997) for the variables under study. Finally, the link between liquidity and volatility (Karnaukh et al., 2015) is apparent but the CCEs were unable to significantly correct for illiquidity in the market.

CHAPTER 5: SUMMARY OF MAIN FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarises the main findings from the empirical tests performed and answers the problem posed. It also provides conclusions including policy implications as well as pragmatic recommendations for future research.

5.1. SUMMARY OF MAIN FINDINGS

The research applied an event study approach to the returns, volatility and liquidity in order to assess the impact of capital control events over the period 1 January 1999 to 31 December 2014. 8 key capital controls were further isolated in each case to assess their effects on the variables under study. An empirical test was therefore performed on 4174 observations and the sample observations for the 8 key controls. In section 1 it was noted that for capital controls to be effective, "this has to be done in the context of a comprehensive administrative system for capital controls, where the government has the ability to interfere in all cross-border transactions" (Pandey et al., 2015, p. iv). South Africa has a somewhat open capital account and the evidence above does indicate that the occasional implementation of capital controls has not yielded the desired effect.

Returns

The dollar factor from Verdelhan (2015) was used as a key variable in the base regression. The outcome of the event study on ZAR/USD exchange rate returns using the abnormal returns (AR) indicated that the t-statistics for the cumulative abnormal returns (CAR) to assess for the impact of the CCEs were not conclusive with the majority of the t-statistics over the range being insignificant. In addition, the exchange rate returns across the period and for the key events were on average no different to zero and the CCEs generally converge towards zero in the period leading up to the post event period. It should be noted that a number of the t-statistics were significant but this would not necessarily be an indication of capital control event impact.

To measure success of an event, the event and direction criterion (Fratzscher, 2005; Pandey et al., 2015) were assessed. Approximately 90% of the events (7 of the 8) were unsuccessful with only one success. As the counterfactual for this research paper is exchange rate returns of zero owing to the efficient market hypothesis, the evidence supports a random walk effect therefore we cannot reject the null hypothesis and conclude that there is no statistically significant

relationship between the capital control event and exchange rate stability. i.e. the expected exchange rate returns are equal or close to zero.

The outcomes were consistent with prior studies for developed and emerging market economies where a couple of factors are at play and do not show expected trends that are a signal of effectiveness (Pandey et al., 2015, p. 10), especially in the long run.

Volatility

The findings of this research report raise further questions surrounding the effectiveness of capital controls. In the first instance, the volatilities are sporadic and there is no pattern as when the controls are considered thus we infer that there was limited impact of the controls.

The average volatility value for the 8 key events which is 15.2593% (0.9612% non-annualised) is close to the average for the period 16.4947% (1.0391% non-annualised). The expectation is that controls would reduce this variability significantly which is not the case in this research. When reviewing the event study for the 8 key events before, during and after each event, there is no indication that a sustained decrease (or increase) in volatility is attributable to the CCEs. This was achieved by inspecting whether volatility increased subsequent to each event window. There is also no discernible trend and the controls would not have distorted or had a negative impact on the exchange rate which could provide merit to the issue of timing of these controls to avoid the adverse effects that regulators are attempting to avoid.

The GARCH (1,1) model was utilised owing to evidence of the leveraged effects and volatility clustering. The sum of α (0.078421) and β (0.906402), the coefficients of the ARCH and GARCH respectively, is very close to 1 (a sum of 0.984823) therefore volatility shocks are highly persistent. It was also illustrated how in this model, the ZAR/USD return volatility is influenced by its own ARCH and GARCH factors, i.e. its own shocks. The variance series was analysed and the GARCH estimate was employed to create a “shock” which would provide an idea of the general behaviour of the residuals. The results show that volatility has not increased substantially (nor is there a marked decrease) as a result of the CCEs and there is no pattern in the data as the residual series (the regression estimate and the GARCH estimate) are more or less similar. The conclusion is that the volatility has neither increased nor decreased during the period following the CCEs therefore the controls had no significant impact, a rejection of the alternative hypothesis.

Liquidity

The results show a constant theme with the results on returns and volatility and is consistent with the literature. For the returns, the USD_GBP LF measure is at its highest when the Rand was under pressure during the collapse in 2001 and during the 2007/08 financial crisis which confirms foreign exchange illiquidity during crisis or sudden stop periods.

The link between volatility and liquidity exists and is shown in the data for the period, which is consistent with empirical research such as in Karnaukh et al. (2015). For volatility, the exponential weighted moving average (EWMA) or exponential weighted volatility was used to proxy for volatility. The LF illiquidity measure and the EWMA follow a similar pattern in the majority of instances with less liquidity during periods of high volatility.

On the event study aspect of liquidity, the estimation interval or benchmark was used to assess the resultant impact of the event on the liquidity as shown by the LF illiquidity measure. None of the events (especially the easing events) show a drop in the LF illiquidity measure, i.e. a sustained improvement in liquidity following the event as the expected outcome of easing of controls would be to enhance liquidity in the market and tightening events should restrict or result in illiquidity. The results show that a link between volatility and illiquidity exist and the CCEs generally did not impact liquidity as intended, thus we cannot reject the null hypothesis.

5.2. PROBLEM DEFINITION AND ANSWER

The research question stated in section 1 was "*Do capital controls contribute to exchange rate stability?*" Evidence from empirical literature (Abdalla, 2012; Farrell, 2001; Forbes et al., 2015; Gidlow, 2005; Glick & Hutchison, 2005, 2011; Gross, 2008; Pandey et al., 2015), although not always comparable as some of the studies were cross-sectional in nature, suggest that they are not effective and do not contribute to exchange rate stability. Findings from this research report are consistent with prior research implying that that capital controls are not as effective.

5.3. POLICY IMPLICATIONS

The foreign exchange market is the biggest market by trading volume and amounts in the global economy. With the South African Rand being an important currency in the market, the impact on returns, volatility and liquidity cannot be ignored as this has far reaching implications on

the wider market. The findings indicate that the liberalisation of controls has a bearing on these three important aspects. In addition, the link between volatility and liquidity creates a contagion effect which magnifies the impact of controls that are not robustly researched.

As indicated in section 4, South Africa's capital account liberalisation (much like India's) involves onerous statutory processes without actually undoing the configuration of capital controls. As a result, measures to ease capital controls might not have the desired effect as the regulators are able to undo past capital control events which could offset the short-term effect of those changes. As such, welfare effects (costs) of having these controls are far greater than the benefit of liberalisation.

Although not specifically reviewed in this research, there are costs and not to mention the administrative burden on market participants to implement or change their processes in order to align with the capital controls. These could lead to market imperfections which would have been better resolved had the market been allowed to operate free of intervention by authorities which would limit unintended consequences of their actions. It is likely therefore that participants will continue to engage in practices to circumvent the controls instead of more productive activities which benefit society as a whole.

The importance of timing of the events is also critical and could be one of the reasons for limited distortions in the market as a result of a number of the events. However, this could be attributed to the inadequacies of some of the events that were targeted as described below.

Finally, capital account openness, and the resulting effect on exchange rates usually occur when the complete sub-category of the capital account changes (Pandey et al., 2015). In most instances, the capital control events generally represent a change in a portion of the sub-categories which in essence will have a minimal effect (if at all) on the exchange rate.

5.4. RECOMMENDATIONS

In considering the results of the research and the implications highlighted, policymakers should re-valuate the concept of gradual removal of capital controls. The occasional implementation of capital controls has not yielded the desired effect and additional research should be channeled towards complete liberalisation of controls.

In addition, an event study approach coupled with propensity score matching should be used as a framework and performed on all capital control events to further provide substantive

evidence for the reduction or abolishment of capital controls in order to benefit from an open economy.

As was apparent in the research and noted by authors such as Fratzscher (2005), it is not always clear what the objectives of the capital control interventions are when implemented by policymakers. As a result, it is not always clear whether the controls have achieved the stated outcome. A recommendation is for the policymakers to improve the transparency on the actions and their objectives, tools to establish the limits as this would easily guide the actions of market participants and lead to a more robust way of measuring the success of capital controls.

Finally, an analysis should be performed on an expanded set of capitals controls as noted above and seek to review, as performed in this research paper, the return effect, volatility and liquidity impact, including the contagion effect of volatility on liquidity.

5.5. PRIORITIES FOR FURTHER RESEARCH

In the context of extending this topic further, propensity score matching should be employed to further improve the robustness of assessing the impact of CCEs. As indicated in the research by Pandey et al. (2015) and Forbes et al.(2015), this can be used to build the counterfactual to enable causal inferences and assess whether the abnormal returns and accompanying distributions when a capital control action (the event) occurred were significantly different to those of the similar date where a CCE did not occur. This date with similar features is obtained using propensity score methodology. Pandey et al. (2015) state that “While an event study with all CCAs allows us to identify changes in a series after a CCA, it does not allow us to make causal inferences unless the CCA is randomly assigned” (Pandey et al., 2015, p. 21). Including causal inferences further assist policymakers when implementing such regimes and adds rigour to empirical research aimed at assessing the effectiveness of capital controls. Propensity scores have been used for the analysis of the causal effects of policy interventions since the early ground-breaking research by Rosenbaum & Rubin (1983). Research has also been done around its use, applicability and relative merits, especially over regression analysis (Angrist & Kuersteiner, 2011; Angrist & Pischke, 2008, Chapter 3). Since then, various authors (Angrist & Kuersteiner, 2011; Forbes et al., 2013, 2015; Glick et al., 2006; Gross, 2008; Pandey et al., 2015) have implemented the approach to refine empirical analysis and control for selection bias.

Future research will use existing work on determinants of capital controls and associated capital flows to calculate the propensity score. Forbes et al. (2015) used the same approach with a weekly frequency and came up with a base logit regression model which includes a probability of a capital control [capital-flow management measures (CFM))], global variables such as interest rate spread, commodity prices and VIX and domestic or country specific variables such capital flows, exchange rate, inflation expectation.

In addition, it would be worth performing the study and assessing the effects after the introduction of the Financial Sector Regulation or "Twin Peaks" model for the South African financial regulatory framework. The study will review the tools that are currently used to establish the limits on exchange restrictions and whether a new approach or new tools can, and should be employed.

Secondly, in keeping in line with previous research (Pandey et al., 2015), future research should be aimed at examining sub-categories of capital controls to assess whether particular kinds of limits would be more impactful than others. This will allow the analysis to be performed on an expanded set of capital controls and not just the 8 key events assessed in this research report. Ideas to enhance the data sets could include using the South African Volatility Index (SAVI) (SAVI Top 40) from the Johannesburg Stock Exchange (JSE) used to assess the market temperament in the South African Equity Markets. The SAVI Top 40 is a forward estimate (generally 3 months) of the Equity Market Risk in South Africa and is moulded on the VIX. In addition, The SAVI Dollar, which predicts the 90-day inferred volatility of the rand against the dollar, can be used to assess the market temperament surrounding the local currency market.

An area not dealt with in this research is whether the benefits of capital controls outweigh the costs using a cost-benefit analysis (Pandey et al., 2015). Research in this area will enable the investigation of whether the micro-, macro- and political economic issues arising from capital controls can be offset by the intended gains of such policy initiatives. As stated in Chapter 2, an investigation of whether exchange control restrictions curtail the undesirable effects that the regulators are attempting to prevent was not performed. The paper did not review issues such as losses due to forced lack of diversification, administrative burden, effect on output and costs (Frenkel, Shimidt, Stadtmann, & Nickle, 2002) on individuals or when investment companies and financial service providers are required to close access to their product after reaching their prudential limits. Research on the cost side as detailed in (Pandey et al. (2015) should also be considered.

5.6. LIMITATIONS OF THE STUDY

A key limitation of the study was the noise in the data as a result of using daily exchange rate data for the period especially since the effects of capital control events are generally observed about a month after the event (Forbes et al., 2016). As such, the results of the event study might indicate that there is no significant different in shorter intervals. In addition, as the model coefficient of determination is considered low at a percentage of around 25%, it might not be considered robust enough to unpack additional variables or factors that create a clear view of the effect of capital control events on capital flows and ultimately the exchange rate. Nevertheless, as there are a number of factors that lead to changes in exchange rates across time, this dollar factor from the market model is consistent over time.

A further limitation concerns the list of variables that have an effect on the exchange rate as these were not exhaustive. Although the study used an event study approach, applying propensity score matching and including additional variables in future research together with advanced estimation techniques will resolve more of the endogeneity and selection bias issues. As stipulated in sections 2.5 and 5.5, event study methodology alone will only identify fluctuations in the series after the event but will add to the more important aspect concerning causal interpretations (Pandey et al., 2015). Including causal inferences further assist policymakers when implementing such regimes and adds rigour to empirical research aimed at assessing the effectiveness of capital controls.

To add on, assumptions were made about the actual motives behind the capital control events from the regulatory authority's point of view and the results they intended to obtain. The motivations could either be to alleviate exchange rate pressures on the one hand or to ease systematic risk uncertainties on the other (Pandey et al., 2015).

An assessment of whether exchange control restrictions curtail the undesirable effects that the regulators are attempting to prevent (e.g. increases transaction costs, circumvention etc.) was not performed. As regards the model, initial testing using other tests of serial correlation, namely the Q-statistic and the Breusch-Godfrey LM test, indicated evidence of higher order serial correlations and this will be resolved by amending the model. These limitations will be assessed in future research.

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Appendix A: Purpose, methods and direction of capital controls

Table 1

Purposes of Capital Controls

Purpose of Control	Method	Direction of Control	Example
Generate Revenue/ Finance War Effort	Controls on capital outflows permit a country to run higher inflation with a given fixed-exchange rate and also hold down domestic interest rates.	Outflows	Most belligerents during WWI and WWII
Financial Repression/ Credit Allocation	Governments that use the financial system to reward favored industries or to raise revenue, may use capital controls to prevent capital from going abroad to seek higher returns.	Outflows	Common in developing countries
Correct a Balance of Payments Deficit	Controls on outflows reduce demand for foreign assets without contractionary monetary policy or devaluation. This allows a higher rate of inflation than otherwise would be possible.	Outflows	U.S. interest equalization tax, 1963-74
Correct a Balance of Payments Surplus	Controls on inflows reduce foreign demand for domestic assets without expansionary monetary policy or revaluation. This allows a lower rate of inflation than would otherwise be possible.	Inflows	German Bardepot scheme, 1972-74
Prevent Potentially Volatile Inflows	Restricting inflows enhances macroeconomic stability by reducing the pool of capital that can leave a country during a crisis.	Inflows	Chilean *encaje*, 1991-98
Prevent Financial Destabilization	Capital controls can restrict or change the composition of international capital flows that can exacerbate distorted incentives in the domestic financial system.	Inflows	Chilean *encaje*, 1991-98
Prevent Real Appreciation	Restricting inflows prevents the necessity of monetary expansion and greater domestic inflation that would cause a real appreciation of the currency.	Inflows	Chilean *encaje*, 1991-98
Restrict Foreign Ownership of Domestic Assets	Foreign ownership of certain domestic assets—especially natural resources—can generate resentment.	Inflows	Article 27 of the Mexican constitution
Preserve Savings for Domestic Use	The benefits of investing in the domestic economy may not fully accrue to savers so the economy, as a whole, can be made better off by restricting the outflow of capital.	Outflows	
Protect Domestic Financial Firms	Controls that temporarily segregate domestic financial sectors from the rest of the world may permit domestic firms to attain economies of scale to compete in world markets.	Inflows and Outflows	

Source: Neely (1999)

Appendix B. GARCH (1,1) model and alternative forms of the conditional variance

The GARCH model equations as presented by Farrell (2001) are as follows

$R_t = c + \theta v_{t-1} + v_t$

$v_t / \Omega_{t-1} - N(0, h_t^2)$

$h_t^2 = \alpha_0 + \alpha_1 v_{t-1}^2 + \beta_1 h_{t-1}^2$

$\alpha_0 > 0;\ \alpha_1 \geq 0;\ \beta_1 \geq 0;\ \alpha_1 + \beta_1 < 1$

where R_t represents the "(100*) the log first differences of the exchange rate data" (Farrell, 2001, p. 3) i.e. return at time t

v_t and v_{t-1} representing the current and lagged residuals

In the econometric modelling approach, the major characteristics of exchange rate volatility stated by Erdemlioglu et al. (2012) include a. intraday periodicity, b. autocorrelation and c. discontinuities and the approach also incorporated periodic volatility patterns and macroeconomic announcements (jump estimations). The EGARCH incorporates the asymmetry while building on the GARCH model where the conditional variance only considers size of the past observations whereas the EGARCH considers their sign as well. By showing the various equations, the model can be expressed in the form shown below.

$R_t = c + \theta v_{t-1} + v_t$

$v_t = h_t \varepsilon_t$

$\varepsilon_t = \Omega_{t-1} \sim N(0, 1)$

$\ln(h_t^2) = \alpha_0 + \alpha_1 g(\varepsilon_{t-1}) + \beta_1 \ln(h_{t-1}^2)$

$g(\varepsilon_t) = \pi\varepsilon_t + \gamma(|\varepsilon_t| - E[|\varepsilon_t|]$

Appendix C. Additional details on event study methodology

In the constant mean return model, X_τ is constant and it represents the market return in the market model. Other types of models (though not discussed further for the purposes of this research paper) include the statistical models such as the factor model, normal performance return model or multifactor models though there are limited benefits of using the multifactor models. The constant mean return model is presented as follows:

$$R_{it} = \mu_i + \zeta_{it}$$

$$E(\zeta_{it}) = 0;\ var(\zeta_{it}) = \sigma^2{}_{\zeta_i}$$

With R_{it} representing the return on security *i* during the interval *t*, μ_i as the mean return and the error term ζ_{it}.

The reasons for selecting a market model as opposed to the other models are as follows. Firstly, it is a simple model and fits in with the purposes of the study. In addition, by eliminating the piece of the return that is associated with the deviation in market return, the market model decreases the variation of the abnormal return. This is key as it will ultimately result in a higher likelihood of uncovering the impact of an event. Unlike the CAPM model, the market model does not have various constraints and the results, unlike the CAPM, are not susceptible to the model constraints. In addition, the APT has limited gains over the generalised market model as adding factors[49] to the APT model does not significantly increase its explanatory power over the market model (MacKinlay, 1997, pp. 18–19).

The specification of the estimation window occurs and the preferred period selected is usually the period before the event window. As a general principle, the event interval is not part of the estimation interval to avoid the contagion effect on the parameter estimates for normal performance[50]. In addition, there should not be an overlay between the event window and the estimation window as this would violate one of the conditions where the effect of the event is depicted by abnormal returns (MacKinlay, 1997, p. 20). The testing outline (econometric structure) for abnormal returns is then constructed once all these elements are in place. This involves key aspects which include:

a. Specifying the null hypothesis; and

[49] The vital factor in the APT performs in much the same manner as a market factor (MacKinlay, 1997, p. 19)

[50] Once these parameter estimates have been determined, the calculation of abnormal performance can occur.

b. The procedures for accumulating[51] the abnormal returns in order for inferences to be made. As this is a time series research paper, this is done across time.

Specifying the null hypothesis for event studies

According to MacKinlay, "…conditional on the event window market returns, the abnormal returns will be jointly normally distributed with a zero conditional mean and conditional variance $\sigma^2 \widehat{AR}_{i\tau}$" (MacKinlay, 1997, pp. 20–21). With this in mind, inferences about intervals within the event window can be made by utilising the distribution aspects of the abnormal performance.

Time series aggregation of abnormal returns

As previously stated, an event study aims to assess if the distribution of returns at the point where the event occurs (cross sectional) is abnormal or whether the distributions for the mean abnormal returns interval around the event (time series) are equal to zero. This involves using statistical analysis to determine whether the distribution of actual values differ from the predicted values. Literature on event studies commonly focuses (and as such the null hypothesis) on the mean of the abnormal returns distribution and whether the values, also known as the average residual (AR), around the interval are equal to zero (Kothari & Warner, 2006; MacKinlay, 1997).

As indicated before, this research is of a time series nature and the focus will be on methods related to that. Therefore, in a time series framework, because we are concerned with the way abnormal returns act before (estimation window) and after (post-event window) an event, it is necessary to include these as they are important in determining the information content and effect of time periods around the event.

Other key items that follow in an event study setup are:

a. Exhibiting the econometric results which as stated in the background of this study, should result in insight into the causes of the effects of capital controls;
b. Depicting the diagnostics.

Part (c) and (d) were dealt with in the methodology section of this research study.

Finally, a majority of the event study methods depend on assumptions surrounding the abnormal returns distribution, i.e. parametric tests. Nonparametric options that do not make assumptions about the return distribution exist. The rank test and the sign test are examples of pupular nonparametric tests for the event study methodology.

[51] MacKinlay (1997) and other authors use the word aggregating.

Appendix D. Data definitions and key variables including research justification and/or sources

Variable	Definition and research justification
$\Delta s_{i,t+1}$	The return[52] or log change in nominal exchange rates, Δs_i, between the South African Rand and the United States Dollar (Verdelhan, 2015). Source: Thomson Reuters Datastream [Barclays and Reuters]
α_t^2	For the GARCH specification, the conditional variance for use in the construction of the variance equation σ^2, a forward looking forecast based on historic information (Abdalla, 2012; Bollerslev, 1986; Dukich et al., 2010; Farrell, 2001)
Dollar factor	The average change of the exchange rates used in the study in terms of the U.S. dollar (Verdelhan, 2015)
Bid-Ask spread	An indication of the difference between the amount the maximum price a price taker is willing and able to pay (bid) and the minimum price the price setter is willing to receive from the sale of an asset. Bloomberg, Karnaukh et al. (2015)
Corwin-Schultz (CS) measure	A low frequency measure of illiquidity obtained from the Hid, Low and High quotes and is adjusted for overnight returns. A larger CS measure indicates less liquidity. (Corwin & Schultz, 2012; Karnaukh et al., 2015)
Capital flows	The volatility and volume of capital flows are crucial elements in determining capital control policy (Neely, 1999)
TED*[53] *spread	The difference between the 3-month London Interbank Offered Rate (LIBOR) and on 3-month Treasury Bill (T-Bill) yield, closing value which can be used to model the change in liquidity; (Forbes et al., 2015) Source: Federal Reserve Bank of St. Louis, Economic Research Division (Federal Reserve Economic Data, https://research.stlouisfed.org/fred2)
VIX (S&P 500)	Index of market volatility as computed by the Chicago Board Options Exchange (CBOE); measures implied volatility or expectation of near term (generally one month) volatility using prices for a range of stock index options and is quoted in percentage points.; (Forbes et al., 2015) **Daily**. Source: CBOE, CBOE Market Statistics. Retrieved from the Federal

[52] Results from the Euler equation and as presented in Verdelhan(2015) and Lustig & Verdelhan (2006), exchange rates are given by $S_{i,t+1} / S_{i,t} = M_{i,t+1} / M_i$ or as logs $\Delta s_{i,t+1} = m_{t+1} - m_{i,t+1}$.

[53] **TED** is derived from **T**-Bills which are short term United States government debt and **ED** being the symbol for Eurodollar futures contracts (on the open outcry as opposed to the electronic where it is GE). T-Bill yield is the interest at which the U.S. Government can borrow for the 3-month period and Libor is the rate at which banks in the financial system can lend to each other on the over a 3-month period. The TED spread is an indicator of credit risk and the stability of the banking environment ("Definition of Ted spread," n.d.).

	Reserve Bank of St. Louis, Economic Research Division (Federal Reserve Economic Data, https://research.stlouisfed.org/fred2)
VXO (S&P 100)	Index of market volatility as computed by the Chicago Board Options Exchange (CBOE); measures implied volatility using prices for a range of options on the S&P 100 index. This was termed the "original" VIX Index prior to 22 September 2003; **Daily**. (Forbes et al., 2015) Source: CBOE, CBOE Market Statistics. Retrieved from the Federal Reserve Bank of St. Louis, Economic Research Division (Federal Reserve Economic Data, https://research.stlouisfed.org/fred2)

Appendix E: Steps to compute the USD_GBP LF illiquidity measures

1. The daily Bid, Ask and Last quotes for ZAR/USD and ZAR/GBP were downloaded from Bloomberg for the period 1 January 1999 to 31 December 2014 with the source set to the Bloomberg Generic Composite rate (BGN). The values for 5, 8, 9, 10 and 11 May 2006 were unavailable[54] for the ZAR/USD Bid and Ask quotes and were therefore replaced with the Bloomberg Data History (BDH) values. In addition, the Mid, Low and High quotes were obtained from Datastream.
2. The next step involved calculating the two daily measures for each foreign exchange pair, in this case one for the ZAR/USD and another for the ZAR/GBP pair.
    a. The first sub-step involved computing the daily relative bid-ask spreads using the formula "*Daily Relative BA spread = (Ask - Bid) / ((Ask + Bid)/2)*"
    b. The second sub-step involved adjusting[55] the values for overnight returns and constructing the two-day CS measure[56].
3. Step 3 involved calculating the two daily measures for each foreign exchange pair, in this case one for the ZAR/USD and another for the ZAR/GBP pair.
    a. The average for all the relative daily bid-ask estimates provides the relative monthly bid-ask spread.
    b. The simple average for positive two-day CS estimates (negative estimates were excluded) for the sample dates would provide the monthly CS measure.
4. The standardise function in Microsoft Excel was used to create the standardised bid-ask spread and CS measure and following that, the average of the two series was used to obtain the LF measure.

[54] According to Bloomberg representatives at the Helpdesk, this unavailability occurs when the number of contributors to a source is less than 2 or 3 thereby rendering the data unreliable for those days therefore an alternative source should be used. In this case, the BDH was utilised.
[55] The adjustment for overnight changes ensures that spreads are not understated and takes into account the impact on instrument returns arising from the assumption that a) trades constantly occur when markets are open and b) instrument values remain constant when trading is not open, see page 726 of Corwin & Schultz (2012).
[56] Refer to formula 14 on page of 724 in Corwin & Schultz (2012) or formulas 5 and 6 on page 7 of the Appendix to Understanding FX liquidity (Karnaukh et al., 2015).

Appendix F: Propensity Score Matching Methodology – A discussion on the approach

Studies to assess the treatment effect take many forms, with the most common application being in clinical trials where one group [(or individual(s)] is given the treatment or drug under investigation while the other group obtains the placebo or non-therapeutic intervention which does not contain the active ingredient of the drug (Goldenholz & Goldenholz, 2016; Levy, 2015; Mathie et al., 2016). The latter is termed the control group and the former, those who received the active drug, are called the treatment group. The success of such trials lies in there being little or no differences between the individuals chosen to be in the control group and the treated group, i.e. the characteristics of the individuals should be as similar as possible to allow for more accurate testing and identification of causal effects.

In a variety of cases, it has been argued that the most effective manner to test this would be to use identical twins as they possess the same genetic make-up and can be expected to react similarly to the intended effect of the drug (as part of assessing the safety of the drug, the appropriate dosage and side effects if any). One would also imagine an alternate universe where the same individual in this world would receive the active drug and at the same time, this same individual, in the alternate universe, would receive the placebo and the effect of the treatment through time would be observed. However, in policy making, it is difficult (and not feasible in the case of the alternate universe) to assess the effect of policy initiatives using the approaches described above. Propensity score matching is one of the methods used to achieve the results that would enable the evaluation of the treatment effect policy initiatives.

Motivations for the use of propensity score matching methodology

The aim of using propensity score matching methodology in a research study is to help establish the treatment effect of capital control events on exchange rate volatility. Propensity scores have been used for the analysis of the causal effects of policy interventions since the early ground-breaking research by Rosenbaum & Rubin (1983). Research has also been done around its use, applicability and relative merits, especially over regression analysis (Angrist & Kuersteiner, 2011; Angrist & Pischke, 2008, Chapter 3). Since then, various authors (Angrist & Kuersteiner, 2011; Forbes et al., 2013, 2015; Glick et al., 2006; Gross, 2008; Pandey et al., 2015) have implemented the approach to refine empirical analysis and control for selection bias. It also allows for the construction of the counterfactual, therefore alleviating the need to model the outcome variables as indicated by Pandey et al. (2015).

Standard regression techniques are not always ideal in assessing the effects of policy initiatives, especially if these are plagued by self-selection bias and endogeneity (Forbes et al., 2015; Gross, 2008; Pandey et al., 2015). The conventional method of addressing the endogeneity issue is to use instrumental variables but weaknesses in this method relate to identifying the variables that are sound and applicable to the study (Gross, 2008). Gross (2008) also goes on to offer a short summary of capital control indices and their pitfalls in measuring effectiveness of capital controls[57]. In order to measure the causality one would have to add additional variables to the regression model (Pandey et al., 2015) assuming random assignment of these events. The authors go on to state that the propensity score methodology allows for the construction of the counterfactual, the control group, therefore alleviating the need to model the outcome variables as indicated by Pandey et al. (2015). This is similar to the view that "Propensity-score estimation puts greater emphasis on modelling the policy change (the changes in CFMs), and it is not necessary to assume any functional form between any of the variables and the outcomes" (Forbes et al., 2015, p. S81). The authors stipulate that this is important when the baseline model is imprecise with regards to lag length, endogeneity and simultaneity (Forbes et al., 2015). In essence we replicate the policy initiative, i.e. the capital control event and "estimate the conditional probabilities" (Pandey et al., 2015, p. 22) for the use of capital control events. The conditional probabilities are another term for propensity scores, which are used to find time intervals (control observations or untreated groups) that have similar features to dates where capital control events occurred, but for these control groups, capital control events did not occur. This coupling comes from these dates having the equivalent propensities to introduce or change the event.

In prior literature, the traditional use of propensity score matching has for been cross-sectional studies, the advantages of propensity score methodology have been extended to time series data as well (Aggarwal & Thomas, 2013; Moura, Pereira, & Attuy, 2013). Angrist and Kuersteiner (2011) assessed the effect of monetary policy shocks showed that these advantages of propensity score matching over regression analysis using ordinary least squares (OLS) are pragmatic in time series studies, even when endogeneity and simultaneity exist. A key benefit of propensity score matching when compared to multivariate regression analysis is that the

[57] The author indicates three shortcomings relating to indices in that (a) they have been unsuccessful in considering capital control "intensity", (b) an inability (the author uses efficacy) to present a clear distinction concerning de facto and de jure controls and (c) elusiveness (the author uses subtlety) surrounding the direction of the controls. Further discussion are included in Edwards (1999).

assumption of a linear relationship surrounding "the treatments, covariates, and outcomes" (Forbes et al., 2015) is not a prerequisite[58]. Angrist & Pischke (2008) consider that the first step in empirical analysis should be regression owing to the criteria that are essential and additional modifications and that should be made before inferences can be made using propensity score methodology. The major obstacle being that there should be large enough quantity of "similar" observations for a control group to be created (Forbes et al., 2015, p. S81).

Key aspects of propensity score matching methodology and proposed application

As stated by Angrist & Pischke (2008), propensity score matching changes the focus from the estimation of $E[Y_i|X_i, D_i]$ to one of the form $p(X_i) \equiv E[D_i|X_i]$. The use of propensity score matching begins by outlining the treated observation, D_i = 1 representing the interval (day, week, month etc.) where the capital control event takes place (the treated) and its equivalent, D_i = 0 to indicate the untreated or control observation. An exclusion window is also defined where a time interval cannot be used as a control observation. Much like Forbes et al. (2015) this research uses an exclusion of 3 months before and 3 months after the event. The outcome variable, the change in the exchange rate is stated as $Y_{1,i}$ for the ith observation or event in the treated group and $Y_{0,i}$ is its counterpart in the control group. Aggregating for members in each of the groups gives $E\big[Y_{1,i}|D_i = 1\big]$ and $E\big[Y_{0,i}|D_i = 0\big]$.

We are able to estimate the "average treatment effect on the treated", the ATT (which cannot be recognised directly) by subtracting the average volatility of the non-treated intervals from the average volatility for the treated intervals. This is given by the equation:

ATT = $E\big[Y_{1,i} - Y_{0,i}|D_i = 1\big]$[59]

Going back to our clinical trial illustration we see the following comparison:

- $\big[Y_{1,i}|D_i = 1\big]$, volatility given a capital control event, is the group of individual who have taken the active ingredient of the drug; and
- $\big[Y_{0,i}|D_i = 0\big]$, volatility where no capital control event occurred, is the group of individual given the placebo or non-therapeutic intervention.

[58] For further details on the advantages and disadvantages of propensity score matching especially when compares to multivariate regression analysis see Forbes et al. (2015) and Pandey et al. (2015) who provide expert descriptions and explanations.

[59] Forbes et al. (Forbes et al., 2015) indicate that the variation in the two observable indicators (statistics) is an amalgamation of the main variable we draw attention to (i.e. the ATT) and sampling bias. They summarise this as $E\big[Y_{1,i}|D_i = 1 - EY_{0,i}|D_i = 0\big]$ = $E\big[Y_{1,i} - Y_{0,i}|D_i = 1\big]$ **(ATT)** + $E\big[Y_{0,i}|D_i = 1 - EY_{0,i}|D_i = 0\big]$ **(sampling bias)**. The bias comes from the variation in outcomes as a result of variations in the treated and control observations (accounting for varying conditions during different time intervals) rather than the effect of the actual treatment

One will see that the rationale behind the propensity score matching is to construct a modelled control group to simulate a randomised experiment (Gross, 2008).

The propensity score, $p(X_i)$ is therefore:

$p(X_i) \equiv Pr[D_i = 1|X_i]$

It is the conditional probability of a capital control event given the features, X_i, that existed before the treatment and as noted in key literature used in this study "which include country-specific and global variables" (Forbes et al., 2015, p. S80). The following base logit regression model with a weekly frequency was used by Forbes et al.:

$Prob\ (CFM_{it} = 1)\ =\ F\left(\Phi_{i,t-1}^{Domestic} B_C + \Phi_{t-1}^{Global} B_G\right)$

- with CFM_{it} being a dummy variable which is 1 if a country i amends its capital control event during week t;
- Φ_{t-1}^{Global} represents of global variables (the VIX, TED spread, commodity prices, interest rate spread) lagged by a week;
- $\Phi_{i,t-1}^{Domestic}$ represents domestic variables outlining domestic country specific aspects which include the main macroeconomic variables (capital flows, exchange rate, inflation expectation, private credit, and reserves) and variables assessing country specific features that seldom change (exchange rate regime, financial market development, income per capita, capital account openness and institutional strength.

As noted by Rosenbaum & Rubin (1985), matching the treated and untreated observations using the propensity score, $p(X_i)$, is adequate.

The next steps required to complete the approach involve selecting (1) selecting the model to employ to estimate the propensity scores and (2) the algorithm used to match the treated observations with the untreated or control observations. Examples of algorithms used include (a) nearest neighbour without replacement, (b) 5 nearest neighbours, (c) local-linear (d) kernel, and (e) radius with caliper (Forbes et al., 2015). Robustness checks are conducted on the algorithms to evaluate the accuracy of the matching and to reduce substantial variations between the treated and control groups. Once done satisfactorily, the ATT can be estimated to:

ATT = $E\left[Y_{1,i}|D_i = 1,\ p(X_i)\right] -\ E\left[Y_{0,i}|D_i = 0,\ p(X_i)\right]$

Methods to create control groups from propensity scores

The propensity scores are used to match the treated observations with the control observations. The method used by Leuven and Sianesi (2015), the PSMATCH2 Stata tool, is commonly utilised to obtain control groups from the propensity scores. A variety of algorithms are used to obtain these score and examples include (a) nearest neighbour without replacement, (b) 5-nearest neighbours, (c) local-linear (d) kernel, and (e) radius with caliper (Forbes et al., 2015). Essama-Nssah (2006) reviewed propensity score matching illustrated it in EViews and assessed it against methods like the double difference, instrumental variable and Heckman's method of selection bias correction. While the author does not indicate a preferred technique or determine whether the propensity score matching is more effective than the other techniques, the general conclusion is that propensity score matching is a valuable ancillary to other techniques.

Once the propensity score matching has been considered sound and the matched pairs are available (treated or control groups), the event study methodology and its key features can be applied to the expanded set of capital control events (and not just the 8 key events). This will be possible because the treated observations can now be compared to the untreated observations which serve as the counterfactual. The abnormal and normal return should also be measured, drawing from research by MacKinlay (1997). Several steps would follow in applying the methodology, which are:

- **First stage logit regression and results**

Obtaining and reviewing the results of the logit regressions using the data under study

- **Consistency checks for the logit regression results**

The section inspects the results of the logit regression for consistency. It also assesses the significance of the propensity scores as well as additional sensitivity tests to refine the results.

- **Creating the control groups using the propensity scores**

The propensity scores are used to match the treated observations with the control observations. The EViews propensity score matching method applied by Essama-Nssah (2006) or the PSMATCH2 Stata tool by Leuven and Sianesi (2015) can be used with nearest neighbour without replacement approach for instance.

- **Assessing the robustness of the propensity score matching exercise**

Additional robustness checks were performed to enhance the precision of the results. This looks at the two main assumptions of propensity score matching, i.e., the (1) common support condition and the (2) independence assumption (balancing test). These check whether the propensity score matching exercise is sound or valid.

- **Assessing the results of the event study applied to the matched pairs**

The simplified form of the model [$\Delta s_{i,t+1} = \alpha_i + \beta_i Dollar_{t+1} + \varepsilon_{i,t+1}$] can also be used to perform the event study on the matched pairs.

The event study methodology will be applied to the 8 key events using the matched pairs (treated or control groups). The effects of the capital control event can then be assessed because the treated observations can now be compared to the untreated observations which serve as the counterfactual. This also includes measuring the abnormal and normal returns and provides a basis to compare the distributions of the two groups to make inferences about the impact of capital controls.

Appendix G: Results of statistical tests (result outputs and graphs)

Table 24 – Unit Root Test for Rand $ BBZARSP Return

Null Hypothesis: RAND_$_BBZARSP_RETURN has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-63.97922	0.0001
Test critical values:	1% level	-2.565516	
	5% level	-1.940900	
	10% level	-1.616649	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RAND_$_BBZARSP_RETURN)
Method: Least Squares
Date: 06/24/16 Time: 02:19
Sample (adjusted): 1/04/1999 12/31/2014
Included observations: 4173 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RAND_$_BBZARSP_RETURN(-1)	-0.990490	0.015481	-63.97922	0.0000

R-squared	0.495242	Mean dependent var	-6.03E-07
Adjusted R-squared	0.495242	S.D. dependent var	0.014628
S.E. of regression	0.010393	Akaike info criterion	-6.295178
Sum squared resid	0.450614	Schwarz criterion	-6.293659
Log likelihood	13135.89	Hannan-Quinn criter.	-6.294641
Durbin-Watson stat	1.999606		

Source: Author, 2016

Table 25 - Unit Root Test for Dollar factor

Null Hypothesis: DOLLAR_FACTOR has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-50.96228	0.0001
Test critical values:	1% level	-2.565516	
	5% level	-1.940900	
	10% level	-1.616649	

*MacKinnon (1996) one-sided p-values.

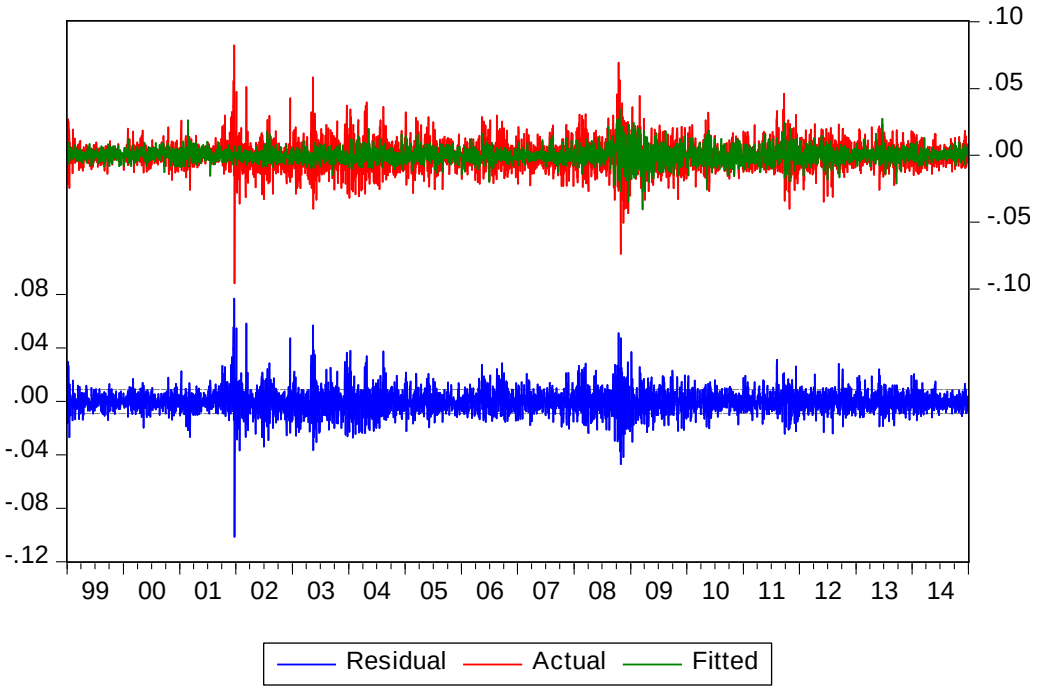
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DOLLAR_FACTOR)
Method: Least Squares
Date: 06/24/16 Time: 02:29
Sample (adjusted): 1/04/1999 12/31/2014
Included observations: 4173 after adjustments

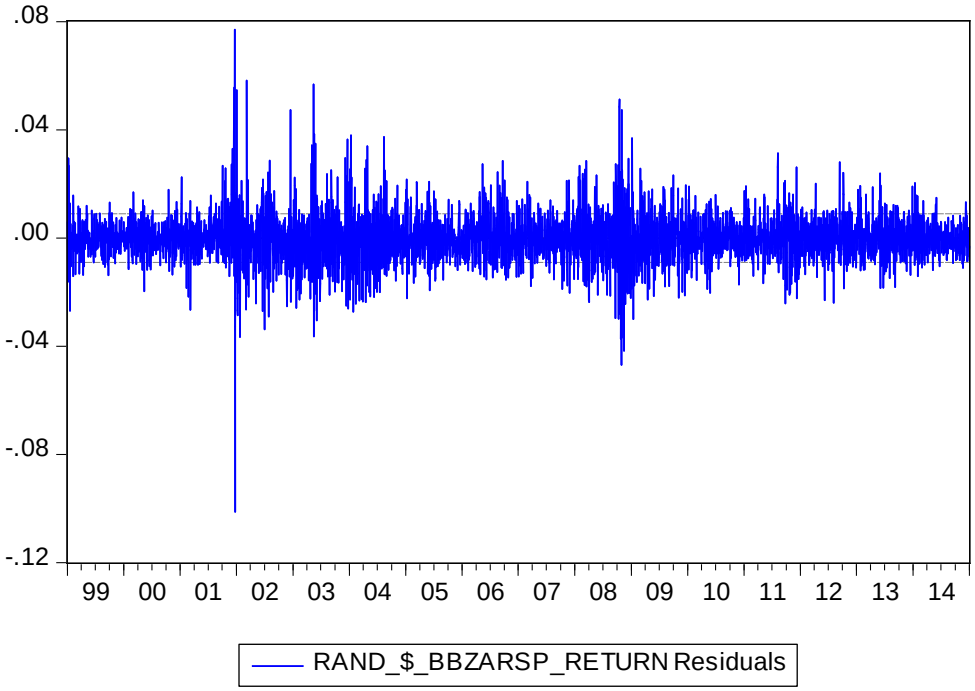
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DOLLAR_FACTOR(-1)	-0.767351	0.015057	-50.96228	0.0000

R-squared	0.383675	Mean dependent var	7.59E-08
Adjusted R-squared	0.383675	S.D. dependent var	0.003606
S.E. of regression	0.002831	Akaike info criterion	-8.896266
Sum squared resid	0.033432	Schwarz criterion	-8.894747
Log likelihood	18563.06	Hannan-Quinn criter.	-8.895729
Durbin-Watson stat	1.994109		

Source: Author, 2016

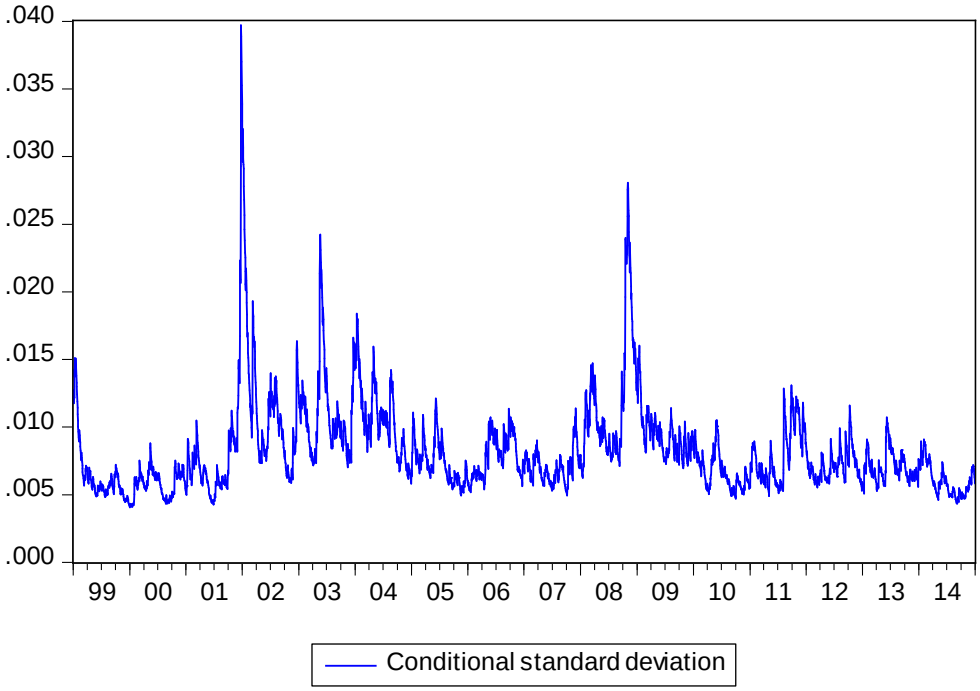
Figure 29 – Residuals against actual and fitted for regression including Dollar factor, TED spread, VIX and VXO





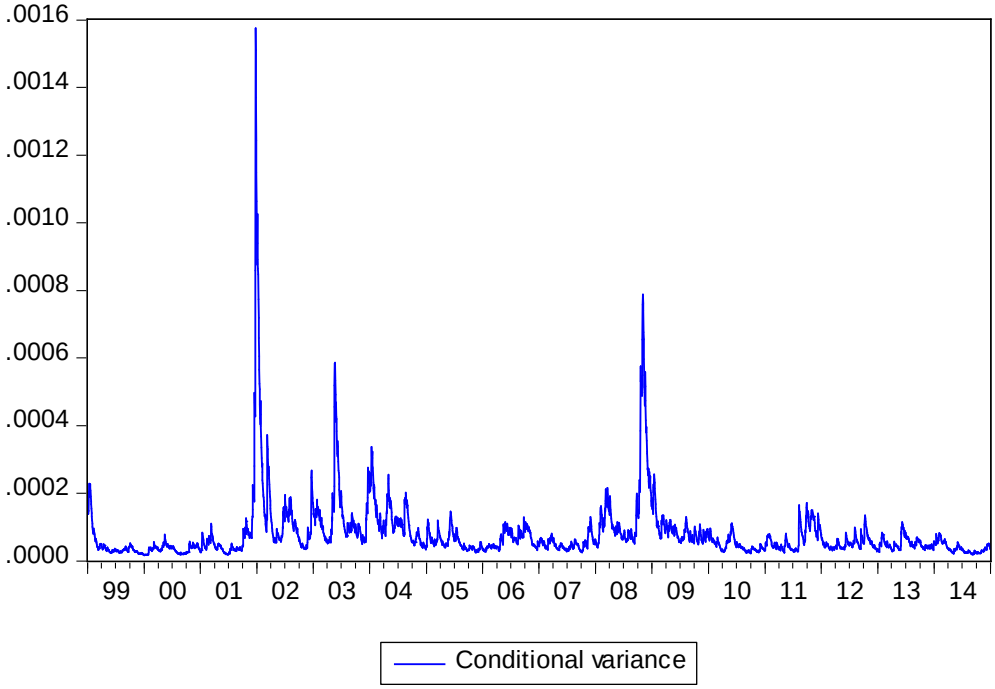
Source: Author, 2016

Figure 30 – GARCH graph on Student's t: Conditional standard deviation



Source: Author, 2016

Figure 31 – GARCH graph on Student's t: Conditional variance



Source: Author, 2016

Mean equation residuals vs GARCH residuals for 8 key events, Source: Author, 2016

Figure 32 - Event 1

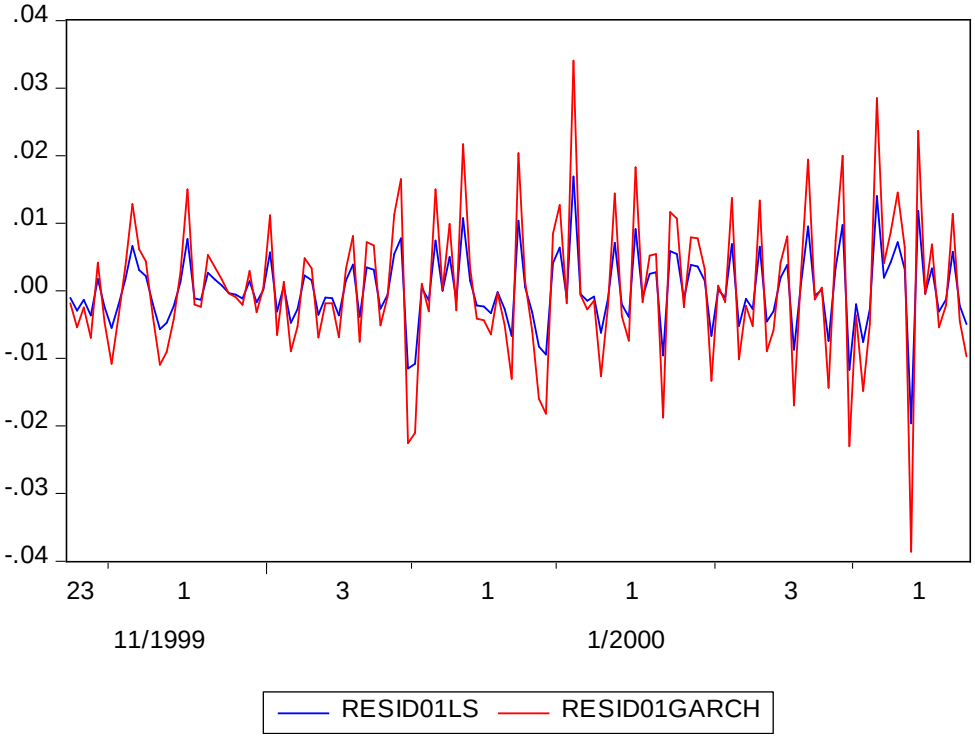


Figure 33 - Event 2

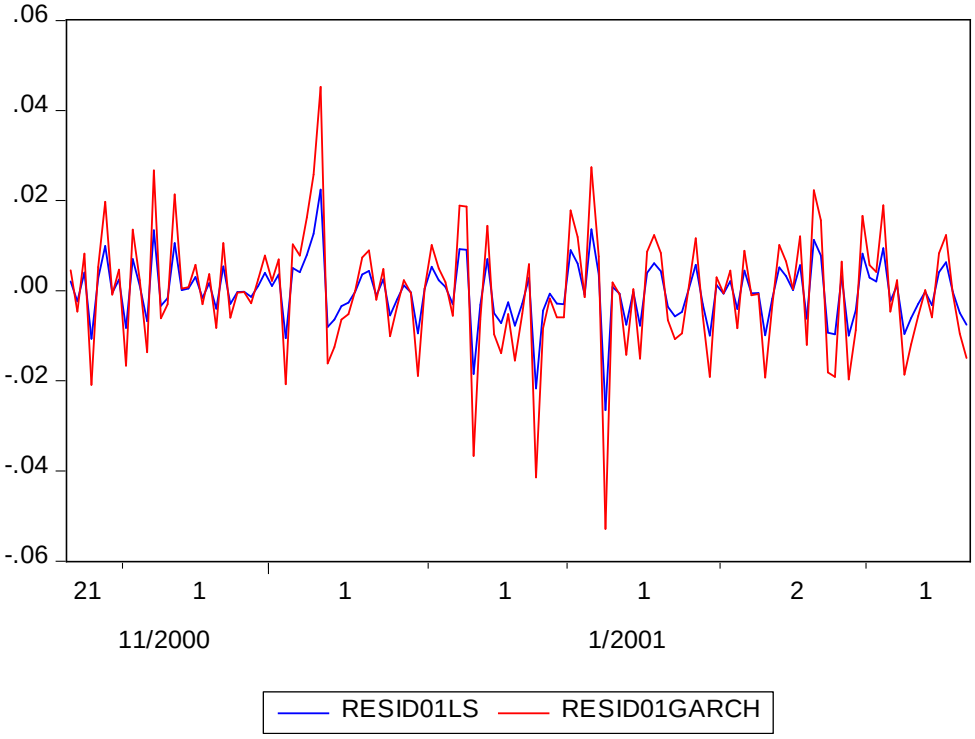


Figure 34 - Event 3

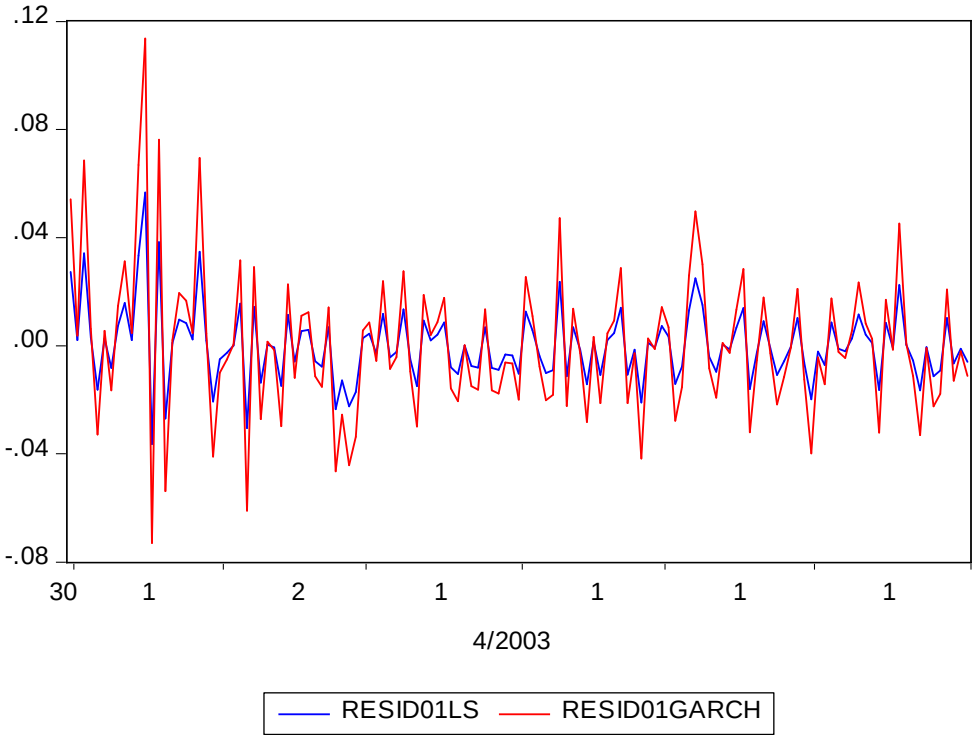


Figure 35 - Event 4

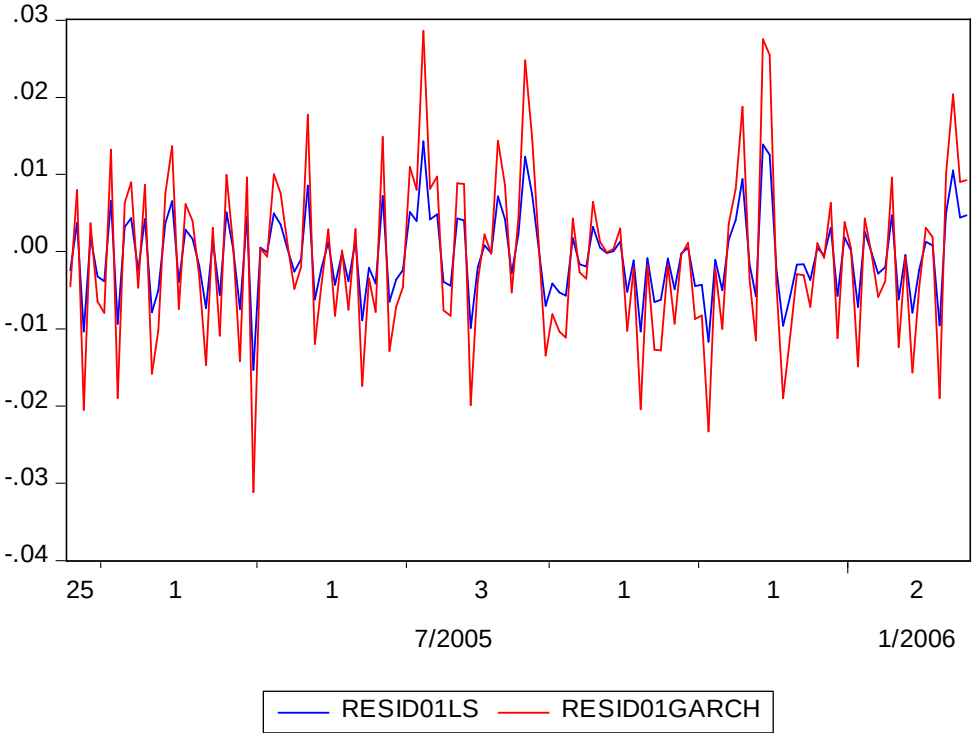


Figure 36 - Event 5

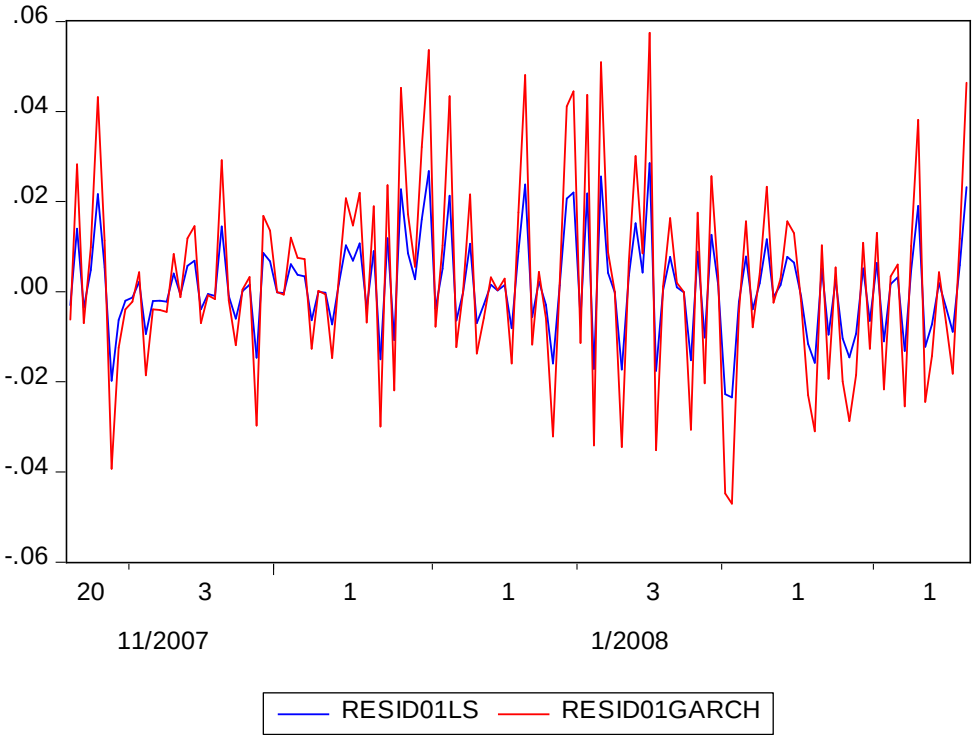


Figure 37 - Event 6

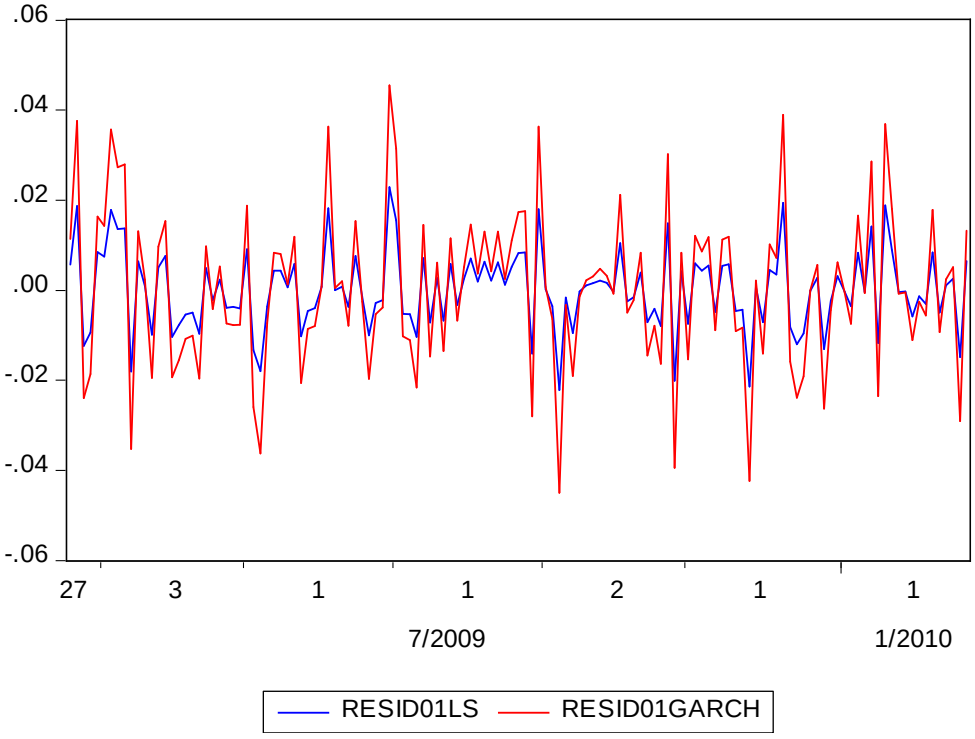


Figure 38 - Event 7

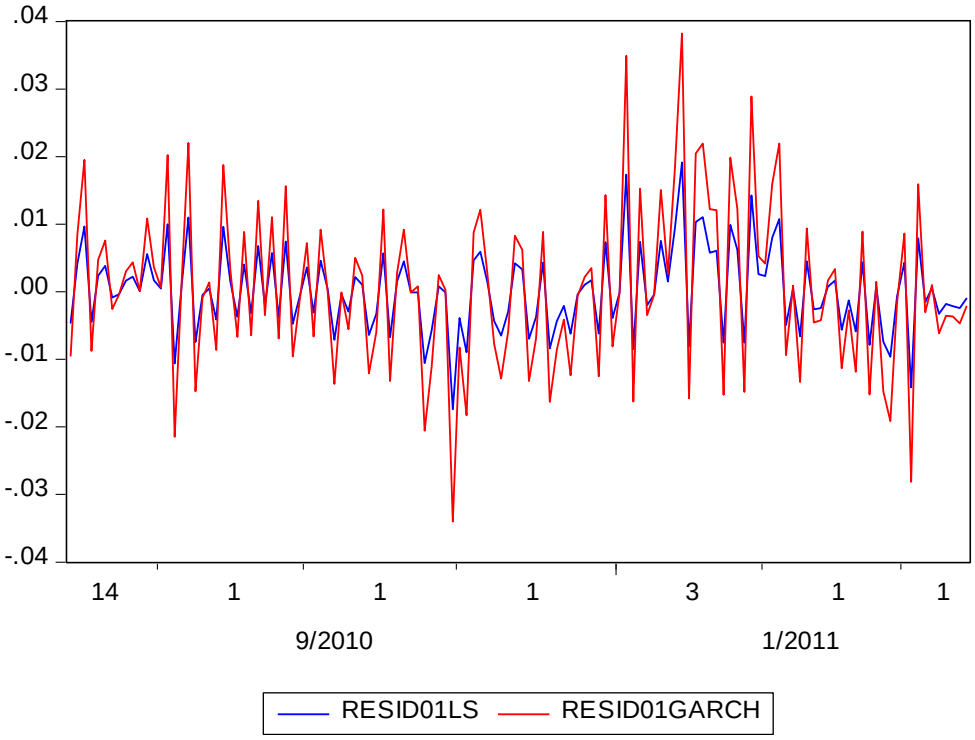


Figure 39 - Event 8